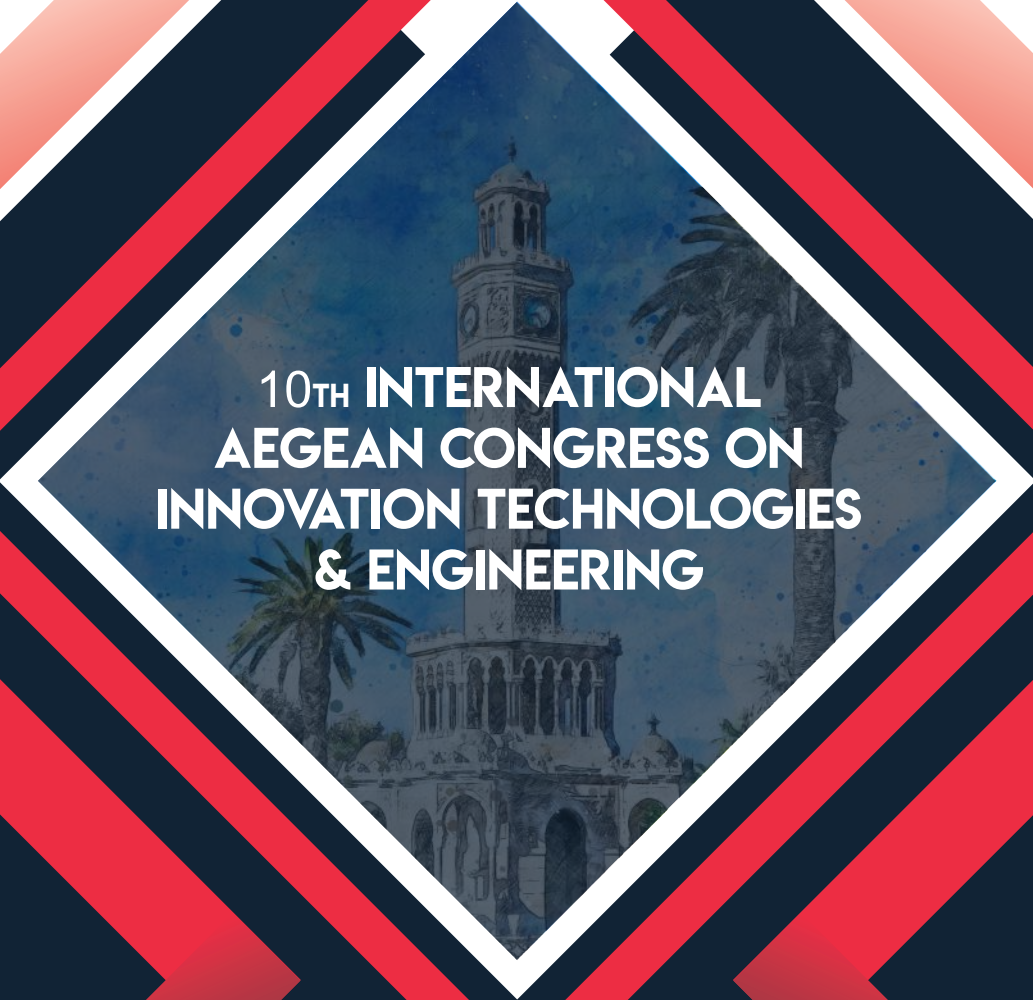


AEGEAN
CONGRESSES



**10TH INTERNATIONAL
AEGEAN CONGRESS ON
INNOVATION TECHNOLOGIES
& ENGINEERING**

PROCEEDINGS BOOK

EDITOR

Assoc. Prof. Dr. Mehmet Emin KALGI

ISBN: 978-625-367-874-6

INTERNATIONAL AEGEAN CONFERENCES

ON INNOVATION TECHNOLOGIES & ENGINEERING-X

October 05-07, 2024 / Izmir, Türkiye



PROCEEDINGS BOOK

EDITOR

Assoc. Prof. Dr. Mehmet Emin KALGI

All rights of this book belong to IKSAD Global Publishing House

Authors are responsible both ethically and juridically

IKSAD Global Publications

Issued: 20.10.2024

ISBN: 978-625-367-874-6

CONFERENCE ID

CONFERENCE TITLE

INTERNATIONAL AEGEAN CONFERENCES
on Innovation Technologies & Engineering

DATE and PLACE

October 05-07, 2024 / Izmir, Türkiye

ORGANIZATION

IKSAD- INSTITUTE OF ECONOMIC DEVELOPMENT AND SOCIAL RESEARCHES
ATLAS INTERNATIONAL JOURNAL ON SOCIAL SCIENCES ISSN - 2616 - 936X

ORGANIZING COMMITTEE

Assoc. Prof. Dr. Mehmet Emin KALGI
Head of Conference

Prof. Dr. Salih ÖZTÜRK
Head of Scientific Committee

Prof. Dr. Natalia LATIGINA
Member of Organizing Committee

Prof. Dr. Akbar VALADBIGI
Member of Organizing Committee

Prof. Dr. Gülzar IBRAGIMOVA
Member of Organizing Committee

Prof. Dr. Ökkeş KESİCİ
Member of Organizing Committee

Assoc. Prof. Dr. Osman Bayraktutan
Member of Organizing Committee

Assist. Prof. Dr. Sinan Özyurt
Member of Organizing Committee

Dr. Muhammad Shoaib KHAN PATHAN
Member of Organizing Committee

Dr. Elvan CAFEROV
Member of Organizing Committee

Lect. Ahmet ALINCA
Member of Organizing Committee

Samiksha JAIN
Member of Organizing Committee

NUMBER of ACCEPTED PAPERS- 111

NUMBER of REJECTED PAPERS- 42

PARTICIPANTS' COUNTRIES

Türkiye (52), Tanzania (1), Iraq (2), Albania (2), Algeria (6), Poland (1), South Africa (1), Saudi Arabia (2), Nigeria (9), Pakistan (3), Oman (3), Philippines (5), India (11), Georgia (1), Romania (2), Ukraine (1), Malaysia (1), Italy (2), Jordan (1), Indonesia (1), Morocco (2), Republic of Korea (1), Russia (1).

**Double blinded evaluation process*



SCIENTIFIC COMMITTEE BOARD

- Dr. Maha Hamdan ALANAZI - *Riyad King Abdullah University*
- Dr. Tamalika SULTANA - *Dakka University of Bangladesh*
- Dr. Kenes JUSIPOV - *Kazak Transportation Academy*
- Dr. Nilgün ULUTASDEMİR - *Gumushane University*
- Dr. Murat EYVAZ - *Gebze Technical University*
- Dr. Menekşe ŞAKİR - *Erciyes University*
- Dr. Mehmet GÖKTÜRK - *Gebze Yüksek Teknoloji institute*
- Dr. Sezen TEKİN - *Çankırı Karatekin University*
- Dr. Hakan EYGÜ - *Atatürk University*
- Dr. G. C. Rana - *NSCBM Govt. College Hamirpur*
- Dr. Mohamed El Malki - *Department of Physics*
- Dr. H. Burçin HENDEN ŞOLT - *Zonguldak Bülent Ecevit University*
- Dr. Fatih YILDIRIM - *Atatürk University*
- Dr. F. Gül KOÇSOY - *Firat University*
- Dr. Praveen KUMAR - *HR & OB Division*
- Dr. Norma-Aurea Rangel-Vázquez - *TECNM/Instituto Tecnológico de Aguascalientes*
- Dr. Yeşim TARHAN- *Ardahan University*



INTERNATIONAL AEGEAN CONFERENCES Innovation Technologies & Engineering-X

October 5-7, 2024
IZMIR, TÜRKİYE

CONFERENCES PROGRAM

Türkiye (52), Tanzania (1), Iraq (2), Albania (2), Algeria (6), Poland (1), South Africa (1), Saudi Arabia (2), Nigeria (9), Pakistan (3), Oman (3), Philippines (5), India (11), Georgia (1), Romania (2), Ukraine (1), Malaysia (1), Italy (2), Jordan (1), Indonesia (1), Morocco (2), Republic of Korea (1), Russia (1).

Online (with ZOOM Conference)
Meeting ID: 860 5266 6988
Passcode: 050607



IMPORTANT, PLEASE READ CAREFULLY

- ❖ To be able to attend a meeting online, login via <https://zoom.us/join> site, enter ID "Meeting ID or Personal Link Name" and solidify the session.
- ❖ The Zoom application is free and no need to create an account.
- ❖ The Zoom application can be used without registration.
- ❖ The application works on tablets, phones and PCs.
- ❖ The participant must be connected to the session 5 minutes before the presentation time.
- ❖ All congress participants can connect live and listen to all sessions.
- ❖ Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session.

Points to Take into Consideration - TECHNICAL INFORMATION

- ◆ Make sure your computer has a microphone and is working.
- ◆ You should be able to use screen sharing feature in Zoom.
- ◆ Attendance certificates will be sent to you as pdf at the end of the congress.
- ◆ Requests such as change of place and time will not be taken into consideration in the congress program.

Önemli, Dikkatle Okuyunuz Lütfen

- ❖ Kongremizde Yazım Kurallarına uygun gönderilmiş ve bilim kurulundan geçen bildirimler için online (video konferans sistemi üzerinden) sunum imkanı sağlanmıştır.
- ❖ Online sunum yapabilmek için <https://zoom.us/join> sitesi üzerinden giriş yaparak "Meeting ID or Personal Link Name" yerine ID numarasını girerek oturuma katılabilirsiniz.
- ❖ Zoom uygulaması ücretsizdir ve hesap oluşturmaya gerek yoktur.
- ❖ Zoom uygulaması kaydolmadan kullanılabilir.
- ❖ Uygulama tablet, telefon ve PC'lerde çalışıyor.
- ❖ Her oturumdaki sunucular, sunum saatinden 5 dk öncesinde oturuma bağlanmış olmaları gerekmektedir.
- ❖ Tüm kongre katılımcıları canlı bağlanarak tüm oturumları dinleyebilir.
- ❖ Moderatör – oturumdaki sunum ve bilimsel tartışma (soru-cevap) kısmından sorumludur.

Dikkat Edilmesi Gerekenler- TEKNİK BİLGİLER

- ◆ Bilgisayarınızda mikrofon olduğuna ve çalıştığına emin olun.
- ◆ Zoom'da ekran paylaşma özelliğine kullanabilmelisiniz.
- ◆ Kabul edilen bildiri sahiplerinin mail adreslerine Zoom uygulamasında oluşturduğumuz oturuma ait ID numarası gönderilecektir.
- ◆ Katılım belgeleri kongre sonunda tarafınıza pdf olarak gönderilecektir
- ◆ Kongre programında yer ve saat değişikliği gibi talepler dikkate alınmayacaktır

Before you login to Zoom please indicate your name_surname and HALL number:

exp. Hall-1, Name SURNAME



DATE

• 05.10.2024



TIME

• 10⁰⁰–12⁰⁰



SESSION

- HALL-5
- SESSION-1


HEAD OF SESSION: Assoc. Prof. Dr. Kamil Bekir AFACAN

Res. Assist. Tansu ORHAN Prof. Dr. Sami ARSOY	Kocaeli University (TÜRKİYE)	INVESTIGATION OF POREWATER PRESSURE GENERATION MODELS IN COHESIONLESS SOILS
MSc. Melis ERSOY Assoc. Prof. Dr. Kamil Bekir AFACAN	Eskişehir Osmangazi University (TÜRKİYE)	COMPARATIVE ANALYSIS OF SPECTRAL MATCHING AND PGA MATCHING FOR SITE-SPECIFIC SEISMIC RESPONSE: METHODOLOGICAL IMPACTS AND IMPLICATIONS
Res. Assist. Kübra KESKİN Prof. Dr. Asena SOYLUK Prof. Dr. İdil AYÇAM	Gazi University (TÜRKİYE)	THE EXAMINATION OF TRADITIONAL CONSTRUCTION TECHNIQUES IN BARTIN IN THE CONTEXT OF FLOOD DISASTER
Res. Assist. Kübra KESKİN Prof. Dr. Asena SOYLUK Prof. Dr. İdil AYÇAM	Gazi University (TÜRKİYE)	THE HISTORICAL TRANSFORMATION OF CHILDREN'S HOSPITALS: AN EVALUATION FROM THE PERSPECTIVE OF FORM AND FUNCTION
Muhammet DAĞLI Prof. Dr. Ahmet DEMİRER Rana UÇAR	Sakarya University (TÜRKİYE)	IMPROVING MECHANICAL PROPERTIES OF RECYCLED HDPE PARTS VIA INJECTION MOLDING PROCESS PARAMETERS
Kasım KARATAŞ Emin Yiğit UMUR Cevat Emre ÖZKAN Hasan ERTUĞRUL	E.C.A. Valf Industry (TÜRKİYE) E.C.A. Valf Industry (TÜRKİYE) Ege University (TÜRKİYE) Ege University (TÜRKİYE)	IMPROVING FLOW CHARACTERISTICS THROUGH DESIGN OPTIMIZATION OF SOLENOID VALVE COMPONENTS
Deniz CURA Emirhan AŞÇI	E.C.A. Valf Industry (TÜRKİYE) Ege University (TÜRKİYE)	FLOW RATE ANALYSIS AND OPTIMIZATION OF OVEN TAPS WITH SAFETY DEVICE




DATE

- 05.10.2024



TIME

- 10⁰⁰–12⁰⁰



SESSION

- HALL-6
- SESSION-1

HEAD OF SESSION: Dr. Erdona Demiraj

S. SANTHOSH KUMAR Dr. J. Ajith kings	St. Joseph University in Tanzania (TANZANIA) St. Xaviers Catholic College of Engineering (INDIA)	A REVIEW OF THE ENVIRONMENTAL SUSTAINABILITY OF BIOFUELS
Atban R. Abdo Ömer Yavuz BOZKURT	Ministry of Industry and Minerals (IRAQ) Gaziantep University (TÜRKİYE)	EFFECT OF GRAPHENE NANOPATES (GNPS) ON THE ENHANCEMENT OF TENSILE PROPERTIES OF THE HYBRID KEVLER/BASALT FIBER REINFORCED EPOXY BASED COMPOSITES
Bahjat Hardan Sulaiman Ahmet Erkiğ	University of Anbar (IRAQ) Gaziantep University (TÜRKİYE)	INFLUENCE OF CARBON FIBER-REINFORCED EPOXY-BASED HYBRID KEVLER/CARBON FIBER NANOTUBE (MWCNT) ON THE IMPROVEMENT OF TENSILE PROPERTIES
Dr. Erdona Demiraj Dr. Irena Duka Ervin Doçaj Dr. Ferdi Brahushi Dr. Seit Shallari	Agriculture University of Tirana (ALBANIA)	HOW CROSS CONTAMINATION CAN INFLUENCE THE QUALITY OF IRRIGATION WATER? – CASE STUDY OF THANA REZERVOIR IN ALBANIA
Rahma BELKAID Lamia YOUB Farid NACERI	University of Batna2 (ALGERIA)	INNOVATIVE ADAPTIVE FUZZY STRATEGY FOR DTC IN DUAL STAR INDUCTION MOTORS



DATE

• 05.10.2024



TIME

• 12³⁰–14³⁰



SESSION

- HALL-5
- SESSION-2

HEAD OF SESSION: Dr. Elif ALTINTAŞ KAHRİMAN

Gökay DAĞDAŞ Batuhan TAŞKAPI Zehra Sude SARI Prof. Dr. M. Fatih AKAY	Çukurova University (TÜRKİYE)	MACHINE LEARNING BASED STAFF CHURN SCORING MODELS FOR THE IT INDUSTRY
Dr. Hürrem Akbıyık Ömer Uçar Erhan Tok Fatih Can Ölmez	Adana Alparslan Türkeş Science and Technology University (TÜRKİYE)	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF STEPPED AIRFOIL DESIGN ON THE AERODYNAMIC PERFORMANCE OF VERTICAL AXIS WIND TURBINES
Res. Assist. Ramazan YERLİKAYA Dr. Ahmet ÇELİK	Kütahya Dumlupınar University (TÜRKİYE)	AN APPLICATION OF MOST EFFICIENT PATH ESTIMATION FOR ELECTRIC VEHICLES: THE CASE OF İSTANBUL
Oğuzcan DEMİR	SKT Spare Parts (TÜRKİYE)	DETERMINATION OF A RELIABLE MEASUREMENT DURATION FOR RADIAL FORCE



DATE

• 05.10.2024



TIME

• 12³⁰–14³⁰

SESSION

- HALL-6
- SESSION-2

HEAD OF SESSION: Natalia Makuch

MENEZLA Fayssal DEBBAL Mohammed BOUREGAA Mouwefeq SADOUKI BOUAMAMA Reda MAHDJOUR Zoubir	University Center Nour El Bachir of El Bayadh (ALGERIA) University of Ain- Temouchent (ALGERIA) Université Mustapha Stambouli Mascara (ALGERIA) University of Saida (ALGERIA) University of Sidi Bel Abbés (ALGERIA)	THE EFFECT OF COMPRESSION FUNCTION ON DIGITAL IMAGES
Natalia Makuch	Poznan University of Technology (POLAND)	COMPARISON OF CORROSION RESISTANCE OF 316L STEEL PRODUCED BY SLM AND CONVENTIONAL METHODS
Anyasi R.O.	University of South Africa (SOUTH AFRICA)	THE MEASUREMENT OF CHROMOLAENA ODORATA GROWTH IN INDOLE BUTYRIC ACID (IBA) TREATED SOIL
Eman Sanad Khalid Z. Elwakeel Mokhtar S. Beheary Ahmed Abdelaal	Port Said University (SAUDI ARABIA) University of Jeddah (SAUDI ARABIA)	USING OF MODIFIED ALGINATE-BASED NANOCOMPOSITES BEADS FOR THE REMOVAL OF SOME HEAVY METALS FROM INDUSTRIAL WASTEWATER
ADEYEMI, Deborah OGUNLEYE, Timothy A.	Tim-R Programming Consult (NIGERIA) Osun State University, Osogbo (NIGERIA)	ANALYSIS OF STATISTICS OF CRIME RATES IN NORTHWEST NIGERIA USING PRINCIPAL COMPONENT TECHNIQUE
Dr. BENADLA Sarra Dr. DEBBAL Mohammed Dr. BENADLA Nadjjet	Higher School of Management (ALGERIA) Ain Temouchent University (ALGERIA) Abou Bakr Belkaid University (ALGERIA)	IMPACT OF TRAJECTORY LENGTH ON SYBIL ATTACK DETECTION IN VEHICULAR NETWORKS
Hafiza Komal Naeem	Superior Group of Colleges (PAKISTAN)	ECOFRIENDLY SYNTHESIS OF MAGNETIC COMPOSITES LOADED ON RICE HUSKS FOR ACID BLUE 25 DECONTAMINATION: ADSORPTION KINETICS, THERMODYNAMICS, AND ISOTHERMS
Usman S. Rilwan Michael O. Oni	Ahmadu Bello University 1 (NIGERIA)	SIGNIFICANCE OF HEAT SOURCE/SINK ON ELECTROMAGNETOHYDRODYNAMICS NATURAL CONVECTION FLOW WITH ELECTROSMOTIC EFFECT



DATE

• 05.10.2024



TIME


• 15⁰⁰–17⁰⁰

SESSION

- HALL-5
- SESSION-3


HEAD OF SESSION: Dr. Mehmet BAY

Dr. Mehmet BAY	Eskişehir Technical University (TÜRKİYE)	ENERGY STORAGE APPLICATION OF BOROPHENE COATED COPPER FOIL ELECTRODES
Yaşar KARADAL Beyza KAHRAMAN	Seval Cable (TÜRKİYE)	THE POTENTIAL OF PLANT-BASED BIOMATERIALS FOR THE COAGULATION PROCESS OF WASTEWATER TREATMENT SYSTEMS: OPUNTIA FICUS-INDICA AS AN ALTERNATIVE TO FeCl ₃
Enes BİGA Prof. Dr. Musa ALCI	Ege University (TÜRKİYE)	ADAPTIVE CONTROLLER DESIGN FOR ELECTRONIC CONTROLLERS IN VENTILATION SYSTEM
Onur ERDOĞAN Assist. Prof. Dr. Saeed LOTFAN	Gebze Technical University (TÜRKİYE)	MATHEMATICAL MODELING AND ANALYSIS OF SHIP-MOUNTED CRANES WITH SHOCK ABSORBER
Murat KUTLU Assist. Prof. Dr. Saeed LOTFAN	Gebze Technical University (TÜRKİYE)	DYNAMIC BEHAVIOR OF ROTOR SYSTEMS WITH SUPPORT NONLINEARITIES
Uğur ERDAL	Senior Frontend Developer Cimri Information Technologies and Systems Inc. (TÜRKİYE)	REAL TIME APPLICATION PERFORMANCE MEASUREMENT
Şule Nur AKÇA Assoc. Prof. Dr. Derya YILMAZ	Gazi University (TÜRKİYE)	PERFORMANCE IMPROVEMENT AND COMPARATIVE ANALYSIS FOR MOVING OBJECT DETECTION ON FIXED CAMERA IMAGES
Burak GÜLER Assoc. Prof. Dr. Veysel ERTURUN Faruk KOCA	Erciyes University (TÜRKİYE)	BONDING JUMPER MATERIALS USED IN AIRCRAFTS
Dr. Tark Kunduracı	Manisa Celal Bayar University (TÜRKİYE)	ANALOGY BETWEEN SWARM BEHAVIOR AND THERMODYNAMIC PARTICLE ASSEMBLY




DATE

- 05.10.2024



TIME

- 15⁰⁰–17⁰⁰




SESSION


- HALL-6
- SESSION-3

HEAD OF SESSION: Mariton Mirantes

Preeti Bhaskar Puneet Gupta Priyanka Bhaskar Rakhi Shukla	University of Technology and Applied Sciences (OMAN) ICFAI University (OMAN) ICFAI Business School (IBS) (OMAN)	UNVEILING CHATGPT'S POTENTIAL: A QUALITATIVE EXPLORATION OF RESEARCHERS' PERSPECTIVES IN ENHANCING ACADEMIC RESEARCH IN INDIAN HIGHER EDUCATION
Mariton Mirantes Aldwin T. Miranda	Don Marcelino National High School (PHILIPPINES) Agri-business and Marine and Aquatic School of Technology Malita (PHILIPPINES)	THEORIZING STUDENTS' MATHEMATICAL RESILIENCY AND MATH PERFORMANCE THROUGH PATH ANALYSIS
Michael O. Oni Taiwo, S. Yusuf Junaid M. Abba Baba I. Mundi	Ahmadu Bello University (NIGERIA) Nigerian Institute of Transport Technology (NIGERIA)	EXACT SOLUTION OF MIXED CONVECTION FLOW OF HEAT GENERATING/ABSORBING FLUID IN A VERTICAL CHANNEL WITH INDUCED MAGNETIC FIELD AND ELECTROKINETICS
Adenegan-Alakinde Taiwo Ayomipo Baderinwa-Adejumo Adejoke Olusola Funmilola Mabel Ojo	Adeyemi Federal University of Education (NIGERIA) Olusegun Agagu University of Science and Technology (NIGERIA)	A COMPARATIVE STUDY OF DETERMINANTS OF CONSUMERS' CHOICES OF SOME VEGETABLES IN ONDO STATE NIGERIA
Mark Anthony G. Baclay Cristina Dominie M. Cortado Aldwin T. Miranda	Institute of Teacher Education and Information Technology (PHILIPPINES)	MOTIVATIONAL STRATEGIES AND MATHEMATICS PERFORMANCE OF COLLEGE STUDENTS
Chelljoy T. Villegas Merie Mae Joy S. Estopa Aldwin T. Miranda	Institute of Teacher Education and Information Technology (PHILIPPINES)	PROBLEM-SOLVING APPRAISALS AND MATHEMATICS PERFORMANCE OF COLLEGE STUDENTS
Honey Queen A. Lumoto Crismar C. Decolas Karen E. Cabalquinto Aldwin T. Miranda	Institute of Teacher Education and Information Technology (PHILIPPINES)	EXPLORING STUDENTS' MATHEMATICS PERFORMANCE THROUGH SELF-REGULATED LEARNING


DATE
• 06.10.2024


TIME
• 10⁰⁰–12⁰⁰


SESSION
• HALL-5
• SESSION-1


HEAD OF SESSION: Dr. Gülçin BAYSAL

Dr. Gülçin BAYSAL	Eskisehir Technical University (TÜRKİYE)	SUSTAINABLE LIGNIN-BASED HYDROGELS: PROPERTIES AND INNOVATIVE APPLICATIONS
Assoc. Prof. Dr. Yasemen UÇAN Nisanur YILDIZ	Yıldız Technical University (TÜRKİYE)	AN APPLICATION ON THE FUZZY ROUGH SET APPROACH
Rabia TURAN Prof. Dr. Atif KOCA	Marmara University (TÜRKİYE)	THE USE OF PHTHALOCYANINE COMPOUND IN ELECTROCHEMICAL SENSORS
Dr. Deniz SAKARYA	Istanbul Univeristy-Cerrahpasa (TÜRKİYE)	ADVANCEMENTS IN METAL-ORGANIC FRAMEWORKS
Dr. Deniz SAKARYA	Istanbul Univeristy-Cerrahpasa (TÜRKİYE)	APPLICATION OF MOFS IN BIOMEDICAL SYSTEMS
Dilay PAR Tuğçe Nazlı KAYA Orhan ŞAHİN Erhan İBRAHİMOĞLU Prof. Dr. Fatih ÇALIŞKAN	Algotrio Chem. Inc. (TÜRKİYE) R&D Manager, Algotrio Chem. Inc. (TÜRKİYE) R&D Manager, Algotrio Chem. Inc. (TÜRKİYE) Sakarya University of Applied Sciences (TÜRKİYE) Sakarya University of Applied Sciences (TÜRKİYE)	THE ROLE OF P2O5 ADDITION IN FRITES USED IN ENAMELS ON THE PHYSICAL, CHEMICAL AND MECHANICAL PROPERTIES OF THE COATING
Assist. Prof. Dr. Şevin EKMEK	Harran University (TÜRKİYE)	HARDENED PROPERTIES PREDICTION OF ROLLER COMPACTED CONCRETE VIA GENE EXPRESSION PROGRAMMING
M.A. Sarlı A.T. Özgüney E.S. Dalbaşı	Ege University (TÜRKİYE)	A REVIEW OF POLYMERIC DISPERSANTS IN THE STABILIZATION OF HYDROPHOBIC DYES AND PIGMENTS




DATE

- 06.10.2024



TIME

- 10⁰⁰–12⁰⁰





SESSION

- HALL-6
- SESSION-1

HEAD OF SESSION: Prof. Dr. Yasser, A.M. Moussa

Laid Elkhiri Miloud Mihoubi	Tiaret University (ALGERIA) USTHB (ALGERIA)	SUPER-CONGRUENCES WITH BINOMIAL COEFFICIENTS AND GENERALATE HARMONIC NUMBERS
Dr. Nadjet BENCHIHEUB Nadhira BIOUD	University Mohamed El Bachir EL IBRAHIMI of Bordj Bou Arreridj (ALGERIA)	EFFECT OF HIGH PRESSURE ON THE DEBYE TEMPERATURE OF CaO MATERIAL
Kumkum Malakar Shiv Lal	Rajasthan Technical University (INDIA)	DESIGN AND SIMULATION STUDIES OF A GRID CONNECTED 1MW WIND ENERGY POWER PLANT USING MATLAB
Himanshi Kumari Shiv Lal Shibna Hussain Santosh Kumar Sharma	INDIA	DESIGN AND DEVELOPMENT OF GRID- CONNECTED 1 KW WIND ENERGY POWER PLANT FOR DRE BUILDING IN RTU INDIA USING MATLAB
Prof. Dr. Yasser, A.M. Moussa	Jazan University (SAUDI ARABIA)	NEURAL NETWORK MODELING FOR SCOUR PREDLCTION AT BRIDGE FOUNDATION
Aremu, O.A. Makinde, O.S. Oyinkanola L.O.A. Mufutau, J. A. Anie, N. O.	The Polytechnic (NIGERIA) Federal School of Surveying (NIGERIA)	DESIGN AND SIMULATION OF RECTANGULAR MICROSTRIP PATCH ANTENNA FOR SATELLITE COMMUNICATIONS AND IOT DEVICES USING FR-4 SUBSTRATE
Chabelita S. Sabanal Jelyan S. Bago Carlito B. Balandra Aldwin T. Miranda	Mariano Peralta National High School (PHILIPPINES)	ATTITUDES TOWARD LEARNING MATHEMATICS AND PERFORMANCE OF GRADE 11 STUDENTS IN THE NEW NORMAL
Dalia Das Assoc. Prof. Dr. Harish Kumar Verma Assist. Prof. Dr. Bhumika Sharma Assist. Prof. Dr. Poonam Pant	Shoolini University (INDIA) The ICFAI University (INDIA) Sharda University (INDIA) Shoolini University (INDIA)	HUMAN RIGHTS OF DOMESTIC WORKERS: UNTANGLING NATIONAL AND INTERNATIONAL LEGAL FRAMEWORKS


DATE
• 06.10.2024


TIME
• 12³⁰–14³⁰


SESSION
• HALL-5
• SESSION-2


HEAD OF SESSION: Assoc. Prof. Dr. Taşkın Deniz YILDIZ

Hande SONSUN Nil YAPICI Nusret NURLU	Çukurova University (TÜRKİYE)	GEOLOGICAL, PETROGRAPHIC, AND MINERALOGICAL CHARACTERISTICS OF BASALTIC ROCKS IN THE TOPRAKKALE (OSMANIYE) REGION
Ercüment BİLGER Nil YAPICI	Çukurova University (TÜRKİYE)	USE OF EXPANDED CLAY IN LIGHTWEIGHT BUILDING MATERIAL
Dr. Ömer ÖZKAN Prof. Dr. Nezih Metin ÖZMUTAF	SOCAR Türkiye (TÜRKİYE) İzmir Katip Çelebi University (TÜRKİYE)	STRATEGIC PERSPECTIVE IN ORGANIZATIONS IN POST-EARTHQUAKE PROCESSES: A RESEARCH WITHIN THE SCOPE OF THE SIX FEBRUARY EARTHQUAKES
Ahmet Yakup CUMBUL Prof. Dr. Dilek KUMLUTAŞ	Dokuz Eylül University (TÜRKİYE)	NUMERICAL INVESTIGATION OF THE CONDENSATION CHARACTERISTICS IN THE CONDENSATION REGION OF A COMBI BOILER UNIT
Assoc. Prof. Dr. Taşkın Deniz YILDIZ Murat MARAL	Adana Alparslan Türkeş Science and Technology University (TÜRKİYE) İstanbul Technical University (TÜRKİYE)	IS IT POSSIBLE TO ENSURE THAT THE PERMANENT SUPERVISOR AND THE OHS EXPERT CAN WORK EFFECTIVELY IN THE MINES IN THE EXISTENCE OF A CONFLICT OF DUTIES BETWEEN THE OHS EXPERT AND THE SUPERVISOR?
Assist. Prof. Dr. Aysegul YUCEL Prof. Dr. Musa SARIKAYA	İskenderun Technical University (TÜRKİYE) Inonu University (TÜRKİYE)	THE EFFECT OF ROASTING ON THE EXTRACTION OF RUBIDIUM FROM BORON ORE WASTES INTO SOLUTION



DATE

- 06.10.2024



TIME

- 12³⁰–14³⁰



SESSION

- HALL-6
- SESSION-2

HEAD OF SESSION: Prof. Dr. Sergo Esadze

Prof. Dr. Sergo Esadze	Georgian Technical University (GEORGIA)	RANDOM VERTICAL SEISMIC VIBRATION OF LARGE SPAN ROOFING TRUSSES
Abiodun Naeemdeen ADEJUMO	Federal University of Technology Minna (NIGERIA)	HYDROGEOCHEMICAL INVESTIGATION OF SHALLOW GROUNDWATER IN PART ABUJA MUNICIPAL AREA COUNCIL, (AMAC) FCT, NIGERIA
Dr. Andrea Amalia MINDA Dr. Olga Ioana AMARIEI Dr. Marius Savu LOLEA Emeric Remus SZABO	Babeş Bolyai" of Cluj Napoca (ROMANIA) Babeş Bolyai" of Cluj Napoca (ROMANIA) University of Oradea (ROMANIA) University of Oradea (ROMANIA)	ASSESSMENT AND INCREASING OF ELECTRICITY AVAILABILITY OF PHOTOVOLTAIC PANELS USING FUZZY LOGIC PRINCIPLES AND CONTROL
Dr. Andrea Amalia MINDA Dr. Olga Ioana AMARIEI Dr. Marius Savu LOLEA Emeric Remus SZABO	Babeş Bolyai" of Cluj Napoca (ROMANIA) Babeş Bolyai" of Cluj Napoca (ROMANIA) University of Oradea (ROMANIA) University of Oradea (ROMANIA)	GEOHERMAL ENERGY EXPLOITATION AND APPLICATIONS IN THE AREA OF BEIUŞ CITY, ROMANIA. PRESENT AND PERSPECTIVES
Aliyu Hassan	Nigerian Air Force (NIGERIA)	ASSESSMENT OF THE EFFECTS OF UNREGULATED SOLID WASTE DISPOSAL ON URBAN FLOODING IN KADUNA METROPOLIS
Eyo Uwem-Obong Joseph Agada Raymond Chubiyo Akor, Ochefije Rita	Heritage Polytechnic Uyo (NIGERIA) Benue State University (NIGERIA) Nasarawa State University (NIGERIA)	THE IMPACTS OF EDUCATIONAL PROGRAMMES OF AKBC RADIO ON STUDENTS OF UYO CITY POLYTECHNIC
Assist. Prof. Dr. K.R.Padma K.R.Don	Sri Padmavati Mahila Visvavidyalayam (Women's University) (INDIA) Bharath Institute of Higher Education and Research (BIHER) Bharath University (INDIA)	EFFECTS OF POLYPROPYLENE AND POLYSTYRENE MICROPLASTICS ON HEPG2 CELL LINE
Boris Zhilyaev Vladimir Petukhov	NAS of Ukraine (UKRAINE)	UNIDENTIFIED AERIAL PHENOMENA. OBSERVATIONS OF SPACE EVENTS
Inyang, J. O.	National Biotechnology Research and Development Agency (NBRDA) (NIGERIA)	EFFECT OF FARMERS SELECTED SOCIO-ECONOMIC FACTORS ON INFORMATION AND COMMUNICATION TECHNOLOGIES UTILIZATION FOR CASSAVA PRODUCTION IN CROSS RIVER STATE, NIGERIA



DATE

• 06.10.2024



TIME


• 15⁰⁰–17⁰⁰

SESSION

- HALL-5
- SESSION-3


HEAD OF SESSION: Murat ŞAHİN

Murat ŞAHİN	Manisa Celal Bayar University (TÜRKİYE)	A LINEAR PROGRAMMING MODEL FOR THE HETEROGENEOUS DRONE FLEET DELIVERY PROBLEM CONSIDERING SETUP TIMES
Serkan ÖZŞAHİN Prof. Dr. Kadir ÇAVDAR	Bursa Uludağ University (TÜRKİYE) Bursa Uludağ University (TÜRKİYE)	JOINING AISI 304 STAINLESS STEEL MATERIALS BY ROBOTIC FIBER LASER WELDING METHOD
Atakan KOÇYİĞİT Rüstem Emre SUNGURBAŞ Caner ARSLAN Hasan Hüseyin DOYĞUN	MEGE Technical Inc. (TÜRKİYE)	HYSTERESIS ANALYSIS OF OPEN COLLECTOR COMPARATORS
Tuğba YÜĞRÜK Assist. Prof. Dr. Gökçe Mehmet GENÇER Mustafa AKARSU	Dokuz Eylul University (TÜRKİYE) Dokuz Eylul University (TÜRKİYE) Volt Technology (TÜRKİYE)	INVESTIGATION OF MECHANICAL PROPERTIES OF LASER TEXTURED Al6063-PA6 HYBRID BEAMS MANUFACTURED IN SINGLE LAP JOINT CONFIGURATION THROUGH A DESIGNED METAL-POLYMER DIRECT BONDING MACHINE
Res. Assist. Ezgi GÜLER	Bilecik Seyh Edebali University (TÜRKİYE)	STATISTICAL EVALUATION OF CHEMICAL FERTILIZER RESOURCES IN TÜRKİYE
Dr. Burak İZGİ	Yozgat Bozok University (TÜRKİYE)	INVESTIGATION OF THERMAL ENERGY STORAGE PERFORMANCE OF NANOPARTICLE-ENHANCED PHASE CHANGE MATERIAL UNDER MICROGRAVITY CONDITIONS
Zeynep ÇOKKIR	Technology&Innovation Engineer (TÜRKİYE)	DEVELOPMENT OF HEAT AGING AND IMPACT RESISTANT POLYAMIDE COMPOSITES FOR USE IN INTERNAL AND EXTERNAL APPLICATIONS IN THE AUTOMOTIVE SECTOR



DATE

- 06.10.2024



TIME

- 15⁰⁰–17⁰⁰



SESSION

- HALL-6
- SESSION-3

HEAD OF SESSION: Disha, Mahendra Kumar Savita

Akanksha Gautam Mahendra Kumar Savita	Naraina Vidyapeeth Engineering and Management Institute (INDIA)	ROLE OF PROTEIN-RICH DIETS IN PROMOTING A HEALTHY LIFE: BENEFITS, SOURCES, AND CONSIDERATIONS
Akanksha, Mahendra Kumar Savita	Naraina Vidyapeeth Engineering and Management Institute (INDIA)	HOME REMEDIES FOR MANAGING SEPTICEMIA IN FISH: A REVIEW OF TRADITIONAL AND NATURAL TREATMENTS
Abhinesh Pal Mahendra Kumar Savita	Naraina Vidyapeeth Engineering and Management Institute (INDIA)	MALARIA: EPIDEMIOLOGY, PATHOGENESIS, AND CONTROL STRATEGIES
Archit Kumar Mahendra Kumar Savita	Naraina Vidyapeeth Engineering and Management Institute (INDIA)	HOME REMEDIES FOR HIGH BLOOD PRESSURE: EXPLORING NATURAL APPROACHES TO HYPERTENSION MANAGEMENT
Ong Hock Siong KongYin Mei Cheah Chee Keong Adam Arif Lee Aik Keang Wong Kok Yaw Nakesvari A/P Shanmugam	Jalan Universiti (MALAYSIA)	THE IMPACT OF SOCIAL MEDIA INFLUENCERS ON FINANCIAL DECISION-MAKING AMONG MALAYSIAN YOUTH: A CONCEPTUAL FRAMEWORK
Nasrin Reza	PAKISTAN	INVESTIGATING HOW SULTANA RAZIA CAME TO POWER
Disha, Mahendra Kumar Savita	Naraina Vidyapeeth Engineering and Management Institute (INDIA)	HOME REMEDIES FOR TUBERCULOSIS: AN OVERVIEW OF TRADITIONAL AND NATURAL APPROACHES TO COMPLEMENT MODERN TREATMENT



DATE

• 07.10.2024



TIME

• 12³⁰–14³⁰




SESSION


- HALL-1
- SESSION-2

HEAD OF SESSION: Assist. Prof. Dr. Funda GENÇER

Assist. Prof. Dr. Sertaç BULUT	İzmir Kâtip Çelebi University (TÜRKİYE)	EVALUATION OF FUEL CELL TECHNOLOGIES AS A CLEAN ENERGY ALTERNATIVE IN MARITIME INDUSTRY
Assist. Prof. Dr. Funda GENÇER	Manisa Celal Bayar University (TÜRKİYE)	ANALYSIS OF THE SPATIAL CHANGES OF THE HANS DISTRICT IN THE HISTORIC CITY CENTER OF MUĞLA
Dr. Seda DURUKAN Abdülşamet GÜVEN	Manisa Celal Bayar University (TÜRKİYE)	IMPACT OF MATRIC SUCTION ON THE UNCONFINED COMPRESSIVE STRENGTH OF A BENTONITE SAND MIXTURE
Mertcan YILMAZ Assoc. Prof. Dr. Tamer DİRİKGİL	Erciyes University (TÜRKİYE)	ESTIMATION OF EARTHQUAKE RISK LEVELS OF RC STRUCTURES WITH ARTIFICIAL INTELLIGENCE METHODS


DATE
• 07.10.2024


TIME
• 12³⁰–14³⁰


SESSION
• HALL-2
• SESSION-2


HEAD OF SESSION: Dr. Suzan TİREKİ

Dr. Suzan TİREKİ	Özyeğin University (TÜRKİYE)	PRODUCTION OF DATES LEATHER WITH INFRARED DRYING METHOD
Dr. Gülden KILIÇ	Alanya University (TÜRKİYE)	GREEN SYNTHESIS OF NANOPARTICLES THROUGH YEASTS
Res. Assist. Nurşah Zeynep ÖZTÜRK Assoc. Prof. Dr. Aysel GÜLBANDILAR	Tekirdag Namik Kemal University (TÜRKİYE) Eskişehir Osmangazi University (TÜRKİYE)	DETERMINATION OF BIOACTIVE PROPERTIES OF POSTBIOTICS OBTAINED FROM CULTURE MEDIA SUPPLEMENTED WITH ORANGE PEEL POWDER
Rana YORNUK Assist. Prof. Dr. Serkan DİKİCİ	Izmir Institute of Technology (TÜRKİYE)	OPTIMIZATION OF SOLVENT AND PROCESS PARAMETERS FOR THE PRODUCTION OF EXTRACELLULAR MATRIX-MIMICKING POLYMERIC FIBRES
Prof. Dr. Rüveyde TUNÇTÜRK Prof. Dr. Murat TUNÇTÜRK Assoc. Prof. Dr. Erol ORAL Assist. Prof. Dr. Lütfi NOHUTCU Lect. Ezelhan ŞELEM	Van Yuzuncu Yil University (TÜRKİYE)	EFFECT OF MYCORRHIZA APPLICATIONS ON SOME PHYSIOLOGICAL PROPERTIES OF SOYBEAN (<i>Glycine max</i> L.) GROWN UNDER SALT STRESS CONDITIONS
Dr. İnci CERİT Dr. Omca DEMİRKOL Dr. Özlem AKTÜRK GÜMÜŞAY	Sakarya University (TÜRKİYE) Sakarya University (TÜRKİYE) Maltepe University (TÜRKİYE)	ULTRASOUND-ASSISTED EXTRACTION OF PHENOLIC COMPOUNDS FROM ARONIA (<i>Aronia Melanocarpa</i>) FRUIT
Cem Tolga Münyas Sibel Demir Boğaçhan Ali Düşgöl	TOFAŞ R&D İzmir Branch (TÜRKİYE) TOFAŞ R&D İzmir Branch (TÜRKİYE) Izmir Institute of Technology (TÜRKİYE)	PARKING SPACE PLANNER ALGORITHM ON LIDAR BASED MAP WITH AUTONOMOUS VEHICLE




DATE

- 07.10.2024



TIME

- 12³⁰–14³⁰




SESSION

- HALL-3
- SESSION-2


HEAD OF SESSION: Prof. Dr. Mohammed Waheeb

Lect. Manikandan Tiruchengode Ramadurai	University of Technology and Applied Science (OMAN)	IMPACT OF CARBON EMISSION PRICING IN ELECTRICAL TRANSMISSION NETWORK UNDER CONSTRAINED DEREGULATED ELECTRICITY MARKET
Syeda Sabika Zahra Naqvi	University of Education (PAKISTAN)	ALLELOCHEMICAL EFFECT ON AVERRHOA CARAMBOLA L. IN ANATOMICAL ARCHITECTURE ON WHEAT GROWTH
Assist. Prof. Dr. K.R.Padma K.R.Don	Sri Padmavati Mahila Visvavidyalayam (Women's University) (INDIA) Bharath Institute of Higher Education and Research (BIHER) Bharath University (INDIA)	A CONCISE REVIEW ON WOMEN IN SCIENCE AND TECHNOLOGY ON 20TH CENTURY
Assoc. Prof. Dr. Neha Singh Assist. Prof. Dr. Suneel Kumar Singh	Mangalayatan University Aligarh (INDIA)	UNVEILING THE THERAPEUTIC POTENTIAL OF LACTUCA SERRIOLA: PHYTOCHEMICAL ANALYSIS AND PHARMACOLOGICAL APPLICATIONS"
Dr. Aurora Dibra Msc. Leonora Haxhiu	University of Shkodra "Luigj Gurakuqi" (ALBANIA) Polis University Tirana (ALBANIA)	DIGITALIZATION PROCESS AS A TOOL FOR THE ASSESSMENT OF LAND EROSION AND ECOSYSTEM ADAPTATION IN THE ADRIATIC LAGOONS IN ALBANIA
Saverio Storani	Sapienza University of Rome (ITALY)	IDENTIFICATION OF PIVOTAL ACTORS IN THE INTERBANKING NETWORKS THROUGH VORONOI TESSELLATION ON NETWORKS
Prof. Dr. Mohammed Waheeb	The Hashemite University (JORDAN)	A UNIQUE OTTOMAN MAQAM/SHRINE IN KHALDYEH-MAFRAQ SOUTH LEVANT
Bilal Shah Dicky Muslim Usama Yaseen	Padjadjaran University (INDONESIA)	DIAGENETIC FEATURES OF EARLY EOCENE AGE CHORGALE FORMATION AT KHANPUR DAM ROAD SECTION, HAZARA BASIN, PAKISTAN




DATE

- 07.10.2024



TIME

- 12³⁰–14³⁰



SESSION

- HALL-4
- SESSION-2

HEAD OF SESSION: Marco Ripà

Djebbara BENZERGA Dr. Adel Chouiter	University of Sciences and Technology of Oran (ALGERIA) University Frères Mentouri Constantine (ALGERIA)	ALTERNATIVE SOLUTION TO REPLACE HYDROSTATIC TESTING OF HDPE PIPES
Cyntia Lasmi Andesti Rahmad Dian Sri Restu Ningsih	Metamedia University, Padang (INDONESIA)	INNOVATION OF STUNTING DETECTION APPLICATION USING CHATBOT AS STRATEGY TO ACHIEVE UNIVERSAL HEALTH COVERAGE IN SDGs
Dr. Maryam ERRAMI Dr. Ahmed ALGOUTI Hayat GHACHOUI Dr. Idir EL KONTY	Cadi Ayyad University (MOROCCO)	MODELING LATERAL FACIES HETEROGENEITY OF AN EARLY JURASSIC CARBONATE PLATFORM (TIGHZA, HIGH ATLAS OF MARRAKECH, MOROCCO)
Marco Ripà	ITALY	GRAHAM'S NUMBER STABLE DIGITS: AN EXACT RESULT
M. Thien Phung Eunbi Kim Sadia Ameen O-Bong Yang M. Shaheer Akhtar	Jeonbuk National University (REPUBLIC OF KOREA)	STABLE AND HIGH PERFORMANCE LITHIUM ION BATTERIES USING EFFECTIVE IONIC LIQUID-MODIFIED LIFS1 ELECTROLYTES
MUJEEBUDHEEN KHAN	University of Technology and Applied Sciences (OMAN)	NEXT-GENERATION HEALTHCARE: AN AI- BASED AUTONOMOUS DRUG DELIVERY SYSTEM
Dr. Aleksandra Mikhailidi Sofya Verbovskaya Margarita Chepurnova	St. Petersburg State University of Industrial Technologies and Design (RUSSIA)	WATER RETENTION AND SORPTION CHARACTERISTICS OF CELLULOSE-BASED HYDROGELS
Hassane ABD-DADA Said BOUDA Atman ADIBA Sadik DANI Abdelmajid HADDIOUI	Sultan Moulay Slimane University (MOROCCO)	GENETIC DIVERSITY ANALYSIS OF EUPHORBIA RESINIFERA IN MOROCCO: A POTENTIAL PLANT TO REMEDY CLIMATE CHANGE, PROTECTING AND RESTORING ECOLOGICAL HABITATS OF PLANT AND ANIMAL SPECIES

erver Hall... Hall 5-Melis... Hall-5, Tansu... H-5 Kübra Ke... Deniz Cura-V... Hall-5, Yaş

erver Hall-5 Hall 5-Melis ERSOY Hall-5, Tansu ORHAN H-5 Kübra Keskin Deniz Cura-VALF A.Ş. Hall-5, Yaşar K

ZEMİN PROFİLİ



erver Hall... Hall-5, Rama... (Hall 5 - Sess... E

INTRODUCTION - I

Information Technology (IT) sector is a broad and dynamic field where numerous innovations emerge. With the significant growth it has experienced in recent years, this sector has become one of the main pillars of the global economy. This expansion has led to a substantial increase in the number of companies operating within the sector and the staff they hire. The most valuable assets of companies in this sector are their experienced and skilled staff with technological expertise. However, the dynamic nature of the sector leads to a high rate of staff turnover, which, in turn, contributes to a higher rate of staff turnover.

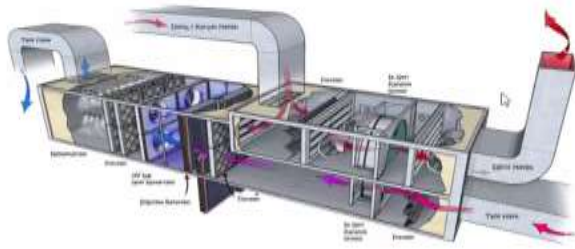
High staff turnover is one of the most critical challenges facing the IT sector. High turnover rates force companies to frequently allocate resources and time to recruitment and training processes. Moreover, the loss of experienced staff reduces the quality of services provided by these companies, leading to decreased customer satisfaction, an increased risk of losing clients, and ultimately, a decline in market share.

Observer Hall...

15:12

Ş

ak Bir Havalandırma Sistemi



Sonraki slayt

Giriş

- Basitçe PID



Not Yok.

TOU UNIVERSITY - INTERNATIONAL JOINT CONFERENCES

app.zoom.us ekranınız paylaşıyor. Paylaşmayı durdur Gizle

Slayt 3/14

Google Chrome

Zoom Workplace Konferans

Observer Hall-6 BAHJAT SULAI...

Observer Hall-6 BAHJAT SULAIMAN

Uses of composite material

- Space technology and production of Aerospace Components (Tails, wings etc.)
- Sport goods e.g. racing car bodies and bicycle frames etc.
- General industrial and engineering structures.
- High speed and fuel efficient transport vehicles.
- Launch vehicles and spacecraft
- Solar panel substrates, antenna reflectors and yokes of spacecraft.

Uses of nanoparticles

Medicine, Manufacturing, Materials, Environment, Energy and Electronics

Windows 10

20°C Sunny 10:00 03.11.2024

Zoom Workplace

Конференция

Zoom (Hall-6, Aldwin Miranda)

Observer Hall-6

Hall-6, Cheljoy...

Hall-6, Mark An...

Участники (7)

- OH Observer... (Сторона наблюдателя, и) 0
- HA Hall-6, Aldwin Miranda
- DM Dr. Michael
- HC Hall-6, Cheljoy VILLEGAS
- HCD Hall-6, CristinaDomisic_CORTADO
- HMA Hall-6, Mark Anthony BACLAY
- HMQ Hall-6 Honey Queen LUMOTO

INTRODUCTION

- The recent global landscapes has challenged the educational system, emphasizing the need to assess students' adaptability to new learning environments.
- Learning independence among students remains weak, requiring support through face-to-face interaction and technology (Mir'atannisa et al., 2019).

Активация Windows

Чтобы активировать Windows, перейдите в магазин "Параметры".

Выключить звук для всех

Звук Видеочат Участники Чат Опросы Поделиться Презентация Дополнительно

Поиск

ZPC Sunny 19:07 09.10.2024

erver Hall... Hall-6, Sessi... Hall-6 sessio... Preeti Bask

erver Hall-6 Hall-6, Session-1, HI... Hall-6 session-1 nadjet... H6 Kunkum Malakar Dalla Das Preeti Bhaskar

EFFECT OF HIGH PRESSURE ON THE DEBYE TEMPERATURE OF Calcium Oxide MATERIAL

N. Benchiheub, N. Bioud

Laboratory of Materials Physics, Radiation and Nanostructures (LPMRN), University Mohamed El Bachir EL IBRAHIMI of Bordj Bou Arreridj, 34000 Bordj Bou Arreridj, Algeria

²*Faculty of Sciences and Technology, University Mohamed El Bachir EL IBRAHIMI of Bordj Bou Arreridj, 34000, Bordj Bou Arreridj, Algeria*

³*Laboratoire d'Optoélectronique et Composants, Faculté des sciences, Université Ferhat Abbas de Sétif1, 19000, Sétif, Algérie.*

CONTENT

CONFERENCES ID	I
PROGRAM	II
PHOTO GALLERY	III
CONTENT	IV

Author	Title	No
Tansu ORHAN Sami ARSOY	INVESTIGATION OF POREWATER PRESSURE GENERATION MODELS IN COHESIONLESS SOILS	1
Melis ERSOY Kamil Bekir AFACAN	COMPARATIVE ANALYSIS OF SPECTRAL MATCHING AND PGA MATCHING FOR SITE- SPECIFIC SEISMIC RESPONSE: METHODOLOGICAL IMPACTS AND IMPLICATIONS	3
Kübra KESKİN Asena SOYLUK İdil AYÇAM	THE EXAMINATION OF TRADITIONAL CONSTRUCTION TECHNIQUES IN BARTIN IN THE CONTEXT OF FLOOD DISASTER	15
Kübra KESKİN Asena SOYLUK İdil AYÇAM	THE HISTORICAL TRANSFORMATION OF CHILDREN'S HOSPITALS: AN EVALUATION FROM THE PERSPECTIVE OF FORM AND FUNCTION	24
Muhammet DAĞLI Ahmet DEMİRER Rana UÇAR	IMPROVING MECHANICAL PROPERTIES OF RECYCLED HDPE PARTS VIA INJECTION MOLDING PROCESS PARAMETERS	34
Kasım KARATAŞ Emin Yiğit UMUR Cevat Emre ÖZKAN Hasan ERTUĞRUL	IMPROVING FLOW CHARACTERISTICS THROUGH DESIGN OPTIMIZATION OF SOLENOID VALVE COMPONENTS	44
Deniz CURA Emirhan AŞÇI	FLOW RATE ANALYSIS AND OPTIMIZATION OF OVEN TAPS WITH SAFETY DEVICE	62
S. SANTHOSH KUMAR J. Ajith kings	A REVIEW OF THE ENVIRONMENTAL SUSTAINABILITY OF BIOFUELS	77
Afban R. Abdo Ömer Yavuz BOZKURT	EFFECT OF GRAPHENE NANOPATES (GNPS) ON THE ENHANCEMENT OF TENSILE PROPERTIES OF THE HYBRID KEVLER/BASALT FIBER REINFORCED EPOXY BASED COMPOSITES	78
Bahjat Hardan Sulaiman Ahmet Erkliğ	INFLUENCE OF CARBON FIBER-REINFORCED EPOXY-BASED HYBRID KEVLER/CARBON FIBER NANOTUBE (MWCNT) ON THE IMPROVEMENT OF TENSILE PROPERTIES	79
Erdona Demiraj Irena Duka Ervin Doçaj Ferdî Brahushi Seit Shallari	HOW CROSS CONTAMINATION CAN INFLUENCE THE QUALITY OF IRRIGATION WATER? – CASE STUDY OF THANA REZERVOIR IN ALBANIA	80
Rahma BELKAID Lamia YOUB Farid NACERI	INNOVATIVE ADAPTIVE FUZZY STRATEGY FOR DTC IN DUAL STAR INDUCTION MOTORS	91
Gökay DAĞDAŞ Batuhan TAŞKAPI Zehra Sude SARI M. Fatih AKAY	MACHINE LEARNING BASED STAFF CHURN SCORING MODELS FOR THE IT INDUSTRY	98

Ömer Uçar Erhan Tok Fatih Can Ölmez Hürrem Akbıyık	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF STEPPED AIRFOIL DESIGN ON THE AERODYNAMIC PERFORMANCE OF VERTICAL AXIS WIND TURBINES	107
Ramazan YERLİKAYA Ahmet ÇELİK	AN APPLICATION OF MOST EFFICIENT PATH ESTIMATION FOR ELECTRIC VEHICLES: THE CASE OF İSTANBUL	126
Oğuzcan DEMİR	DETERMINATION OF A RELIABLE MEASUREMENT DURATION FOR RADIAL FORCE	139
MENEZLA Fayssal DEBBAL Mohammed BOUREGAA Mouweffeq SADOUKI BOUAMAMA Reda MAHDJOUB Zoubir	THE EFFECT OF COMPRESSION FUNCTION ON DIGITAL IMAGES	140
Natalia Makuch	COMPARISON OF CORROSION RESISTANCE OF 316L STEEL PRODUCED BY SLM AND CONVENTIONAL METHODS	141
Anyasi R.O.	THE MEASUREMENT OF CHROMOLAENA ODORATA GROWTH IN INDOLE BUTYRIC ACID (IBA) TREATED SOIL	149
Eman Sanad Khalid Z. Elwakeel Mokhtar S. Beheary Ahmed Abdelaal	USING OF MODIFIED ALGINATE-BASED NANOCOMPOSITES BEADS FOR THE REMOVAL OF SOME HEAVY METALS FROM INDUSTRIAL WASTEWATER	161
ADEYEMI, Deborah OGUNLEYE, Timothy A.	ANALYSIS OF STATISTICS OF CRIME RATES IN NORTHWEST NIGERIA USING PRINCIPAL COMPONENT TECHNIQUE	163
BENADLA Sarra DEBBAL Mohammed BENADLA Nadjet	IMPACT OF TRAJECTORY LENGTH ON SYBIL ATTACK DETECTION IN VEHICULAR NETWORKS	189
Hafiza Komal Naeem	ECOFRIENDLY SYNTHESIS OF MAGNETIC COMPOSITES LOADED ON RICE HUSKS FOR ACID BLUE 25 DECONTAMINATION: ADSORPTION KINETICS, THERMODYNAMICS, AND ISOTHERMS	190
Usman S. Rilwan Michael O. Oni	SIGNIFICANCE OF HEAT SOURCE/SINK ON ELECTROMAGNETOHYDRODYNAMICS NATURAL CONVECTION FLOW WITH ELECTROSMOTIC EFFECT	191
Mehmet BAY	ENERGY STORAGE APPLICATION OF BOROPHENE COATED COPPER FOIL ELECTRODES	192
Yaşar KARADAL Beyza KAHRAMAN	THE POTENTIAL OF PLANT-BASED BIOMATERIALS FOR THE COAGULATION PROCESS OF WASTEWATER TREATMENT SYSTEMS: OPUNTIA FICUS-INDICA AS AN ALTERNATIVE TO FeCl ₃	193
Enes BİGA Musa ALCI	ADAPTIVE CONTROLLER DESIGN FOR ELECTRONIC CONTROLLERS IN VENTILATION SYSTEM	195
Onur ERDOĞAN Saeed LOTFAN	MATHEMATICAL MODELING AND ANALYSIS OF SHIP-MOUNTED CRANES WITH SHOCK ABSORBER	205
Murat KUTLU Saeed LOTFAN	DYNAMIC BEHAVIOR OF ROTOR SYSTEMS WITH SUPPORT NONLINEARITIES	207
Uğur ERDAL	REAL TIME APPLICATION PERFORMANCE MEASUREMENT	208
Şule Nur AKÇA Derya YILMAZ	PERFORMANCE IMPROVEMENT AND COMPARATIVE ANALYSIS FOR MOVING OBJECT DETECTION ON FIXED CAMERA IMAGES	210
Burak GÜLER Veysel ERTURUN Faruk KOCA	BONDING JUMPER MATERIALS USED IN AIRCRAFTS	225

Tarik Kunduraci	ANALOGY BETWEEN SWARM BEHAVIOR AND THERMODYNAMIC PARTICLE ASSEMBLY	238
Preeti Bhaskar Puneet Gupta Priyanka Bhaskar Rakhi Shukla	UNVEILING CHATGPT'S POTENTIAL: A QUALITATIVE EXPLORATION OF RESEARCHERS' PERSPECTIVES IN ENHANCING ACADEMIC RESEARCH IN INDIAN HIGHER EDUCATION	240
Mariton Mirantes Aldwin T. Miranda	THEORIZING STUDENTS' MATHEMATICAL RESILIENCY AND MATH PERFORMANCE THROUGH PATH ANALYSIS	241
Michael O. Oni Taiwo, S. Yusuf Junaid M. Abba Baba I. Mundi	EXACT SOLUTION OF MIXED CONVECTION FLOW OF HEAT GENERATING/ABSORBING FLUID IN A VERTICAL CHANNEL WITH INDUCED MAGNETIC FIELD AND ELECTROKINETICS	242
Adenegan-Alakinde Taiwo Ayomipo Baderinwa-Adejumo Adejoke Olusola Funmilola Mabel Ojo	A COMPARATIVE STUDY OF DETERMINANTS OF CONSUMERS' CHOICES OF SOME VEGETABLES IN ONDO STATE NIGERIA	243
Mark Anthony G. Baclay Cristina Dominie M. Cortado Aldwin T. Miranda	MOTIVATIONAL STRATEGIES AND MATHEMATICS PERFORMANCE OF COLLEGE STUDENTS	244
Chelljoy T. Villegas Merie Mae Joy S. Estopa Aldwin T. Miranda	PROBLEM-SOLVING APPRAISALS AND MATHEMATICS PERFORMANCE OF COLLEGE STUDENTS	245
Honey Queen A. Lumoto Crismar C. Decolas Karen E. Cabalquinto Aldwin T. Miranda	EXPLORING STUDENTS' MATHEMATICS PERFORMANCE THROUGH SELF-REGULATED LEARNING	246
Gülçin BAYSAL	SUSTAINABLE LIGNIN-BASED HYDROGELS: PROPERTIES AND INNOVATIVE APPLICATIONS	247
Yasemen UÇAN Nisanur YILDIZ	AN APPLICATION ON THE FUZZY ROUGH SET APPROACH	261
Rabia TURAN Atif KOCA	THE USE OF PHTHALOCYANINE COMPOUND IN ELECTROCHEMICAL SENSORS	263
Deniz SAKARYA	ADVANCEMENTS IN METAL-ORGANIC FRAMEWORKS	264
Deniz SAKARYA	APPLICATION OF MOFS IN BIOMEDICAL SYSTEMS	265
Dilay PAR Tuğçe Nazlı KAYA Orhan ŞAHİN Erhan İBRAHİMOĞLU Fatih ÇALIŞKAN	THE ROLE OF P2O5 ADDITION IN FRITES USED IN ENAMELS ON THE PHYSICAL, CHEMICAL AND MECHANICAL PROPERTIES OF THE COATING	266
Şevin EKMEK	HARDENED PROPERTIES PREDICTION OF ROLLER COMPACTED CONCRETE VIA GENE EXPRESSION PROGRAMMING	279
M.A. Sarli A.T. Özgüney E.S. Dalbaşı	A REVIEW OF POLYMERIC DISPERSANTS IN THE STABILIZATION OF HYDROPHOBIC DYES AND PIGMENTS	281
Laid Elkhiri Miloud Mihoubi	SUPER-CONGRUENCES WITH BINOMIAL COEFFICIENTS AND GENERALATE HARMONIC NUMBERS	294
Nadjet BENCHIHEUB Nadhira BIOUD	EFFECT OF HIGH PRESSURE ON THE DEBYE TEMPERATURE OF CaO MATERIAL	297
Kumkum Malakar Shiv Lal	DESIGN AND SIMULATION STUDIES OF A GRID CONNECTED 1MW WIND ENERGY POWER PLANT USING MATLAB	302

Himanshi Kumari Shiv Lal Shibna Hussain Santosh Kumar Sharma	DESIGN AND DEVELOPMENT OF GRID- CONNECTED 1 KW WIND ENERGY POWER PLANT FOR DRE BUILDING IN RTU INDIA USING MATLAB	322
Yasser, A.M. Moussa	NEURAL NETWORK MODELING FOR SCOUR PREDLCTION AT BRIDGE FOUNDATION	323
Aremu, O.A. Makinde, O.S. Oyinkanola L.O.A. Mufutau, J. A. Anie, N. O.	DESIGN AND SIMULATION OF RECTANGULAR MICROSTRIP PATCH ANTENNA FOR SATELLITE COMMUNICATIONS AND IOT DEVICES USING FR-4 SUBSTRATE	333
Chabelita S. Sabanal Jelyan S. Bago Carlito B. Balandra Aldwin T. Miranda	ATTITUDES TOWARD LEARNING MATHEMATICS AND PERFORMANCE OF GRADE 11 STUDENTS IN THE NEW NORMAL	334
Dalia Das Harish Kumar Verma Bhumika Sharma Poonam Pant	HUMAN RIGHTS OF DOMESTIC WORKERS: UNTANGLING NATIONAL AND INTERNATIONAL LEGAL FRAMEWORKS	335
Hande SONSUN Nil YAPICI Nusret NURLU	GEOLOGICAL, PETROGRAPHIC, AND MINERALOGICAL CHARACTERISTICS OF BASALTIC ROCKS IN THE TOPRAKKALE (OSMANIYE) REGION	342
Ercüment BİLGER Nil YAPICI	USE OF EXPANDED CLAY IN LIGHTWEIGHT BUILDING MATERIAL	352
Ömer ÖZKAN Nezih Metin ÖZMUTAF	STRATEGIC PERSPECTIVE IN ORGANIZATIONS IN POST-EARTHQUAKE PROCESSES: A RESEARCH WITHIN THE SCOPE OF THE SIX FEBRUARY EARTHQUAKES	364
Ahmet Yakup CUMBUL Dilek KUMLUTAŞ	NUMERICAL INVESTIGATION OF THE CONDENSATION CHARACTERISTICS IN THE CONDENSATION REGION OF A COMBI BOILER UNIT	378
Taşkın Deniz YILDIZ Murat MARAL	IS IT POSSIBLE TO ENSURE THAT THE PERMANENT SUPERVISOR AND THE OHS EXPERT CAN WORK EFFECTIVELY IN THE MINES IN THE EXISTENCE OF A CONFLICT OF DUTIES BETWEEN THE OHS EXPERT AND THE SUPERVISOR?	380
Aysegul YUCEL Musa SARIKAYA	THE EFFECT OF ROASTING ON THE EXTRACTION OF RUBIDIUM FROM BORON ORE WASTES INTO SOLUTION	382
Sergo Esadze	RANDOM VERTICAL SEISMIC VIBRATION OF LARGE SPAN ROOFING TRUSSES	385
Abiodun Naeemdeen ADEJUMO	HYDROGEOCHEMICAL INVESTIGATION OF SHALLOW GROUNDWATER IN PART ABUJA MUNICIPAL AREA COUNCIL, (AMAC) FCT, NIGERIA	390
Andrea Amalia MINDA Olga Ioana AMARIEI Marius Savu LOLEA Emeric Remus SZABO	ASSESSMENT AND INCREASING OF ELECTRICITY AVAILABILITY OF PHOTOVOLTAIC PANELS USING FUZZY LOGIC PRINCIPLES AND CONTROL	391
Andrea Amalia MINDA Olga Ioana AMARIEI Marius Savu LOLEA Emeric Remus SZABO	GEOHERMAL ENERGY EXPLOAITATION AND APLLICATIONS IN THE ARIA OF BEIUŞ CITY, ROMANIA. PRESENT AND PERSPECTIVES	392
Aliyu Hassan	ASSESSMENT OF THE EFFECTS OF UNREGULATED SOLID WASTE DISPOSAL ON URBAN FLOODING IN KADUNA METROPOLIS	393

Eyo Uwem-Obong Joseph Agada Raymond Chubiyo Akor, Ochefije Rita	IMPACTS OF EDUCATIONAL PROGRAMMES OF AKBC RADIO ON STUDENTS OF UYO CITY POLYTECHNIC	394
K.R.Padma K.R.Don	EFFECTS OF POLYPROPYLENE AND POLYSTYRENE MICROPLASTICS ON HEPG2 CELL LINE	401
Boris Zhilyaev Vladimir Petukhov	UNIDENTIFIED AERIAL PHENOMENA. OBSERVATIONS OF SPACE EVENTS	402
Inyang, J. O.	EFFECT OF FARMERS SELECTED SOCIO- ECONOMIC FACTORS ON INFORMATION AND COMMUNICATION TECHNOLOGIES UTILIZATION FOR CASSAVA PRODUCTION IN CROSS RIVER STATE, NIGERIA	403
Murat ŞAHİN	A LINEAR PROGRAMMING MODEL FOR THE HETEROGENEOUS DRONE FLEET DELIVERY PROBLEM CONSIDERING SETUP TIMES	404
Serkan ÖZŞAHİN Kadir ÇAVDAR	JOINING AISI 304 STAINLESS STEEL MATERIALS BY ROBOTIC FIBER LASER WELDING METHOD	406
Atakan KOÇYİĞİT Rüstem Emre SUNGURBAŞ Caner ARSLAN Hasan Hüseyin DOYĞUN	HYSTERESIS ANALYSIS OF OPEN COLLECTOR COMPARATORS	408
Tuğba YÜÇRÜK Gökçe Mehmet GENÇER Mustafa AKARSU	INVESTIGATION OF MECHANICAL PROPERTIES OF LASER TEXTURED Al6063-PA6 HYBRID BEAMS MANUFACTURED IN SINGLE LAP JOINT CONFIGURATION THROUGH A DESIGNED METAL- POLYMER DIRECT BONDING MACHINE	410
Ezgi GÜLER	STATISTICAL EVALUATION OF CHEMICAL FERTILIZER RESOURCES IN TÜRKİYE	413
Burak İZGİ	INVESTIGATION OF THERMAL ENERGY STORAGE PERFORMANCE OF NANOPARTICLE-ENHANCED PHASE CHANGE MATERIAL UNDER MICROGRAVITY CONDITIONS	423
Zeynep ÇOKKIR	DEVELOPMENT OF HEAT AGING AND IMPACT RESISTANT POLYAMIDE COMPOSITES FOR USE IN INTERNAL AND EXTERNAL APPLICATIONS IN THE AUTOMOTIVE SECTOR	432
Akanksha Gautam Mahendra Kumar Savita	ROLE OF PROTEIN-RICH DIETS IN PROMOTING A HEALTHY LIFE: BENEFITS, SOURCES, AND CONSIDERATIONS	434
Akanksha, Mahendra Kumar Savita	HOME REMEDIES FOR MANAGING SEPTICEMIA IN FISH: A REVIEW OF TRADITIONAL AND NATURAL TREATMENTS	439
Abhinesh Pal Mahendra Kumar Savita	MALARIA: EPIDEMIOLOGY, PATHOGENESIS, AND CONTROL STRATEGIES	443
Archit Kumar Mahendra Kumar Savita	HOME REMEDIES FOR HIGH BLOOD PRESSURE: EXPLORING NATURAL APPROACHES TO HYPERTENSION MANAGEMENT	447
Ong Hock Siong KongYin Mei Cheah Chee Keong Adam Arif Lee Aik Keang Wong Kok Yaw Nakesvari A/P Shanmugam	THE IMPACT OF SOCIAL MEDIA INFLUENCERS ON FINANCIAL DECISION-MAKING AMONG MALAYSIAN YOUTH: A CONCEPTUAL FRAMEWORK	451
Nasrin Rezai	INVESTIGATING HOW SULTANA RAZIA CAME TO POWER	453
Disha, Mahendra Kumar Savita	HOME REMEDIES FOR TUBERCULOSIS: AN OVERVIEW OF TRADITIONAL AND NATURAL APPROACHES TO COMPLEMENT MODERN TREATMENT	454

Sertaç BULUT	EVALUATION OF FUEL CELL TECHNOLOGIES AS A CLEAN ENERGY ALTERNATIVE IN MARITIME INDUSTRY	458
Funda GENÇER	ANALYSIS OF THE SPATIAL CHANGES OF THE HANS DISTRICT IN THE HISTORIC CITY CENTER OF MUĞLA	471
Seda DURUKAN Abdülşamet GÜVEN	IMPACT OF MATRIC SUCTION ON THE UNCONFINED COMPRESSIVE STRENGTH OF A BENTONITE SAND MIXTURE	473
Mertcan YILMAZ Tamer DİRİKGİL	ESTIMATION OF EARTHQUAKE RISK LEVELS OF RC STRUCTURES WITH ARTIFICIAL INTELLIGENCE METHODS	480
Suzan TİREKİ	PRODUCTION OF DATES LEATHER WITH INFRARED DRYING METHOD	489
Gülden KILIÇ	GREEN SYNTHESIS OF NANOPARTICLES THROUGH YEASTS	491
Nurşah Zeynep ÖZTÜRK Aysel GÜLBANDILAR	DETERMINATION OF BIOACTIVE PROPERTIES OF POSTBIOTICS OBTAINED FROM CULTURE MEDIA SUPPLEMENTED WITH ORANGE PEEL POWDER	493
Rana YORNUK Serkan DİKİCİ	OPTIMIZATION OF SOLVENT AND PROCESS PARAMETERS FOR THE PRODUCTION OF EXTRACELLULAR MATRIX-MIMICKING POLYMERIC FIBRES	495
Rüveyde TUNÇTÜRK Murat TUNÇTÜRK Erol ORAL Lutfi NOHUTCU Ezelhan ŞELEM	EFFECT OF MYCORRHIZA APPLICATIONS ON SOME PHYSIOLOGICAL PROPERTIES OF SOYBEAN (<i>Glycine max L.</i>) GROWN UNDER SALT STRESS CONDITIONS	496
İnci CERİT Omca DEMİRKOL Özlem AKTÜRK GÜMÜŞAY	ULTRASOUND-ASSISTED EXTRACTION OF PHENOLIC COMPOUNDS FROM ARONIA (<i>Aronia Melanocarpa</i>) FRUIT	507
Cem Tolga Münyas Sibel Demir Boğaçhan Ali Düşgöl	PARKING SPACE PLANNER ALGORITHM ON LIDAR BASED MAP WITH AUTONOMOUS VEHICLE	509
Manikandan Tiruchengode Ramadurai	IMPACT OF CARBON EMISSION PRICING IN ELECTRICAL TRANSMISSION NETWORK UNDER CONSTRAINED DEREGULATED ELECTRICITY MARKET	525
Syeda Sabika Zahra Naqvi	ALLELOCHEMICAL EFFECT ON AVERRHOA CARAMBOLA L. IN ANATOMICAL ARCHITECTURE ON WHEAT GROWTH	526
K.R.Padma K.R.Don	A CONCISE REVIEW ON WOMEN IN SCIENCE AND TECHNOLOGY ON 20TH CENTURY	527
Neha Singh Suneel Kumar Singh	UNVEILING THE THERAPEUTIC POTENTIAL OF LACTUCA SERRIOLA: PHYTOCHEMICAL ANALYSIS AND PHARMACOLOGICAL APPLICATIONS"	528
Aurora Dibra Leonora Haxhiu	DIGITALIZATION PROCESS AS A TOOL FOR THE ASSESSMENT OF LAND EROSION AND ECOSYSTEM ADAPTATION IN THE ADRIATIC LAGOONS IN ALBANIA	529
Saverio Storani	IDENTIFICATION OF PIVOTAL ACTORS IN THE INTERBANKING NETWORKS THROUGH VORONOI TESSELLATION ON NETWORKS	531
Mohammed Waheeb	A UNIQUE OTTOMAN MAQAM/SHRINE IN KHALDYEH-MAFRAQ SOUTH LEVANT	532
Dicky Muslim Bilal Shah Usama Yaseen	DIAGENETIC FEATURES OF EARLY EOCENE AGE CHORGALE FORMATION AT KHANPUR DAM ROAD SECTION, HAZARA BASIN, PAKISTAN	533
Djebbara BENZERGA Adel Chouiter	ALTERNATIVE SOLUTION TO REPLACE HYDROSTATIC TESTING OF HDPE PIPES	541

Cyntia Lasmi Andesti Rahmad Dian Sri Restu Ningsih	INNOVATION OF STUNTING DETECTION APPLICATION USING CHATBOT AS STRATEGY TO ACHIEVE UNIVERSAL HEALTH COVERAGE IN SDGs	542
Maryam ERRAMI Ahmed ALGOUTI Hayat GHACHOUI Idir EL KONTY	MODELING LATERAL FACIES HETEROGENEITY OF AN EARLY JURASSIC CARBONATE PLATFORM (TIGHZA, HIGH ATLAS OF MARRAKECH, MOROCCO)	543
Marco Ripà	GRAHAM'S NUMBER STABLE DIGITS: AN EXACT RESULT	545
M. Thien Phung Eunbi Kim Sadiah Ameen O-Bong Yang M. Shaheer Akhtar	STABLE AND HIGH PERFORMANCE LITHIUM ION BATTERIES USING EFFECTIVE IONIC LIQUID-MODIFIED LIFS1 ELECTROLYTES	546
MUJEEBUDHEEN KHAN	NEXT-GENERATION HEALTHCARE: AN AI-BASED AUTONOMOUS DRUG DELIVERY SYSTEM	547
Aleksandra Mikhailidi Sofya Verbovskaya Margarita Chepurnova	WATER RETENTION AND SORPTION CHARACTERISTICS OF CELLULOSE-BASED HYDROGELS	548
Hassane ABD-DADA Said BOUDA Atman ADIBA Sadik DANI Abdelmajid HADDIOUI	GENETIC DIVERSITY ANALYSIS OF EUPHORBIA RESINIFERA IN MOROCCO: A POTENTIAL PLANT TO REMEDY CLIMATE CHANGE, PROTECTING AND RESTORING ECOLOGICAL HABITATS OF PLANT AND ANIMAL SPECIES	550

**KOHEZYONSUZ ZEMİNLERDE BOŞLUK SUYU BASINCI OLUŞUM
MODELLERİNİN İNCELENMESİ**
INVESTIGATION OF POREWATER PRESSURE GENERATION MODELS IN
COHESIONLESS SOILS

Tansu ORHAN

Arş.Gör., Kocaeli Üniversitesi, Mühendislik Fakültesi, İnşaat Mühendisliği Anabilim Dalı
Res.Asst., Kocaeli University, Faculty of Engineering, Department of Civil Engineering

ORCID ID: 0000-0002-3773-3764

Sami ARSOY

Prof.Dr., Kocaeli Üniversitesi, Mühendislik Fakültesi, İnşaat Mühendisliği Anabilim Dalı
Prof.Dr., Kocaeli University, Faculty of Engineering, Department of Civil Engineering

ORCID ID: 0000-0003-0125-8612

ÖZET

Sismik zemin sıvılaşması, drenajsız yükleme koşullarının hakim olduğu kohezyonsuz zeminlerin tekrarlı yüklere maruz kalması sonucunda gözlenen bir zemin yenilmesi türüdür. Sıklıkla doygun durumdaki gevşek ince kum ve plastik olmayan silt gibi göreceli düşük permeabiliteli zeminlerde karşılaşılan sıvılaşma durumu, boşluk suyu basıncının deprem ile artarak düşey efektif gerilmeye eşit olmasıdır. Sıvılaşma mekanizması fazla boşluk suyu basıncının ($+\Delta u$) oluşumu, sıvılaşma anı ve fazla boşluk suyu basıncının sönmülmesi olmak üzere 3 aşamadan oluşur. Dobry & Matasovic modeli, GMP modeli, Park & Ahn modeli ve Genelleştirilmiş Enerji modeli, $+\Delta u$ oluşum sürecini teorik olarak tahmin etmekte yaygın olarak kullanılan yaklaşımlardır. Bu çalışmada sıvılaşma potansiyelinin belirlenmesinde kullanılan analitik yöntemlerden biri olan Çevrimsel Gerilme Oranı Yaklaşımı (CSR) kullanılarak temsili zemin profilleri oluşturulmuştur. Senaryo zemin ve deprem koşulları için DeepSoil v7 programı kullanılarak 1 boyutlu doğrusal olmayan dinamik analizler yapılmıştır. Analizlerde, seçilen $+\Delta u$ oluşum modelleri için gerekli olan parametreler kullanılarak, tabaka orta noktasında boşluk suyu basıncındaki değişimin etkisi dikkate alınmıştır. Sıvılaşma riskinin kontrolü için boşluk suyu basıncı oranının (r_u) zamanla değişimi irdelenmiştir. Çalışma sonucunda literatürde yaygın olarak kullanılan $+\Delta u$ oluşum modellerinin kullanımına ait sınırlar sunulmuştur. Tüm modeller için analitik çözüm sonuçları ile 1 boyutlu dinamik analiz sonuçları karşılaştırılmıştır. Elde edilen sonuçlar doğrultusunda seçilen boşluk suyu basıncı modellerinin avantaj ve dezavantajları belirlenerek kullanımlarına dair bazı önerilerde bulunulmuştur.

Anahtar Kelimeler: Sıvılaşma, Fazla Boşluk Suyu Basıncı, DeepSoil, CSR.

ABSTRACT

Seismic soil liquefaction is a type of soil failure observed as a result of the cyclic loading of cohesionless soils dominated by undrained loading conditions. Liquefaction, which is frequently encountered in relatively low permeability soils such as saturated loose fine sand and non-plastic silt, is defined as the porewater pressure increasing with the earthquake and becoming equal to the vertical effective stress. The liquefaction mechanism consists of 3 stages: the generation of excess porewater pressure ($+\Delta u$), liquefaction process and the dissipation of excess porewater pressure. Dobry & Matasovic, GMP, Park & Ahn and Generalized Energy models are widely used approaches to theoretically estimate the $+\Delta u$ build up process. In this study, representative soil profiles were created using the Cyclic Stress Ratio Approach (CSR), one of the analytical methods used in determining the liquefaction potential. 1D non-linear dynamic analyses were performed with DeepSoil v7 for the scenario soil and earthquake conditions. In the analyses, the effect of the change in pore water pressure at the layer midpoint was considered by using the parameters required for the selected $+\Delta u$ generation models. The change of excess porewater pressure ratio (r_u) against time was examined for the control of liquefaction risk. As a result of the study, the limits for the use of $+\Delta u$ generation models widely used in the literature are presented. Analytical solution results were compared with 1D dynamic analysis results for all models. In line with the obtained results, the advantages and disadvantages of the selected pore water pressure models were determined and some suggestions were made for their use.

Keywords: Liquefaction, Excess Porewater Pressure, DeepSoil, CSR.

**SAHAYA ÖZEL SİSMİK TEPKİ İÇİN SPEKTRAL EŞLEŞTİRME VE PGA
EŞLEŞTİRMENİN KARŞILAŞTIRMALI ANALİZİ: METODOLOJİK ETKİLER VE
ÇIKARIMLAR**

**COMPARATIVE ANALYSIS OF SPECTRAL MATCHING AND PGA MATCHING FOR
SITE-SPECIFIC SEISMIC RESPONSE: METHODOLOGICAL IMPACTS AND
IMPLICATIONS**

Melis ERSOY

Yüksek Lisans Öğrencisi, Eskişehir Osmangazi Üniversitesi, Mühendislik Mimarlık Fakültesi,
İnşaat Mühendisliği Bölümü Geoteknik Anabilim Dalı

MSc. Student., Eskişehir Osmangazi University, Department of Eng. And Arch.,

Department of Civil Engineering Geotechnical Division

ORCID ID: 0009-0002-9518-6049

Kamil Bekir AFACAN

Doç. Dr., Eskişehir Osmangazi Üniversitesi, Mühendislik Mimarlık Fakültesi,
İnşaat Mühendisliği Bölümü Geoteknik Anabilim Dalı

Assoc. Prof. Dr., Eskişehir Osmangazi University, Department of Eng. And Arch.,

Department of Civil Engineering Geotechnical Division

ORCID ID: 0000-0002-3667-4432.

ÖZET

Geoteknik deprem mühendisliğinde, sahaya özel yer hareketi tepkilerinin doğru bir şekilde tahmin edilmesi, etkili yapısal tasarım ve risk azaltma için çok önemlidir. Yönetmelikler, seçilecek deprem kayıtları ve bu kayıtların ölçeklendirilmesini yönlendirerek, anakaya ya da elastik kaya için kullanılacak ivmelerin belirlenmesini sağlar. Dinamik yükler altında bir elemanın maruz kalacağı yük, gelen ivmeyle belirlenirken, geleneksel yaklaşım olarak en büyük ivme hesaplara katılarak maksimum dinamik yük belirlenir ve tasarım yükü olarak göz önünde bulundurulur. Bu çalışma, sahaya özel tepki analizleri üzerindeki etkilerini değerlendirmek için yer hareketlerini ölçeklendirmeye yönelik iki yaygın yöntemi (spektral eşleştirme ve Tepe Yer İvmesi (PGA) eşleştirme) karşılaştırmaktadır. Spektral eşleştirme, yer hareketlerini bir hedef tepki spektrumuyla uyumlu hale getirerek çeşitli frekanslarda beklenen sismik taleplerle ayrıntılı bir eşleşme sağlar. Buna karşılık, PGA eşleştirme maksimum yer ivmesini bir hedef değere ölçeklendirmeye odaklanır, bu da ayarlama sürecini basitleştirebilir ancak yer hareketlerinin frekansa bağlı etkilerini tam olarak yakalayamayabilir. Bu araştırma bu iki yöntemin, bir boyutlu analizler yardımıyla (DeepSoil) eşdeğer lineer ve lineer olmayan yöntemler kullanılarak, sahaya özgü tepki karakteristiklerini amplifikasyon açısından yansıtmadaki etkinliğini değerlendirmeyi hedeflemiştir. Bulgular, spektral eşleştirmenin beklenen sismik tepkinin daha kapsamlı bir temsilini sunarken, PGA eşleştirmesinin basitlik ve hesaplama verimliliğinin öncelikli olduğu belirli uygulamalar için hala değerli

olabileceğini göstermektedir. Ayrıca diğer deprem karakteristikleri kapsamında yüzey hareketleri kıyaslanarak, yüzey davranışı tahmin etme bakımından diğer önemli parametrelerin varlığı araştırılmıştır. Bu karşılaştırmalı analiz, her bir yaklaşımın avantajları ve sınırlamaları hakkında eşdeğer lineer ve lineer olmayan yaklaşımları göz önünde bulundurmak suretiyle fikir vererek deprem mühendislerine kendi özel sismik değerlendirme ihtiyaçları için en uygun yöntemi seçmelerinde yol göstermektedir. Son olarak seçilen kayıtların sahaya özel davranışı etkilemede ne kadar önemli olduğu belirlenmiştir.

Anahtar Kelimeler: PGA, Ölçeklendirme, Sahaya Özel Analiz, Deprem Karakteristikleri.

ABSTRACT

In geotechnical earthquake engineering, accurate prediction of site-specific ground motion responses is crucial for effective structural design and risk reduction. Regulations guide the choice of earthquake records and their scaling, and determine the accelerations to be used for bedrock or elastic rock. The load that a member will be subjected to under dynamic conditions is determined by the incident acceleration. The conventional approach is to determine the maximum dynamic load by including the maximum acceleration in the calculations and consider it as the design load. This study compares two common methods for scaling ground motions (spectral matching and Peak Ground Acceleration (PGA) matching) to assess their impact on site-specific response analyses. Spectral matching provides a detailed match to expected seismic demands at various frequencies by aligning ground motions with a target response spectrum. In contrast, PGA matching focuses on scaling the maximum ground acceleration to a target value, which can simplify the tuning process but may not fully capture the frequency-dependent effects of ground motions. This research aimed to evaluate the effectiveness of these two methods in reflecting site-specific response characteristics in terms of amplification, using equivalent linear and non-linear methods with the aid of one-dimensional analyses (DeepSoil). The findings show that while spectral matching provides a more comprehensive representation of the expected seismic response, PGA matching can still be valuable for specific applications where simplicity and computational efficiency are priorities. In addition, surface motions in the context of other earthquake characteristics are compared to investigate the presence of other important parameters for predicting surface behavior. This comparative analysis provides insight into the advantages and limitations of each approach by considering equivalent linear and non-linear approaches, guiding earthquake engineers to select the most appropriate method for their specific seismic evaluation needs. Finally, it is determined how important the selected recordings are in influencing site-specific behavior.

Keywords: PGA, Scaling, Site Specific Analysis, Earthquake Characteristics.

GİRİŞ

Mühendislik yapıları, genellikle yerkabuğ üzerine kurulan karmaşık temel sistemlerdir. İnşaat mühendisleri, bu yapıların dayandığı zeminin özelliklerini detaylı bir şekilde inceleyerek, zemin parametreleri ve farklı gerilme koşullarında nasıl davranacakları konusunda bilgi sahibi olurlar. Bu süreçte, zemin parametreleri ve yapı davranışları arasındaki ilişkiyi anlamak önemlidir.

Geoteknik mühendisliği, zeminin mekanik özelliklerini ve özellikle de kritik durumlar altındaki davranışlarını inceleyen inşaat mühendisliğine ait bir bilim dalıdır. Ayrıca, yapı zemin etkileşiminden kaynaklanan potansiyel sorunları tespit edip, çözümler geliştirmek de bu mühendislik dalının sorumluluğundadır.

Ülkemizde, özellikle projelendirme ve inşaa aşamalarından önce gerçekleştirilen zemin etüdü çalışmalarının, konusund uzman geoteknik mühendisleri tarafından yürütülmediği durumlarda, kaza anlarında can ve mal kayıpları meydana gelebilmektedir. Bu nedenle, doğru zemin parametrelerini yorumlayabilen ve uygun çözümler üretebilen geoteknik mühendislerin katkısı büyük önem taşır.

Geoteknik mühendisliğinin alt dallarından biri olan geoteknik deprem mühendisliği, yapı temel zemininin depreme karşı direncini tasarlamayı amaçlar. Depreme dayanıklı yapıların projelendirilmesi için deprem, zemin ve yapı özelliklerinin detaylı bir şekilde bilinmesi gereklidir.

Deprem, litosferin ani ve güçlü sarsılması olayıdır. Bu doğal afet, yer kabuğu üzerinde sarsıntı ve titreşim etkisi meydana getirir. Bu durum, yapıların zamana bağlı deplasman hareketi oluşturarak mesnetlenmelerine neden olur ve aynı zamanda dinamik etkiler meydana getirir. Türkiye'nin bulunduğu konum, Alp-Himalaya deprem kuşağı gibi aktif deprem kuşaklarının bir parçası olması açısından büyük bir önem taşır. Bu nedenle, geoteknik mühendisliği ve özellikle de geoteknik deprem mühendisliği, yapı güvenliği açısından kritik bir rol oynar.

Sahaya özel sismik ölçeklendirme, yerel zemin koşulları, deprem büyüklüğü ve fay hattına uzaklık gibi faktörleri dikkate alarak yapıların deprem sırasında maruz kalacağı gerçekçi sismik etkileri belirlemek için yapılır. Bu, yapıların doğru analiz edilmesini, güvenli bir şekilde tasarlanmasını ve yerel yönetmeliklerle uyumlu hale getirilmesini sağlar. Bu sayede yapıların deprem karşısındaki performansı optimize edilir ve güvenlik artırılır.

Deprem kayıtlarının ölçeklendirilmesi için birçok araç geliştirilmiş olup farklı ölçeklendirme yöntemleri uzun yıllardır analiz edilmiştir. Bu çalışmada ise bu yöntemlerden olan spektral eşleştirme ve yüzey pik ivmesi (PGA) eşleştirme incelenmiştir. Bu incelemede, farklı ivme kayıtlarını eşdeğer lineer ve lineer olmayan yaklaşımlar ile analiz ederek en gerçekçi sismik etkiyi belirlemek amacıyla çalışılmıştır.

LİTERATÜR ÇALIŞMALARI

Yasin M. FAHJAN (2008), Z1, Z2, Z3 ve Z4 yerel zemin sınıfları için Pacific Earthquake Engineering Research (PEER) veritabanından belirli özelliklerde 10 zaman tanım alanı kaydı ile ölçeklendirme faktörleri üzerine bir çalışma yapmıştır. Ölçeklendirme yöntemi ile belli bir periyot aralığında DBYBHY 2007 yönetmeliğine uygun zaman tanım alanı kayıtları elde edilmiştir.

Pan Liu, Hongya Qu, Jianzhong Li, Gao Ma (2024), Arias Yoğunluğu Uyumlama (AIF) ve PGA düzeltme algoritmaları ile maksimum yer ivmesi (PGA) ve Arias yoğunluğu seviyelerini korumayı amaçladıkları yeni bir yöntem hazırlamışlardır. Spektral eşleştirme yöntemiyle bu yöntemi karşılaştırarak yapısal sismik analizlerde hedef spektruma uygun ve ölçeklenmiş ivme kayıtları üretilmeye çalışılmıştır. Önerilen yöntem ile iyi bir performans yakalanmıştır.

Ahmet Demir, Ali Haydar Kayhan, Mehmet Palanci (2023), farklı katlardaki binaların farklı zemin sınıflar için spektral eşleşmeli yer hareketi seçim stratejilerinin sismik tepkileri üzerindeki etkisini incelemişlerdir. Spektral eşleştirmenin yer hareketlerin spektral ivme değerlerinin yayılımını kontrol etmeye yardımcı olabileceği sonucuna varılmıştır.

Ruifu Zhang, Luqi Zhang, Chao Pan, Qingjun Chen, Yanchao Wang (2021), çalışmada spektral eşleştirme yöntemi üzerinde ufak değişikliklerle spektral uyum artırılmaktadır. Sonuçlar, önerilen yöntemin yüksek doğrulukta birden çok dayanıklılık süresi ivme fonksiyonları (ETAF) ürettiğini, böylece sismik performans analizi için yalnızca bir ETAF kullanarak yeterli doğruluğun sağlandığını göstermektedir. Yöntem, gerçek yer hareketlerinden elde edilen ortalama ivme spektrumlarını eşleştirme yeteneğine de sahiptir.

Armen Adekristi, Matthew R. Eatherton (2015), bu çalışmada deprem yer hareketlerinin zaman alanında spektral eşleştirilmesi için yeni bir algoritma gösterilmektedir. Algoritma, ivme tarihine dalga paketleri ekleyerek hedef spektrumla uyum sağlamaktadır. İstenmeyen bir durum olarak ise dalga paketlerinin eklenmesi tepe yanıtının zamanını kaydırabilir veya farklı zamanlarda ikinci bir tepe oluşturabilir. Broyden güncellemesi ile ikinci bir tepe oluşması engellenebilir. Sonuç olarak ise, hedef spektrumu eşleştirirken spektral durağanlık, enerji gelişimi ve orijinal zaman tarihinin frekans içeriğini makul ölçüde koruyabildiği anlaşılmıştır.

Guochen Zhao, Longjun Xu, Xingji Zhu, Shibin Lin, Lili Xie (2022), çalışmalarında yapıların sismik analizi ve tasarımında spektral olarak eşleştirilmiş yer hareketlerinin seçiminde kullanılan Kare Hata Toplamı (SSE) yönteminin eksiklerinden dolayı Siamese Konvolüsyonel Sinir Ağları (SCNN) ile yeni bir yöntem denemişlerdir. A, B, C ve D sınıfı ivme tasarım spektrumları ile her sınıf için 40 örnek kullanıldığında çok uyumlu sonuçlar elde edilmiştir. Ayrıca, bu yöntem, SSE tabanlı yaklaşımlara göre daha düşük standart sapma ile sonuçlar vermektedir.

Vincenzo Manfredi, Angelo Masi, Ali Guney Ozcebe, Roberto Paolucci (2022), bu çalışmada İtalya'da farklı bina türlerinin kırılma eğrilerini belirlemek amacıyla kullanılan "Select &

Match (S&M)” aracını tanıtmaktadır. S&M, sismik tehlikeyi temsil eden ivme kayıtlarını seçmek ve spektral olarak eşleştirmek için kullanılmaktadır. Çalışmada, dört katlı betonarme bina modeli üzerinde doğrusal olmayan dinamik analizler yapılmıştır. Bu çalışma, spektral olarak eşleştirilmiş ivme kayıtlarının kırılma eğrilerinde daha düşük standart sapma sağladığını ve daha güvenilir sonuçlar elde edildiğini göstermektedir.

Alex Kurniawandy, Muhammad Aminsyah, Belva Ulfah Cahyadi, Zulfikar dj (2023), çalışma için Endonezya’da kaydedilmiş yer hareketi veri sayısının yetersizliği sebebiyle yedi çift deprem kaydıyla birlikte genlik ölçekleme ve spektral eşleştirme olmak üzere iki modifikasyon yöntemi kullanmışlardır. Çalışmanın sonuçlarına göre, spektral eşleştirme yöntemi, yer hareketi verilerini hedef yanıt spektrumlarına ve pik yer ivmesi (PGA) değerlerine daha iyi uyarlamaktadır. Bu nedenle, dinamik analizlerde spektral eşleştirme yöntemi önerilmektedir.

ARAŞTIRMA BULGULARI

Analizlerde Kullanılacak Deprem Kaydı Seçimleri ve Ölçeklendirme

Bu çalışma kapsamında 2 farklı kayıt tercih edilmiştir. Kayıtlarla alakalı bilgiler Tablo 1’de sunulmuştur.

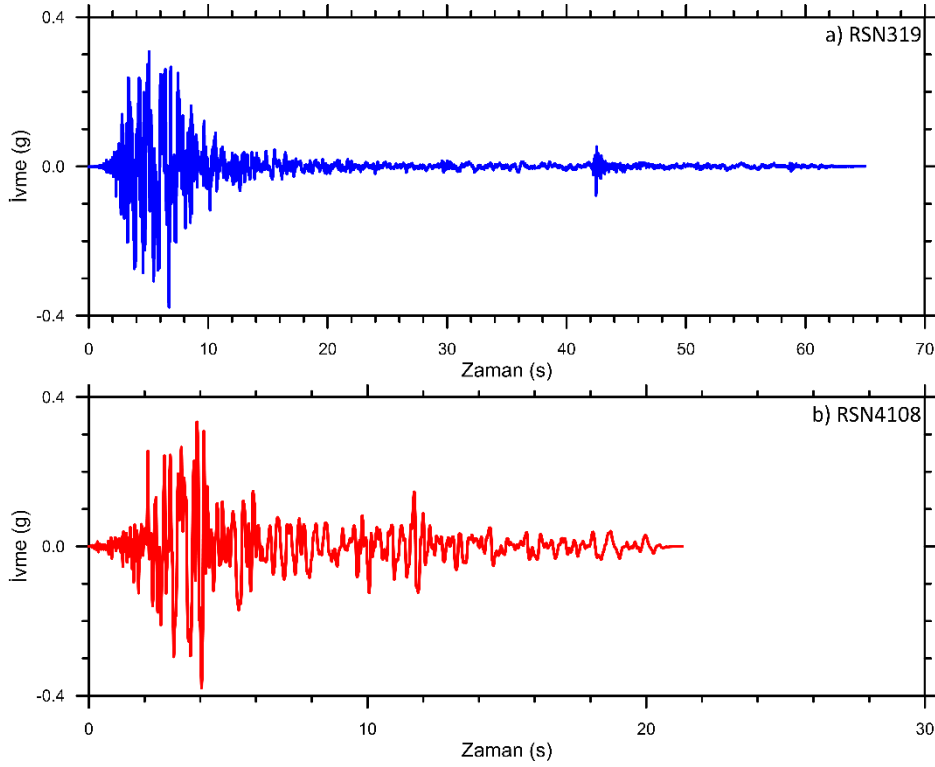
Adı	Parkfield-02	Westmorland
Deprem Sıra Sayısı (RSN)	319	4108
Pik ivme (g)	0.377	0.378
Büyüklik (M_w)	6.0	5.9
En büyük hız (cm/sec)	44.14	22.95
En büyük deplasman (cm)	15.51	3.42
Arias Yoğunluğu	1.76	1.43
Karakteristik Yoğunluk	0.069	0.078
Toplam Mutlak Hız (cm/sec)	1008.0	821.3
Housner Yoğunluğu (cm)	179.6	74.3
Baskın Periyot (sec)	0.14	0.46
Anlamli Süre (sec)	6.875	9.435

Tablo 1: Deprem Kayıtları Kıyaslanması

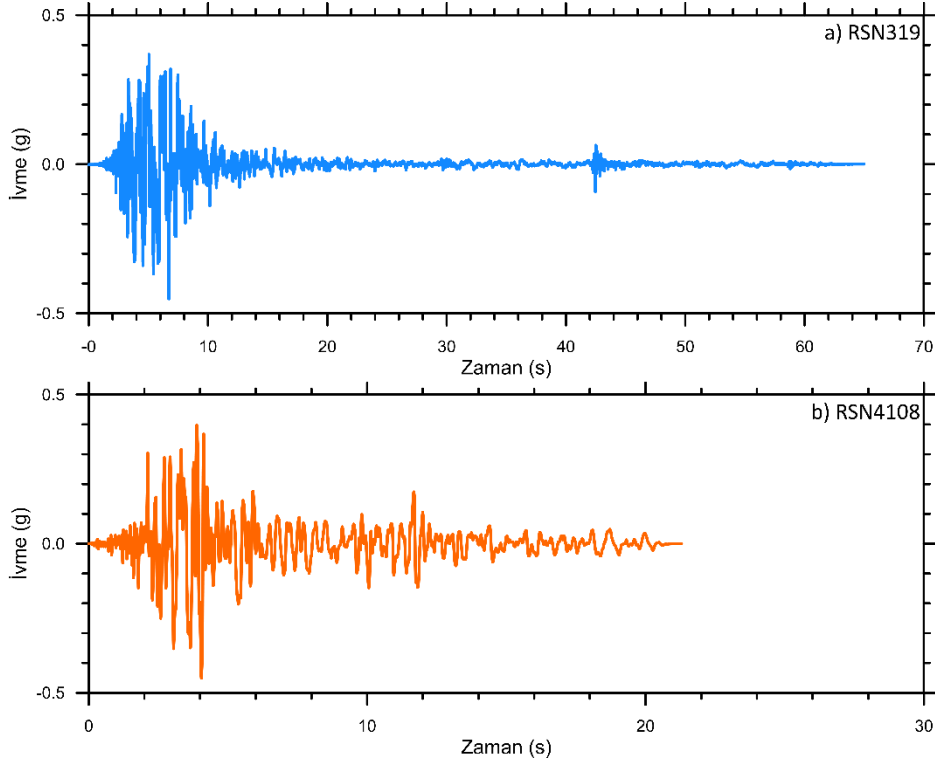
Deprem kaydı seçimi sırasında birbirine çok yakın pik ivmeye (pga) sahip 2 kayıt seçilmiş olup, diğer özelliklerinde farklılıklar görülmektedir. Pik ivmeler 0.377 g ve 0.378 g iken, Arias yoğunluğu 1.76 ve 1.43 olarak hesaplanmış, Housner yoğunluğunda 179.6 ve 74.3 olarak bulunmuştur. Tasarımda kullanılan ivmelerde salt pga kıyasının doğru bir yaklaşım olmadığı, süre veya anlamlı süre dışında olan kayıtların diğer karakteristik özelliklerinin de göz önünde bulundurulması gerektiği not edilmelidir.

Seçilen kayıtlara ait ivme zaman grafikler Şekil 1’de sunulmuştur. Bir kayıt diğerine göre daha uzun olmakla birlikte genel hareket iki kayıta da yaklaşık 15 sn’den sonra sönümlenmektedir. Analizlerde kullanılacak zemin profili için sismik haritadan seçilen pga

değeri 0.451g ve S_{DS} ve S_{D1} değerleri 1.120 ve 0.798 olup, seçilen kayıtlar sırasıyla pga değerine ve sahaya ait spektraya göre ölçeklendirilerek Şekil 2 ve Şekil 3'te sunulmuştur.

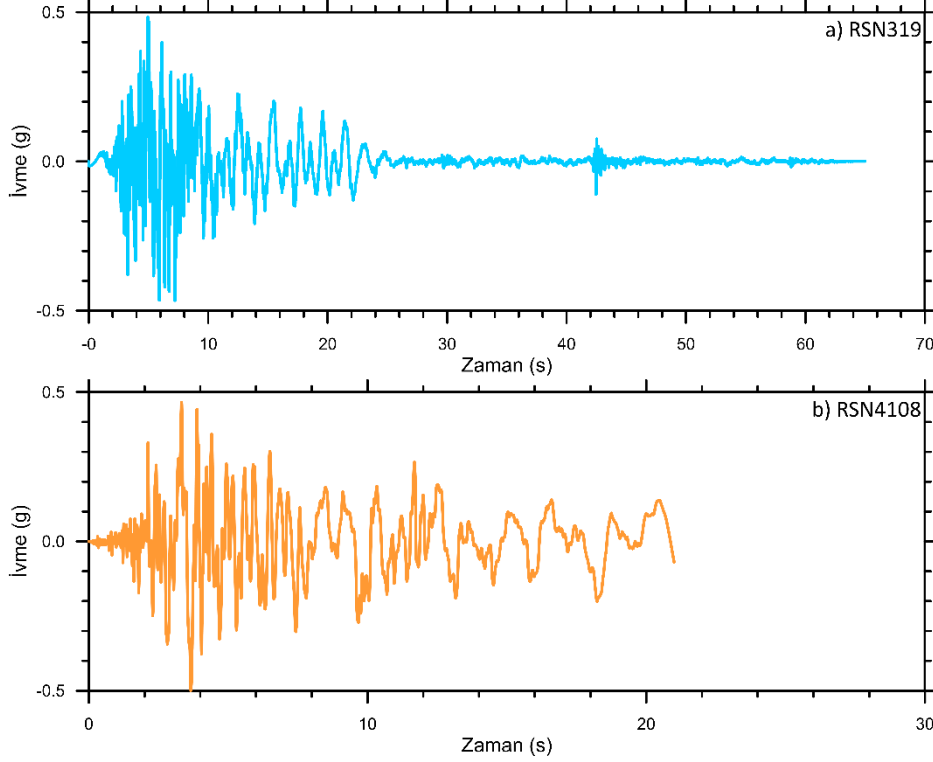


Şekil 1: Orijinal İvmeler



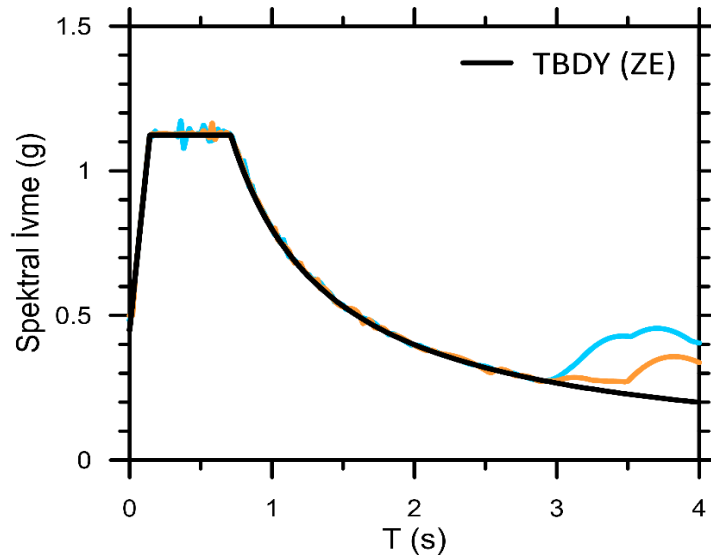
Şekil 2: PGA'ya göre Ölçeklendirilmiş İvmeler

Şekil 2’de görüldüğü üzere, kayıtların frekans içeriklerinde herhangi bir değişiklik olmadan pik ivme değerleri 0.38g den 0.45 g’ye ölçeklendirilmiştir. Büyüklük dışında herhangi bir değişiklik olmamıştır.



Şekil 3: Spektraya göre Ölçekli İvmeler

Şekil 3’te ise spektraya göre ölçeklendirilmiş ivmeler yer almakta olup, orijinal kayıtlara kıyasen frekans içeriğinde farklılıklar belirlenmiştir. Ölçeklendirme sonucu ortaya çıkan spektra uyumu ise Şekil 4’te yer almaktadır. Burada katı bir ölçeklendirme tercih edilmiş ve yüksek periyotlara kadar tam uyum sağlanmıştır.



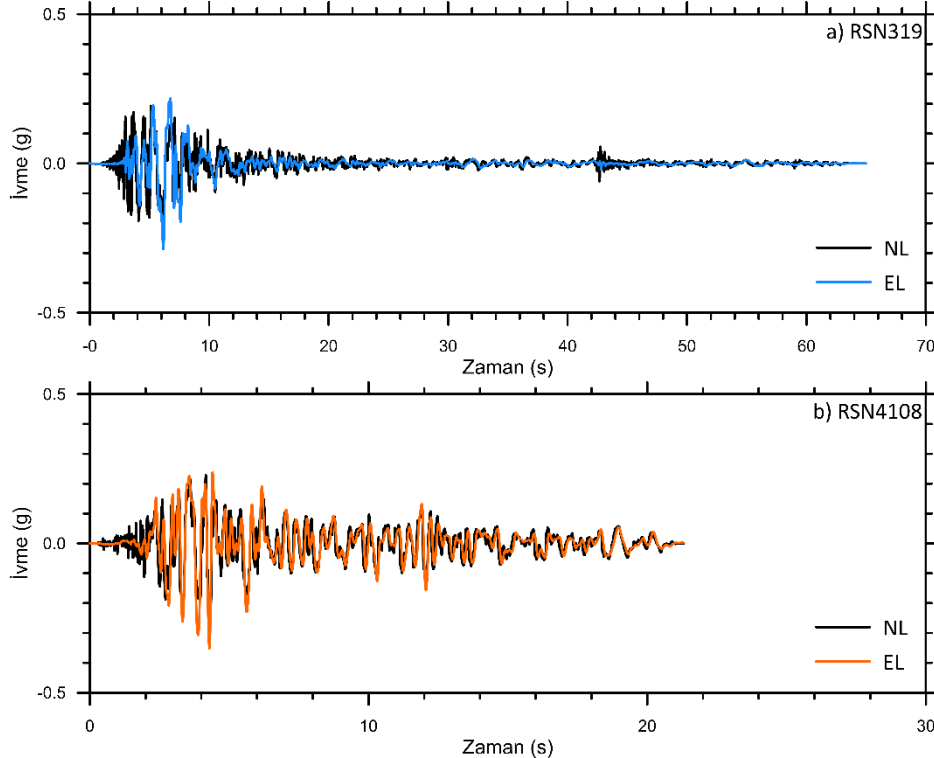
Şekil 4: Spektra Uyuşumu

Analizlerde Kullanılacak Zemin Profili ve Özellikleri

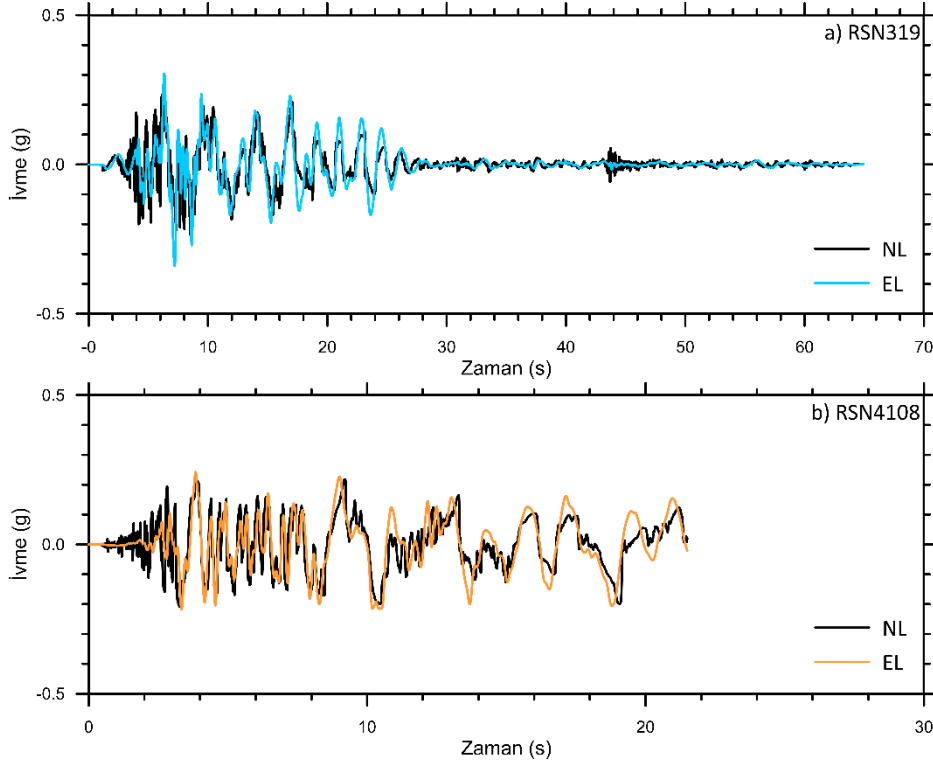
Analizlerde kullanılan zemin, 30 m boyunca yumuşak kil davranışı gösteren düşük plastisiteli bir profilden oluşmaktadır. Plastisite indisi 15-20 arasında, birim ağırlığı ise 17-17.5 kN/m³ olan zeminin 30 m boyunca ortalama kayma dalgası hızı 180 m/s olarak ölçülmüştür. Bu değer zemini yönetmeliğe göre ZE zemin sınıfı olarak tanımlar. Anakaya derinliği bilinmemekte olup, 30 m’de zemin özellikleri en alt zemin özellikleriyle aynı alınarak elastik kaya olarak tanımlanmıştır. Laboratuvarında yapılan deneyler sonucunda drenajsız kayma dayanımı profil boyunca 35-80 kPa arasında hesaplanmış olup zeminin dinamik davranışlarında Darendeli (2001) modeli kullanılmıştır. Yer altı su seviyesi yüzeye yakın olduğu tespit edilmiş, analizlerde su seviyesinin yüzeyde olduğu kabul edilmiştir.

Analiz Sonuçları

2 farklı ivme, 2 farklı ölçeklendirme yöntemi yardımıyla 4 elastik anakaya kaydına dönüştürülmüş ve eşdeğer lineer (EL) ve lineer olmayan (NL) yöntemlerle analizler tamamlanmıştır. Şekil 5’te 2 farklı ölçeklendirmeye göre elde edilen yüzey ivme kayıtları gösterilmektedir. Anakaya ivmesinin en büyük değerinin 0.451 g olduğu göz önünde bulundurulursa, bu zemin profilinin anakaya ivmesini azalttığı anlaşılmaktadır. Eşdeğer lineer analiz sonuçları göz önüne alındığında, RSN319 nolu kayıt için, yüzey pik ivmesi 0.29g seviyelerine kadar küçülmüşken, RSN4108 için bu değer 0.35g civarındadır. Lineer olmayan (siyah çizgiler) analizler göz önünde bulundurulduğunda ise de-amplifikasyonun daha fazla olduğu anlaşılmaktadır. İki analiz yöntemi kıyaslandığında yüzey pik değerlerinin ile olduğu zamanın ve anlamlı büyüklüğe sahip çevrim sayılarının farklı olduğu görülmektedir.



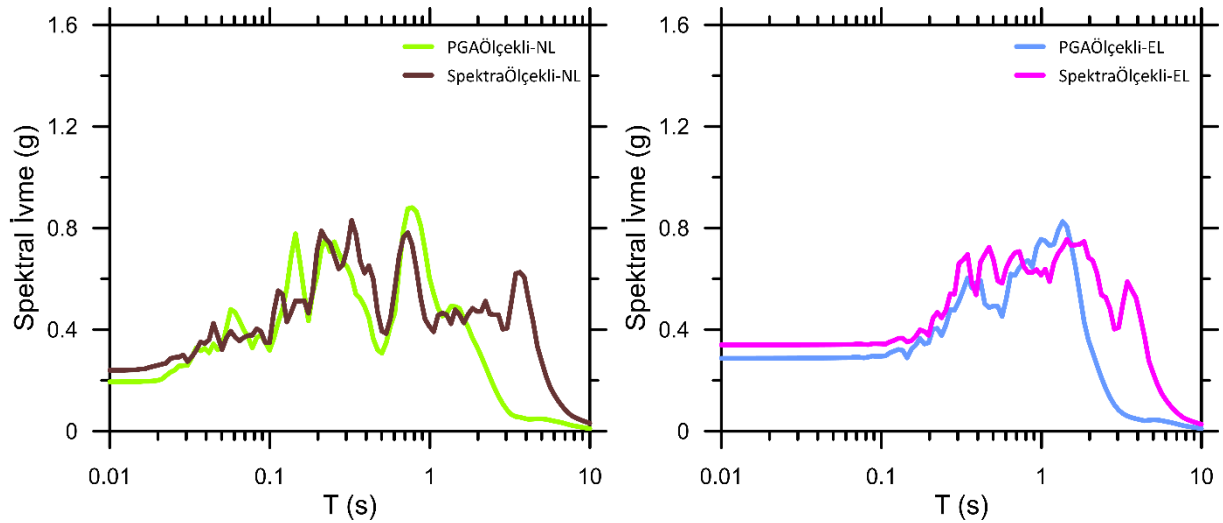
Şekil 5: PGA'ya göre Ölçekli Kayıtlar Kullanılarak Elde Edilen Yüzey İvme Kayıtları



Şekil 6: Spektra Sonuçları

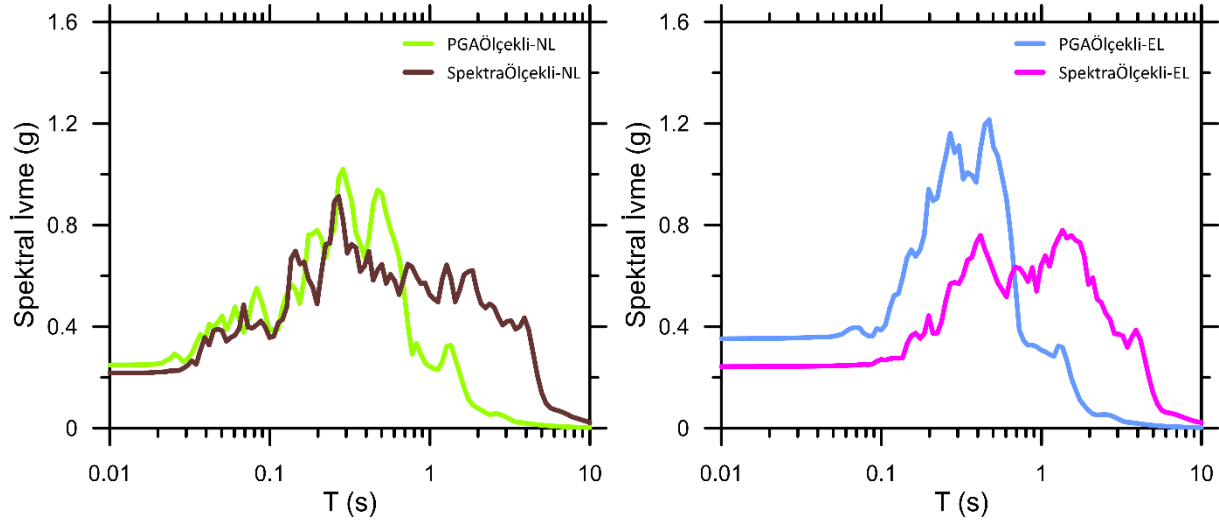
Şekil 6'da ise Şekil 5'in aksine RSN4108 kaydı zemin tarafından daha fazla sönmülmüşken, RSN319 kaydı daha az sönmülmüş ve daha büyük yüzey ivmesi vermiştir. İlk saniyeler dışında iki farklı yöntemle de olsa benzer yüzey ivmesi ve çevrim sayısı görülmektedir. Buradan da anlaşılacağı üzere, ölçeklendirmeye bağlı olarak yüzey davranışı değişmekte ve deprem kayıtlarının karakteristik özellikleri de yüzey ivmesine etkimektedir.

Elde edilen yüzey ivmelerinin yanında, davranışı tanımlayan diğer özelliklerle de spektral ivmedir. Şekil 7 ve Şekil 8 farklı kayıtlar için elde edilen yüzey spektralarını göstermektedir.



Şekil 7: Yüzey Spektra Kıyaslanması-RSN319

RSN319 kaydı kullanılarak elde edilen yüzey spektraları göz önünde bulundurulduğunda, ölçeklendirme yönteminden ve analiz çeşitinden bağımsız anakaya ivmesinin sönümlendiği görülmektedir. Kısa ve orta periyot davranışları birbirlerine paralel iken, uzun periyotlarda (2 sn) davranışlar farklılık göstermiş, spektra ölçekli olan anakaya kayıtları spektral davranışı uzun periyotlara uzatmıştır. Bunun dışında genel olarak lineer olmayan ve eşdeğer lineer yöntemler kendi aralarında T=2 sn öncesi bir uyum göstermektedir. Tüm analizler için maksimum spektral ivme 0.8g civarında olduğu anlaşılmaktadır.



Şekil 8: Yüzey Spektra Kıyaslanması-RSN4108

Şekil 8’de ise RSN41018 kaydı kullanılarak elde edilen yüzey spektrumları sunulmaktadır. Bir önceki grafiğin aksine kısa periyotlarda uyum varken, orta ve uzun periyotlarda spektral davranış değişmektedir. Burada zeminin lineer olmayan özelliklerinin yanında kullanılan deprem karakteristiğinin de önemli olduğu anlaşılmaktadır. Özellikle eşdeğer lineer analizler göz önünde bulundurulduğunda pik değerler ve olduğu periyotlar birbirlerinden çok farklı olup maksimum spektral ivmenin yayıldığı periyot aralıkları da birbirlerinden farklılıklar göstermektedir. Bir önceki kayda kıyasen, en büyük spektral ivmeler 0.8g ile 1.2g arasında değişmekte olup kısa periyot davranışı eşdeğer lineer yöntemde yaklaşık olarak %50 farklılık göstermektedir.

SONUÇLAR

Birbirine çok yakın PGA değerleri olan iki kayıt ile ZE sınıfı 30 m olan yumuşak bir kil zeminde Darendeli modeli ile yapılan eşdeğer lineer (EL) ve lineer olmayan (NL) analizler yardımıyla PGA eşleştirmesi ve spektral eşleştirme arasındaki benzerlikler ve farklılıklar tespit edilmeye çalışılmıştır. Her ne kadar yakın pik ivmeye sahip kayıtlar seçilse de diğer karakteristik özelliklerinde farklılıklar olabilmektedir. Yüzey ivmeler ve spektral ivmeler incelenmiş ve karakteristik özelliklerin etkisi de çalışmaya dahil edilmiştir.

PGA’ya göre ölçeklendirilmiş ivmeler analiz edildiğinde her iki kayıt için de pik ivme değerlerinde artış olduğunu gözükmemektedir ancak frekansları hakkında değişiklik

olmadığından yorum yapılamamaktadır. Spektraya göre ölçeklendirilmiş ivmelerde ise frekans farklılıkları da gözlemlenmiştir.

Deepsoil programı ile yapılan iki kayıt için iki farklı ölçeklendirme yöntemi ve iki farklı analiz yöntemi karşılaştırıldığında daha verimli sonuçlar elde edilmiştir. İki kayıt için de eşdeğer lineer ve lineer olmayan analizler PGA'ya göre ölçeklendirme yöntemi karşılaştırıldığında yüzey pik ivmesinin iki analiz yöntemiyle de daha küçük çıktığı ancak lineer olmayan analizler sonucunda yüzey pik ivmesinde daha fazla bir küçülme olduğu gözlemlenmiştir. Ancak her ne kadar benzer sonuçlar elde edilse de RSN319 kaydının RSN4108 kaydına göre daha düşük bir yüzey pik ivmesi elde edildiği farkedilmiştir. Spektraya göre ölçeklendirilen analizlerde ise tam tersi olarak RSN4108 kaydının daha fazla sönümlendiği görülmüştür.

Spektral ivmeye göre ise eşdeğer lineer ve lineer olmayan analizler iki farklı ölçeklendirme yöntemine göre iki farklı kayıta incelendiğinde RSN319 kaydı için eşdeğer lineer ve lineer olmayan analizlerin iki ölçeklendirme için uyumlu olduğu ve uzun periyotlar hariç davranışların benzer olduğu gözlemlenmiştir. Ancak RSN4108 kaydı için orta ve uzun periyotlarda da farklılıklar gözlemlenmiştir. Ayrıca RSN4108 kaydında eşdeğer lineer analizin lineer olmayan analize kıyasla pik ivmeler açısından da farklı olduğu görülmektedir.

Sonuç olarak yakın iki pik ivme seçilse farklı karakteristik özellikleri, ölçeklendirme yöntemleri ve analiz seçimleri de yüzey davranışında etkili olmaktadır.

KAYNAKLAR

TBDY, Türkiye Bina Deprem Yönetmeliği, AFAD, Türkiye, 2018.

Yasin M. FAHJAN, 2008. Türkiye Deprem Yönetmeliği (DBYBHY, 2007) Tasarım İvme Spektrumuna Uygun Gerçek Deprem Kayıtlarının Seçilmesi ve Ölçeklenmesi, İMO Teknik Dergi, 2-22.

Pan Liu, Hongya Qu, Jianzhong Li, Gao Ma, 2024. An improved time domain spectral matching method using particle swarm optimization, Soil Dynamics and Earthquake Engineering, 182.

Ahmet Demir, Ali Haydar Kayhan, Mehmet Palanci, 2023. Response- and probability-based evaluation of spectrally matched ground motion selection strategies for bi-directional dynamic analysis of low- to mid-rise RC buildings, Structures, 58.

Ruifu Zhang, Luqi Zhang, Chao Pan, Qingjun Chen, Yanchao Wang, 2021. Generating high spectral consistent endurance time excitations by a modified time-domain spectral matching method, Soil Dynamics and Earthquake Engineering, 145.

Armen Adekristi, Matthew R. Eatherton, 2015. Time-Domain Spectral Matching of Earthquake Ground Motions using Broyden Updating, Journal of Earthquake Engineering, 20(5), :1-20.

- Guochen Zhao, Longjun Xu, Xingji Zhu, Shibin Lin, Lili Xie, 2022. Spectrum-matched ground motion selection method based on Siamese Convolutional Neural Networks, *Soil Dynamics and Earthquake Engineering*, 163.
- Vincenzo Manfredi, Angelo Masi, Ali Guney Ozcebe, Roberto Paolucci, 2022. Selection and spectral matching of recorded ground motions for seismic fragility analyses, *Bulletin of Earthquake Engineering*, 20(3).
- Alex Kurniawandy, Muhammad Aminsyah, Belva Ulfah Cahyadi, Zulfikar dj, 2023. Comparative study of the simulation ground motion by amplitude scale and spectral matching, *E3S Web of Conferences*, 464(9).

**THE EXAMINATION OF TRADITIONAL CONSTRUCTION TECHNIQUES IN
BARTIN IN THE CONTEXT OF FLOOD DISASTER**

Kübra KESKİN

Res. Ast., Gazi University, Faculty of Architecture, Department of Architecture

Asena SOYLUK

Prof. Dr., Gazi University, Faculty of Architecture, Department of Architecture

İdil AYÇAM

Prof. Dr., Gazi University, Faculty of Architecture, Department of Architecture

ABSTRACT

Bartın province, located in the Western Black Sea Region, is frequently exposed to flood disasters due to the Bartın Stream passing through the city center. Considering that traditional Bartın houses, which form the characteristic architecture of the city, are an important part of Bartın's cultural heritage, their protection against floods and flood disasters is of great importance. Bartın houses are generally built with a wooden carcass system, with courtyards, gardens, and mansion type buildings that can reach up to four floors. Stone is also used as a carrier on the ground floors of these buildings. These houses, where trees such as pine, oak, and hornbeam are used as the main building material, need special care and protection due to the risk of rapid deterioration of the wood due to natural and man-made reasons. This study aims to examine the effects of the flood disasters in Bartın on the traditional architectural structure of the city and to discuss the conservation methods that can be taken for the safe transfer of this cultural heritage to future generations. In the research, firstly, the physical characteristics and water resources of Bartın province were analyzed, then the regions under flood risk and the traditional building stock in these regions were identified. In this context, the material and construction characteristics of the traditional buildings in the city were analyzed in detail and their strengths and weaknesses against flood disasters were evaluated. Focusing on how the weaknesses can be improved, various suggestions have been presented to make historical buildings more resilient by integrating modern conservation methods and local materials. In conclusion, the protection of Bartın's traditional buildings from floods is crucial for the preservation of both their physical integrity and the cultural identity of the city. The strategies proposed here will support the preservation and strengthening of these structures and ensure their safe transfer to future generations.

Keywords: Bartın, Flood, Historical buildings, Traditional construction techniques.

INTRODUCTION

Bartın province is located in the Western Black Sea Region of Turkey and is a city that attracts attention with its historical texture and natural beauty. This city, which has been inhabited throughout history, is frequently exposed to flood disasters due to its geographical structure and especially the physical characteristics of the Bartın Stream that runs through the center of the city. The climatic structure of the region also increases these risks, and floods are inevitable when the water level of the stream rises during periods of heavy rainfall.

Bartın houses, which represent the characteristic traditional architecture of Bartın, are among the structures threatened by flood disasters and can be damaged more than today's buildings. Bartın houses are mansion-type buildings with courtyards and gardens, usually built with a wooden frame system. These houses, which are a part of the local architectural culture of Bartın, have one to four stories. It is seen that the basic building material is trees such as pine, oak, and hornbeam, which are easily accessible in the region. In addition to houses made entirely of wood, stone walls are also used on the ground floors of some houses. The use of natural building materials such as wood and stone increases the importance of these buildings in the architectural heritage, but also increases the possibility of damage to the building in the face of sudden and destructive disasters such as floods, as wood is sensitive to natural conditions. In addition to the flood disaster, the high humidity in the region is also an important threat to these houses made of wood.

This study aims to comprehensively examine the effects of flood disasters in Bartın on the traditional architectural structures of the city. For this purpose, firstly the topography, water resources, and climatic characteristics of Bartın are analyzed. Then, the regions under flood risk and the traditional building stock in these regions were identified. The strengths and weaknesses of traditional buildings against flood disasters were analyzed and strategies were developed on various conservation methods and integration of modern conservation methods with local materials, especially for the improvement of weaknesses. In this context, concrete recommendations for the protection of Bartın's cultural heritage are presented and it is aimed that these buildings will continue to exist in a safe and sustainable manner in the future.

As a result, the protection of Bartın's traditional architecture from flood disasters ensures the sustainability of the city's cultural identity as well as protecting its physical integrity. The strategies proposed in this study support both the physical preservation of traditional buildings and the continuity of Bartın's historical and cultural heritage.

MATERIALS AND METHOD

In this study, a comprehensive analysis process was followed in order to evaluate the condition of traditional buildings in Bartın province in the face of flood disasters. This process has been carried out in four main stages; site analysis, building stock analysis, assessment of strengths and weaknesses, and recommendations for preservation methods.

1. Site Analysis

Firstly, the geographical and physical characteristics of Bartın province are discussed in detail. Existing water resources, topography, local climatic conditions, and factors that increase flood risk around the water resources of the region were analyzed. In particular, areas with frequent floods were found and evaluated in terms of water flow, drainage systems, and meteorological conditions that lead to river flooding in these areas. This analysis is important in terms of revealing how susceptible Bartın is to flood risk.

2. Building Stock Analysis

The traditional building stock in Bartın has been analyzed in detail in terms of building materials and construction techniques. The main material used in the construction of Bartın houses is wood and the capacity of wood to withstand flood disasters has been revealed. Especially the sensitivity of these houses with wooden carcass systems to water and moisture has been taken into consideration and the risks that these structures will be exposed to in the long term have been determined. In addition, the construction techniques used in Bartın houses are detailed and the resistance of these techniques against floods is examined.

3. Assessment of Strengths and Weaknesses

In the third stage, the strengths and weaknesses of Bartın houses against flood disasters were identified. Strengths include the use of local materials and traditional techniques, while weaknesses include the sensitivity of wooden materials to water and moisture. The identification of strengths and weaknesses is an important guideline for the recommendations to be presented.

4. Recommendations for Preservation Methods

In the last stage, suggestions for improving the weaknesses of the traditional buildings in Bartın are presented. The methods presented for improving the weaknesses and making the structures durable are selected among modern conservation methods, and it is emphasized that they are respectful of the traditional texture. In addition, the integration of these methods with local materials ensures the preservation of local architecture. Suggestions include strategies such as improving existing drainage systems, increasing the strength of materials, and applying structural strengthening techniques.

The aim of this four-stage analysis process is to address the situation of traditional buildings in Bartın in the face of flood disasters with a multifaceted approach. In the field analysis, data on the physical conditions and disaster risks of the region were collected; in the building stock analysis, the materials and construction techniques of the buildings were discussed and determined to be vulnerable to flood disasters; in the strengths and weaknesses analysis, areas requiring intervention were identified; and in the last stage, suggestions for interventions that can be made to improve the weaknesses identified were presented. This whole process reveals

a comprehensive perspective on both the preservation of the original identity of local architecture and the application of modern techniques in traditional architecture.

RESULTS AND DISCUSSION

Bartın, located in the Western Black Sea Region (Fig 1), was settled by the Romans in 70 BC. The city, which has a flatter geography than the surrounding provinces of Zonguldak, Karabük, and Kastamonu, takes its name from the Bartın Stream passing through it. Established about 10 km inland from the sea, the city maintains its importance thanks to its historical, touristic, and natural beauties. With an area of 2080 km², the altitude of the city center is 25 meters and there is a 59 km coastline (Bartın Governorship, 2024).

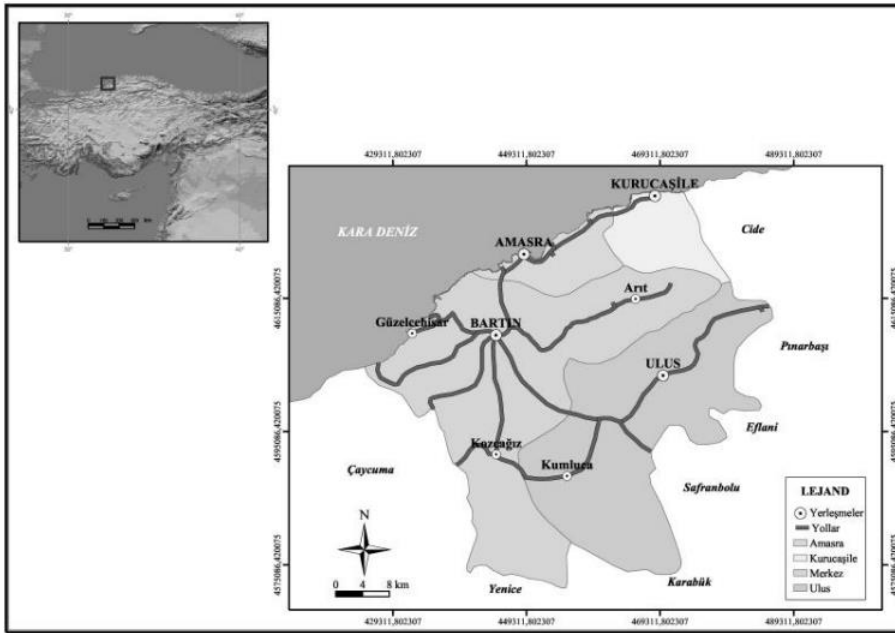


Figure 1. Bartın Province Map (Turoğlu & Özdemir, 2005)

Bartın has a temperate maritime climate (Black Sea Climate) with hot summers and cool winters. The annual average number of rainy days in the city is 125 and the amount of precipitation exceeds 1,200 mm per square meter. When the water resources of the city, which receives abundant rainfall in four seasons of the year, are examined, it is seen that the most important river is the Bartın Stream. Bartın Stream; It is a river consisting of two branches, although the amount of water it carries is large, its regime is regular and ships can navigate on it. Bartın Stream is the only navigable river in Turkey because its flow rate is low and it is quite deep (Günebakan, 2009).

Although Bartın Stream has a regular flow with its existing water potential, it carries a flood risk as a result of heavy and heavy rainfall in the city. Especially in recent years, the amount of precipitation during the year is irregular due to changing climatic conditions. As a result of the irregular precipitation regime and the increase in average temperatures, the risk of flooding increases in the Bartın Stream basin. Geomorphologic and hydrographic characteristics of the region also cause an increase in flood risk (Turoğlu, 2014).

The changes in the floodplains of Bartın Stream reveal how the land use and vegetative cover in the region have changed over time. The increase in agricultural areas and the destruction of forests are among the most important factors that increase the risk of flooding. Analyses with remote sensing data show that forest areas in the Bartın Stream basin decreased by 5.6% between 1992 and 2000, while agricultural areas increased by 6.31%. These changes have led to the deterioration of the natural balance in the region, resulting in increased flood risk (Tunay & Ateşoğlu, 2004).

The traditional houses of Bartın were built in large gardens surrounded by stone walls, in the courtyard plan type, with buried basement floors, using bagdadi or brick. The facades of the houses are plastered or wooden clad. In some of the buildings where stone material is mostly used as a carrier in the basement or foundation, brick bearing walls are also used. Open or closed overhangs used on the facades can be seen in different positions from building to building. As seen in Figure 2, many plan types were used in Bartın traditional houses. The concept of “sofa”, which is expressed as “Common Space”, is an indispensable part of the traditional Turkish House plan scheme and is frequently used in Bartın. The traditional houses shaped around the sofa gained importance with the registration of Bartın Stream and the green area around it as a natural protected area, and it was aimed to protect the historical texture by creating a conservation zoning plan in 1991 (Tosun, 2001).

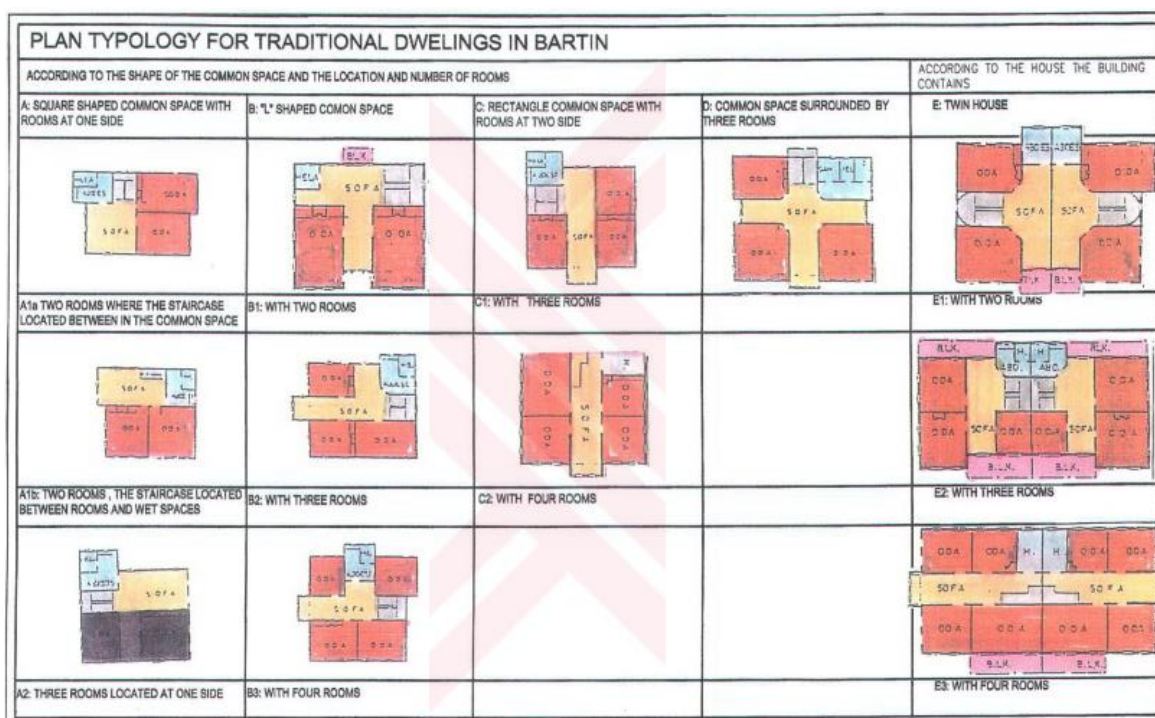


Figure 2. Traditional House Plan Typology in Bartın (Tosun, 2001)

The traditional houses of Bartın have hipped roofs sloping in four directions and have eaves ranging between 50-70 cm. The bottom of the eaves is covered with mansion pressure wooden cladding and the roof is covered with tiles. Since it is the main material of the region, it is seen that wood is mostly used in the buildings. Especially trees such as pine, oak, and

hornbeam were used in abundance. Guillotine windows were generally used in the houses carried by wooden uprights, and connections were made between the uprights at the top and bottom of the windows. The overhangs seen in some houses were generally closed and supported by buttresses from the lower level of the floor (Cingöz, 2018).

The traditional houses of Bartın are largely constructed with natural materials such as wood and stone and are particularly vulnerable to flooding due to wood materials. As can be seen in Figure 3, these structures built with wooden building elements start to rot and deteriorate over time, especially in environments with high humidity. In addition, floods caused by heavy rainfall in and around the Bartın Stream also pose a risk for such structures. However, the correct application of traditional techniques increased the strength of these structures, especially the stone foundations and basement floors, which were built entirely with stone, contributing to the strengthening of the areas first affected by the flood. However, wooden building elements on the upper floors are more vulnerable to moisture and flooding.



Figure 3. Examples of Traditional Houses in Bartın (Tosun, 2001)

In order to overcome these weaknesses that make structures vulnerable to flooding, this study suggests combining modern protection methods with traditional fabric. In particular, wood preservation methods such as impregnation for the protection of wooden building elements are thought to protect these structures against water and moisture. In order to improve waterproofing, innovations can be made in roofing materials and the upper floors of buildings can be protected more against precipitation by expanding the eaves dimensions. Additional drainage systems can also be added to the foundations and gardens of buildings to remove water away from the building. Such interventions will enable the use of modern techniques to make buildings more resistant to flooding and moisture while preserving the authenticity of Bartın's traditional architecture.

In addition to these retrofitting recommendations, sustainable materials and techniques can also be used to make Bartın's traditional houses more resilient to environmental conditions.

For example, repairs with natural materials can integrate the building with its environment and increase its strength. The use of composite materials with the same aesthetic qualities instead of wooden elements can provide greater strength while keeping the traditional appearance of the buildings. In addition, optimizing the green areas and water drainage systems around the buildings can provide protection against flooding by reducing the negative effects of flooding. Thus, supporting the traditional texture with modern conservation methods will ensure the healthy transfer of this valuable heritage to future generations.

CONCLUSION

In this study, the vulnerability of traditional buildings in Bartın to flood disasters was determined and various suggestions were developed for the protection of these buildings by strengthening them. Bartın is a region that stands out with its efforts to protect its rich cultural heritage from the past to the present with its historical, natural, and architectural texture. However, the geographical structure and climatic conditions of the region make the region vulnerable to flood events and cause historical buildings to be at risk. In this context, the preservation of traditional buildings is not only a physical necessity but also important for the continuity of the cultural heritage of the region. Because these buildings not only form the historical identity of Bartın but also reflect the lifestyle and social values of the local people.

The first phase of the study, field research, provided an understanding of Bartın's topographical, climatic, historical texture, and architectural features. Bartın houses, which constitute an important part of traditional Turkish architecture, were built with the skillful use of local materials such as wood and stone. However, the destruction caused by flood disasters is one of the most important factors threatening these structures. Within the scope of the study, the effects of floods on the structures, especially the damages to the foundation and wall structure, are presented in detail and how this situation affects the longevity of the structures is discussed.

The building stock analysis carried out in the second phase allowed for the identification of the current condition of traditional buildings in Bartın and their vulnerabilities to flooding. These analyses focused on factors such as the use of local materials, the structural durability of buildings, and current conservation practices. It was also found that many of the current conservation methods are inadequate and require the integration of modern technologies. In this context, it becomes clear that the conservation of traditional buildings should not only take into account historical values but also develop modern solutions that are suitable for today's conditions.

The third stage, the assessment of strengths and weaknesses, was carried out in the light of the structural characteristics and environmental conditions of Bartın houses. Among the weaknesses, the low water resistance of the existing building materials, inadequate drainage systems, and lack of planned maintenance practices stand out. At this point, it is of great importance to increase the measures that can be taken against flood disasters in buildings. In

addition to the measures taken in this region, which has been facing floods for many years, strengths such as the use of traditional materials and local construction workmanship offer various opportunities for conservation efforts. Bringing these strengths to the forefront is critical for both preserving the cultural identity of the buildings and adapting them to today's conditions.

Finally, attention has been paid to ensuring that the proposed conservation methods respect local materials and adapt contemporary techniques to historic buildings. Strategies such as impregnation of timber structural elements, waterproofing systems, and environmentally resilient building solutions are suggested. These approaches increase the physical durability of buildings and contribute to their protection against flooding. In addition, education and awareness programs in cooperation with local governments can encourage the public to support the preservation of these structures.

The results of this study emphasize the necessity of a holistic approach to the conservation of traditional buildings in Bartın. Projects to be realized in cooperation with local administrations, architects and engineers will not only ensure the physical preservation of the buildings but also the future of Bartın's cultural heritage. In this region where natural disasters such as floods are frequently experienced, the protection and strengthening of historical buildings is a social responsibility. While Bartın's historical buildings bear the traces of the past, they should also remain as a legacy for the future.

As a result, this study constitutes an important resource in determining the steps that can be taken for the protection and strengthening of traditional buildings in Bartın and reveal the strategies needed to make these buildings resistant to flood disasters. The architectural and cultural richness of Bartın sheds light not only on the past but also on the future. In this process, every step to be taken for the protection of traditional buildings is of great importance for the protection of Bartın's cultural heritage and its transfer to future generations.

REFERENCES

- Bartın Governorate. (2024). Bartın Historical and Geographical Structure. URL: <http://www.bartın.gov.tr/bartın-tarihi-ve-cografı-yapısı>
- Cingöz, P. G. (2018). Bartın Geleneksel Dokusunun ve Bartın Evlerinin Gölbucağı Mahallesi Örneğinde İncelenmesi. Master's Thesis. Mimar Sinan Fine Arts University Graduate School of Natural and Applied Sciences.
- Günebakan, H. T. (2009). Zonguldak ve Bartın bölgesi kıyı kullanımı ve Bartın ili sürdürülebilir kıyı alanları yönetimi. Master's Thesis. İstanbul University Institute of Marine Sciences and Management.
- Tosun, Ç. B. (2001). Reorganization of Traditional Dwellings in Bartın Asma Street According to the User Characteristics. Master's Thesis. The Middle East Technical University The Graduate School of Natural and Applied Sciences.

- Turođlu, H. & Özdemir, H. (2005). Bartın İlinin Ekoturizm Potansiyelinin Belirlenmesi. *Eastern Geographical Review*. 10(13), 97-116.
- Turođlu, H. (2014). İklim Deđişikliği ve Bartın Çayı Havza Yönetimi Muhtemel Sorunları. *Eastern Geographical Review*. 12(1), 1-22.
- Tunay, M., Ateşođlu, A. (2004). Bartın İli Taşkın Sahalarındaki Deđişimin Uzaktan Algılama Verileriyle İncelenmesi. *Turkish Journal of Forestry*. 5(2), 60-72.

**THE HISTORICAL TRANSFORMATION OF CHILDREN'S HOSPITALS: AN
EVALUATION FROM THE PERSPECTIVE OF FORM AND FUNCTION**

Kübra KESKİN

Res. Ast., Gazi University, Faculty of Architecture, Department of Architecture

Asena SOYLUK

Prof. Dr., Gazi University, Faculty of Architecture, Department of Architecture

İdil AYÇAM

Prof. Dr., Gazi University, Faculty of Architecture, Department of Architecture

ABSTRACT

Children's hospitals are defined as health structures where diagnosis, treatment, recovery, and follow-up processes are carried out for children between the ages of 0-18. The design of these hospitals is of special importance as the physical and psychological conditions of pediatric patients are significantly different from those of adult patients. Within the scope of this study, the form and function changes of children's hospitals in the historical process are examined in detail. Traditionally, the prioritization of function in hospital buildings has required the evaluation of the relationship between form and function through various criteria. This study aims to provide a framework for a better understanding of the relationship between form and function. Important criteria have been identified in the architectural design of children's hospitals. These criteria include construction systems, natural lighting, use of color, acoustics, ergonomic design, technology integration, flexibility of space, and social activities. These elements stand out as important factors that positively affect the healing processes of patients. Form-specific criteria include aesthetic and environmental elements such as scale and proportion, symmetry, rhythm, transparency, sustainability, and organic form. In addition, these features ensure that hospitals offer a balanced design visually and functionally. In this study, the historical development of children's hospitals was analyzed in terms of form and function criteria and turned into a detailed table. This table reveals how the hospitals have transformed from past to present. As a result, the recently built children's hospitals have most of the form and function criteria and only lack the symmetry criterion. It has been determined that the children's hospitals designed today have a patient-oriented design approach that supports the healing processes of children and offers them a safe and comfortable environment.

Keywords: Children's hospital, Form and Function, Hospital design, Children's experience.

INTRODUCTION

Children's physical and psychological differences from adults are also evident in their disease processes. Therefore, being treated in hospitals for adults may negatively affect the recovery process of pediatric patients. This necessitates that children's hospitals designed to serve children between the ages of 0-18 should be different from hospitals built for adults. Although the typological transformation of children's hospitals is not as well documented as hospital buildings, it is possible to say that the first children's hospitals were built due to epidemics among children such as smallpox, whooping cough, and measles, which could result in death. The high mortality rates among children revealed that children should be cared for with more attention than adults. Accordingly, the Hospital des Enfants Malades was first established in Paris in 1802. Afterward, children's hospitals, which started to spread throughout European countries, were initially built in a limited way due to economic problems, but over time, various designs began to be seen by achieving a child-oriented health service understanding (Fonsace Pinhao, 2016).

This study, which examines the transformation of children's hospitals over time, focuses on the relationship between form and function, which has been frequently discussed in architectural design since the past. In the discussions on the relationship between form and function, it is seen that architects accept one of three different situations and use them in their designs. The first is that form is more important and prioritized than function. In this point of view, function follows form. In this point of view, of which Le Corbusier was a part, it is emphasized that form is a product of thought, reflects emotions, and establishes the balance of the building, and therefore function should follow the form (Behne, 1996). In the second case, it is thought that form should follow function. Louis Sullivan was also a part of this idea, arguing that the important thing is the function and that both the structural system and the form should follow the function (Sullivan, 1947). The third position, also advocated by Frank Lloyd Wright, is that form and function do not follow each other and are inseparable. According to this idea, form and function should be in harmony and if these two form a unity, the building becomes meaningful (Azquotes, 2018).

MATERIALS AND METHOD

This study examines the transformation of the relationship between form and function in children's hospitals in the historical process. The main purpose of the research is to understand how architectural design is shaped in children's hospitals and to reveal the specific application of the concepts of form and function in children's hospitals. Accordingly, both literature review and analytical analysis methods were used in the study.

Firstly, the historical development of children's hospitals, the relationship between the concepts of form and function, and the views of prominent architects discussing this relationship are examined through the literature review method. The approaches of architects such as Le Corbusier, Louis Sullivan, and Frank Lloyd Wright, who are frequently referenced

in the literature, on form and function were analyzed in detail. In light of the information obtained, certain criteria were established to understand the relationship between form and function in children's hospitals.

In the analytical part of the study, in order to evaluate the change in the architectural design of children's hospitals over time, the period from the 1980s to the present day was analyzed in ten-year periods. In this analysis, the architectural features and design approaches of children's hospitals in each period were evaluated comparatively in terms of form and function. The ten-year periods were chosen to examine which design criteria the children's hospitals were built based on and which form-function balance was prioritized. The social, economic, and technological conditions of each period were taken into consideration and these buildings were categorized.

The evaluation criteria used in the study were developed to examine how form and function are balanced in the design of children's hospitals. These criteria include parameters such as scale and proportion, symmetry, rhythm, transparency, sustainability, use of natural light, acoustic arrangements, ergonomic design, flexibility, and social activity areas. Each criterion was evaluated according to the extent to which it was prominent in the architectural design of hospitals in the relevant periods.

At the end of the study, the data obtained according to the form and function criteria were presented in table format and how these criteria were applied for each period was visualized. In this way, it was clearly demonstrated which elements were prioritized in the architectural design of children's hospitals over time and the effects of these priorities on the balance of form and function. As a result, the methodological framework of the study is based on an approach that evaluates the architectural transformation of children's hospitals in the context of form and function within the historical process. Using both qualitative and quantitative methods, this review aims to provide a comprehensive and systematic analysis of the design processes of children's hospitals.

FINDINGS

The history of health centers built for child patients dates back to the Renaissance Period. Established in Florence to meet the basic needs of orphaned children and to ensure their care and treatment, these structures were polyclinics that were usually built in connection with churches at that time. By the 18th century, patient buildings gained the closest form to their current meaning. Due to the increase in diseases such as smallpox, measles, and whooping cough, which can result in death, especially in children, the Hospital des Enfants Malades (Fig 1), the first pediatric hospital in the world, was opened in Paris in 1802. Following the opening of the hospital, many pediatric hospitals were opened throughout Europe with the developing concept of pediatrics, economic conditions, and the search for new treatments (Baroni, 2012).



Figure 1. Hospital des Enfants Malades (URL-1).

Between 1802 and 1850, 25 children's hospitals were opened, and between 1850 and 1879, 67 children's hospitals were opened. In 1827, the first children's hospitals were opened in Ireland, in 1852 in England, and in 1855 in the United States of America. The architectural style adopted in these buildings, which are the first examples of children's hospitals, is mostly pavilion style built in blocks (Silav, 1998).

The first children's hospital in Turkey was opened in 1899. Hamidiye Etfal Hastane-i Âlisi (Fig 2), which was built with the pavilion system, was built in the last period of the Ottoman Empire. The hospital structure consisting of ten buildings was planned as a central building, bacteriology, and chemistry laboratory, examination room, polyclinics, infectious diseases pavilion, internal diseases pavilion, kitchen, laundry, incubator, and heating room. The buildings were organized around a large pavilion in order to refresh the air and prevent the transfer of microbes between the units (Altıntaş Selçuk and Çolak, 2012).

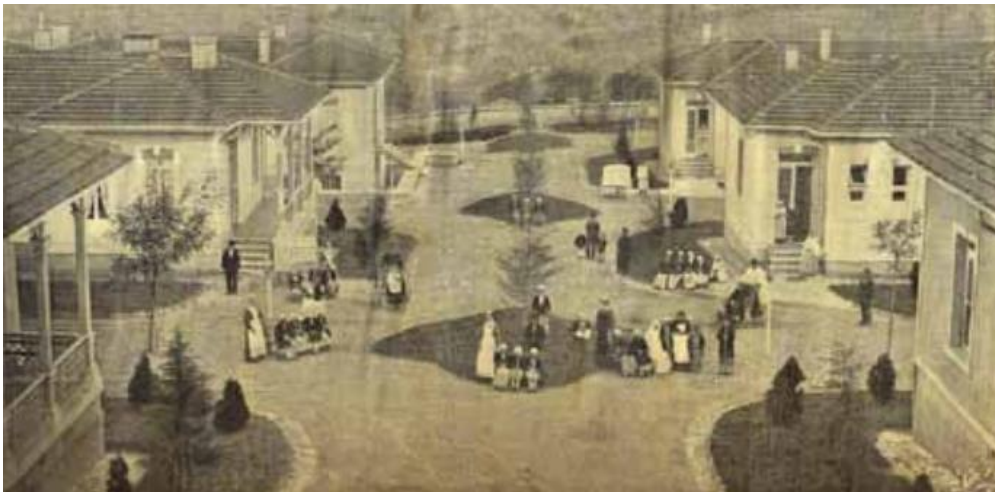


Figure 2. Hamidiye Children's Imperial Hospital (URL-2).

Within the scope of this study, pediatric hospitals are analyzed over four periods. The first period is 1980-1990, the second period is 1990-2000, the third period is 2000-2010 and the fourth period is 2010-2020.

1ST PERIOD 1980-1990 CHILDREN'S HOSPITALS

From the construction of the first children's hospitals until the 2000s, designs that prioritize function are seen. Since the priority was considered to be child health and psychology, the forms were not prioritized, considering that the buildings should be functionally functional spaces.

In the first period children's hospitals, designs that emphasize natural lighting are seen. In architectural plans aiming to connect children with the outside world, movie and television characters, and nursery-themed mascots were added to the interior arrangements, as well as plenty of green areas. Compared to previous periods, these features were not characterized as threatening objects for children, and it was foreseen that they could contribute to their psychological healing process. When children's hospitals built in North America during this period, such as Phoenix Children's Hospital (1983), are examined, it is seen that they are mostly fed by atriums. It is possible to come across buildings with symmetrical plan schemes, especially in this period when designs that center around the atrium plan scheme were used (Adams et.al 2010).

2ND 1990-2000 CHILDREN'S HOSPITALS

In the second period, function was also at the forefront, but child psychology was also addressed and form-specific developments were experienced. In this period, which can be considered as the beginning of aesthetic concerns in children's hospital design, colors that are important for children were used, and spaces with new functions were added to the hospital needs program. Examples of these spaces include activity rooms and sleeping rooms. In hospitals built in this period, atriums were used as in the first period (Barahona, 2001).

In the second period, hospital project competitions became famous in Turkey. Approximately twenty different hospital design competitions were organized between these years, leading to the emergence of different types of hospital buildings. Organized in 1992, the projects participating in the Ankara Children's Hospital architectural project competition were deemed highly qualified by the relevant jury and architectural circles, and it was revealed that not only construction but also ornate and formalist structures could be designed with design tools in Turkey (Sayar, 2004).

3RD PERIOD 2000-2010 CHILDREN'S HOSPITALS

Thanks to the 21st century's developing technological opportunities, many innovations have begun to be seen in the field of architecture. Changing daily life conditions have created changes in the understanding of architects working on design. In the case of children's hospitals, the relationship between form and function has been more scrutinized and attention

has started to be drawn to the form feature of the design. In this period, when the concept of child psychology was more clearly defined, criteria such as material, form, and color gained much more importance. It was revealed that these form criteria, which were seen to contribute positively to the treatment and healing processes, were the criteria that needed more attention in the design process. In this direction, the children's hospitals of the period came to the forefront with designs using different facade systems. The use of curtain glass facades and the use of colors on the facade started to be seen for the first time in this period.

The improvements made in the form of reducing the negative effects of being in hospitals support the concept of the hospital as a more interesting place for children by breaking the frighteningness of the hospital concept. On the other hand, flexible spaces were emphasized in the hospital. Considering that the needs of different age groups may be different, the planned spaces have been transformed into designs that can be changed according to the needs. Green areas, which had been used since the previous periods, became more widespread in this period, and various studies have shown that children relax in these areas and are more motivated in their recovery processes. Thanks to the positive feedback from children and pediatric therapists, it has been revealed that the concept of green space in hospitals is very important (Allahyar; Kazemi, 2021).

4TH PERIOD 2010-2020 CHILDREN'S HOSPITALS

In addition to the user-oriented design approach, environmental sustainability ideas emerged in children's hospitals of this period. In the design approach based on patient experience, natural and human elements that affect the psychology of children and families and the therapeutic effects of colors have been the main topics for a healthier process. Accordingly, in children's hospitals equipped with advanced technologies, social areas such as playrooms and art workshops have been increased, and specially designed spaces have been included for parents who need to stay with their child during the healing process.

In this period when sustainable architectural structures equipped with environmentally friendly technologies have come to the forefront, significant developments are also seen in children's hospitals. In this period of energy efficiency and initiatives to reduce carbon footprint, buildings were designed in accordance with various certificates. The use of natural lighting and ventilation is prioritized, and organic forms have also begun to be seen in the buildings.

FORM AND FUNCTION RELATIONSHIP

The relationship between form and function, which has been discussed in the history of architecture, especially since the emergence of modernity, plays an important role in the design process. Designers' approach to form and function manifests itself in three different situations. The first one is the idea that function follows form, which is also supported by Le Corbusier. According to this idea, form is a product of thought and reflects emotions. Therefore, the function should be designed to follow form. The second case is the idea, also

supported by Louis Sullivan, that form should follow function. According to this idea, both the structural system and the form should follow the function. The main thing is that the building works in a functional sense. The third situation is that both ideas, which Frank Lloyd Wright also supported, should meet on a common ground. According to Wright, form and function are inseparable and if they are used as a whole, the building becomes meaningful (Sullivan, 1947; Behne, 1996; Azquotes, 2018).

Hospital buildings have a complex system of horizontal and vertical relationships. Hospitals, which have more special requirements compared to other building plans, are expected to have different criteria in addition to the special design for children. One of the factors to be considered in the design of children's hospitals, where many issues from medical developments to human psychology must be mastered, is the adequate incorporation of form and function.

Form and function criteria in children's hospitals

The form and function criteria for the design and planning of children's hospitals were determined according to the physical and psychological characteristics of children and their effects on the healing process. Accordingly, form criteria are proportion, symmetry, rhythm, transparency, sustainability, and organic form. Function criteria include the features required for the building to be used healthily and safely. Accordingly, the functional criteria are structural system, natural lighting, use of color, acoustics, ergonomic design, technology integration, flexible spaces, and social activity areas. Figure 3 shows the criteria collectively.

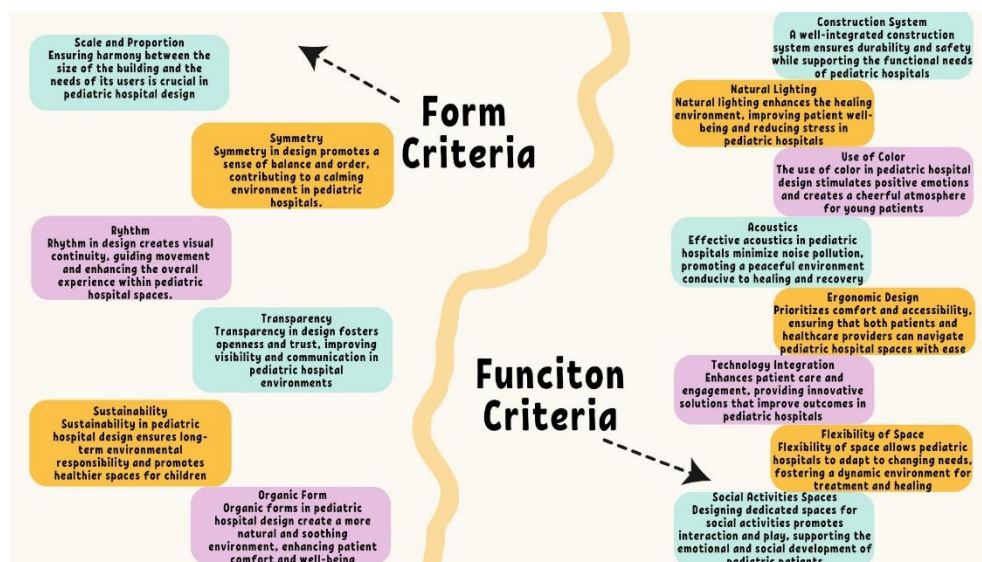


Figure 3. Form and Function Criteria (created by author).

RESULTS AND DISCUSSION

Within the scope of the study, the relationship between form and function in the designs of children's hospitals and their transformation in the historical process were examined. To make

this examination, the historical development of children's hospitals was first analyzed in four different periods. Then, the criteria for analyzing form and function were determined. Table 1 and Table 2 show in which periods the criteria were taken into consideration and in which periods they were ignored.

Table 1. Form Criteria in Children's Hospital Periods

Form Criteria	1980-1990 period	1990-2000 period	2000-2010 period	2010-2020 period
Scale and Proportion	x	✓	✓	✓
Symmetry	✓	x	x	x
Rhythm	✓	✓	✓	✓
Transparency	x	x	✓	✓
Sustainability	x	x	x	✓
Organic Form	x	x	x	✓

Table 2. Function Criteria in Children's Hospital Periods

Function Criteria	1980-1990 period	1990-2000 period	2000-2010 period	2010-2020 period
Construction System	✓	✓	✓	✓
Natural Lighting	✓	✓	✓	✓
Use of Color	x	x	✓	✓
Acoustics	✓	x	✓	✓
Ergonomic Design	x	✓	✓	✓
Technology Integration	x	✓	✓	✓
Flexibility of Space	x	x	✓	✓
Social Activities Spaces	x	✓	✓	✓

CONCLUSION

This study comprehensively reveals how children's hospitals have transformed in terms of form and function criteria between 1980 and 2020. The analysis of the last forty years over a period of ten years emphasizes the importance of a user-oriented approach in the design of children's hospitals. In particular, it is concluded that the physical and psychological conditions of the users, children, should be prioritized.

The findings of the research show that the use of natural lighting and furniture is prominent in every period in terms of the functional criteria of children's hospitals. However, the

prevalence of the use of natural lighting varies between the periods; in the last two periods, more suitable colors and comfort for children were prioritized in furniture choices. It has been determined that the children's hospitals built in the 2010-2020 period meet all functional criteria.

Analyses in terms of form criteria show that rhythm is a preferred design approach in every period. The children's hospitals built between 2010-2020 include criteria other than symmetry, and elements such as sustainability and organic form have become integral parts of the contemporary design approach. This situation reveals that form and function complement each other and need to be harmoniously integrated in design processes. In addition to meeting functional requirements, taking aesthetic elements into consideration increases both the functionality and user experience of children's hospitals.

In conclusion, this study emphasizes the importance of the relationship between form and function in the design of children's hospitals and provides important findings on how to balance these two components. These criteria, which should be taken into account in future design processes, will contribute to the user-oriented and effective development of health structures and will have a positive impact on the well-being of children.

REFERENCES

- Adams, A., Theodore, D., Goldenberg, E., McLaren, C., McKeever, P. (2010). Kids in the atrium: Comparing architectural intentions and children's experiences in a pediatric hospital lobby. *Social Science & Medicine*. 70(5), 658-667.
- Allahyar, M., Kazemi, F. (2021). Landscape preferences of a children's hospital by children and therapists. *Urban Forestry & Urban Greening*. 58, 126984.
- Altıntaş Selçuk, B., Çolak, C. (2012). Hamidiye Etfal Hastane-i Âlisi; The First Children's Hospital of Turkey. *Mersin University School of Medicine Lokman Hekim Journal of History of Medicine and Folk Medicine*. 2(1), 11-14.
- Azquotes. (2018). azquotes.com. Retrieved October 2, 2018, from <https://www.azquotes.com>.
- Barahona, L. F. (2001). New trends in health architecture for children and the effects of the built environment on young patients. Master's Thesis. Florida International University.
- Baroni, M. (2012). L'hôpital des Enfants malades de Paris, 1802-1914: du soin maternel à la pédiatrie. These de doctorat. Ecole doctorale Cultures et Sociétés.
- Behne, A. (1996). *The Modern Functional Building*. Santa Monica: The Getty Research Institute for the History of Art and the Humanities.
- Fonseca Pinhao, C. (2016). Children's Hospitals- The role of architecture in children's recovery and development. Master Thesis, Universidade Tecnica de Lisboa.
- Sayar, Y. (2004). Architectural Project Competitions in Türkiye 1930-2000: An Evaluation. *Architecture*.320.
- Silav, M. (1998). The Formation of interior space according to all necessities in the patient children's bedrooms in the children's hospital. Master's Thesis. Hacettepe University.

Sullivan, L. (1947). Kindergarten Chats and Other Writing. London: Routledge.

URL-1: La Socialisation des Enfants Malades, <https://la-socialisation-des-enfants-malades-97.websself.net/aspect-historique>

URL-2: Hamidiye Children's Imperial Hospital
<https://dergipark.org.tr/tr/pub/mutfd/issue/43159/523449>

**GERİ DÖNÜŞTÜRÜLMÜŞ YYPE PARÇALARIN ENJEKSİYON KALIPLAMA
PROSES ŞARTLARI İLE MEKANİK ÖZELLİKLERİNİN İYİLEŞTİRİLMESİ**
IMPROVING MECHANICAL PROPERTIES OF RECYCLED HDPE PARTS VIA
INJECTION MOLDING PROCESS PARAMETERS

Muhammet DAĞLI

Sakarya University of Applied Sciences, Graduate Education Institute, Mechanical Engineering, Turkey
ORCID ID: 0000-0002-1336-903X

Ahmet DEMİRER

Sakarya University of Applied Sciences, Faculty of Technology, Mechanical Engineering, Turkey
ORCID ID: 0000-0003-1252-9203

Rana UÇAR

Sakarya University, Institute of Science, Metallurgy and Materials Engineering, Turkey
ORCID ID: 0009-0001-2417-8108

ÖZET

Yüksek yoğunluklu Polietilen (YYPE)'in geri dönüşümü hem çevresel etkileri azaltmak hem de malzemenin yeniden kullanımıyla kaynak tasarrufu sağlamak açısından büyük bir öneme sahiptir. Yer altı ve yer üstü akışkan taşıma uygulamalarında YYPE borular çok yaygın bir kullanıma sahiptir. Bu boru hatlarında da çeşitli ekleme parçaları kullanılmaktadır. Bu ekleme parçaları enjeksiyon kalıplama yöntemiyle elde edilmektedir. Bu çalışmada, YYPE ekleme parçalarında geri dönüştürülmüş malzeme kullanımının mekanik özelliklere etkisi incelenmiştir. Ayrıca farklı geri dönüşüm oranlarında, farklı enjeksiyon proses parametreleri denenmiş ve mekanik özelliklerindeki değişimine bakılmıştır. Ekleme parçaları, plastik enjeksiyon kalıplama yöntemiyle manşon taslağı olarak boru formunda üretilmiştir. Test numuneleri ise bu boru parçalarından kesilerek elde edilmiştir. Plastik enjeksiyon yöntemiyle üretilen numunelerde, enjeksiyon basıncı ve ütüleme basıncı gibi değişken parametrelerin, çekme dayanımı ve sertlik gibi mekanik özellikler üzerindeki etkileri incelenmiştir. Çalışmada %20, %40, %60, %80 ve %100 oranlarında geri dönüştürülmüş YYPE kullanılarak numuneler hazırlanmıştır. Her bir oran için çekme dayanımı ve sertlik değerleri elde edilmiştir. Deneysel çalışmalarda enjeksiyon basıncı 70 ve 80 bar, ütüleme basıncı 65 ve 80 bar değerlerinde alınarak çevrim süreleri optimize edilmiştir (55 saniye). Sonuç olarak, proses parametrelerinin optimize edilmesiyle geri dönüştürülen YYPE parçaların mekanik özelliklerinde önemli iyileştirmeler sağlanmıştır. Özellikle enjeksiyon ve ütüleme basıncındaki artışlar sertliği %0,9 arttırırken, çekme dayanımlarında %11,99'a varan dayanım artışlarına ulaşılmıştır.

Anahtar Kelimeler: Geri dönüştürülmüş Yüksek Yoğunluklu Polietilen (YYPE), Proses Parametreleri, Enjeksiyon kalıplama, Çekme Dayanımı, Sertlik.

ABSTRACT

The recycling of High Density Polyethylene (HDPE) is of great importance both in reducing environmental impacts and conserving resources through material reuse. High-density polyethylene (HDPE) pipes are widely used in both underground and above-ground fluid transport applications. Various joint fittings are also employed in these pipe systems. These fittings are produced using the injection molding method. In this study, the effect of using recycled materials on the mechanical properties of HDPE joint fittings was investigated. Additionally, different injection process parameters were tested at varying recycling rates, and the changes in mechanical properties were examined. The joint fittings were produced in the form of pipe segments designed as coupling blanks using the plastic injection molding method. Test specimens were obtained by cutting sections from these pipe parts. The effects of variable parameters, such as injection pressure and packing pressure, on mechanical properties such as tensile strength and hardness were analyzed in the samples produced by the plastic injection method. Samples were prepared using 20%, 40%, 60%, 80%, and 100% recycled HDPE. Tensile strength and hardness values were obtained for each ratio. In the experimental studies, injection pressure was set between 70-80 bar, packing pressure between 65-80 bar, and cycle times were optimized at 55 seconds. As a result, significant improvements in the mechanical properties of recycled HDPE parts were achieved by optimizing process parameters. Notably, increases in injection and packing pressures resulted in a 0.9% increase in hardness, while tensile strength improvements reached up to 11.99%.

Keywords: Recycled High Density Polyethylene (HDPE), Process Parameters, Plastic Injection Molding, Tensile Strength, Hardness.

1. GİRİŞ

Geri dönüştürülmüş polimer malzemelerden özellikle polietilenin (PE), çevresel sürdürülebilirlik ve doğal kaynakları koruma konusundaki önemi artmaktadır. Plastik tüketimi son yıllarda hızla artmış ve 2019'da 460 milyon tonun üzerine çıkmıştır; plastik atık miktarı ise 353 milyon tona ulaşarak çevre üzerindeki baskıyı artırmıştır. Plastik atıklar, küresel sera gazı emisyonlarının %3,4'ünü oluşturmaktadır, bu nedenle plastik atıkların geri dönüşümü ve tekrar kullanılması çevre kirliliğini azaltmak bakımından kritiktir (Kharmoudi ve ark., 2024). Yüksek yoğunluklu polietilen (HDPE), geri dönüşüm sürecinde yaygın olarak kullanılan bir malzemedir. HDPE'nin ekstrüzyon sırasında yapısal değişikliklere uğradığı belirtilmektedir ve bu değişiklikler özellikle ilk 30 çevrimde belirgin hale gelmektedir (Schyns & Shaver, 2020). Polimerlerin geri dönüşümü, modern toplumun karşılaştığı en büyük çevresel ve sosyal zorluklardan biridir. Küresel polimer üretimi 1960'lardan bu yana yirmi kat artarak 2014'te 311 milyon tona ulaşmıştır ve 2050'ye kadar yıllık 1,2 milyar tona ulaşması beklenmektedir (Frank ve ark., 2018). Bu durum, PE ve benzeri polimerlerin sürdürülebilir kullanımlarını zorunlu kılmaktadır. Geri dönüştürülmüş HDPE'nin (rHDPE) mühendislik uygulamalarındaki

potansiyeli, özellikle geri dönüşüm sürecinde karşılaşılan zorluklar konusunda araştırma gerektirmektedir. Bazı çalışmalar, rHDPE'nin belirli durumlarda saf HDPE'ye (vHDPE) kıyasla benzer veya daha yüksek gerilme özellikleri sergileyebileceğini göstermiştir (Malyuta, 2023). Ancak, basınçlı boru sistemlerinde rHDPE'nin kullanımı sınırlıdır ve bu alanda daha fazla araştırmaya ihtiyaç vardır (Lang ve ark., 2016). Alzerreca ve arkadaşları, rHDPE'nin uzun vadeli mekanik performansının saf HDPE'ye kıyasla daha düşük olduğunu belirtmiştir; bu durum, malzemenin yavaş çatlak büyümesine ve yorgunluğa karşı direncinin azalması ile ilişkilendirilmiştir (Alzerreca ve ark., 2015). Son yıllarda plastik endüstrisi, döngüsel ekonomi çerçevesinde geri dönüştürülmüş malzemelerin kullanımını teşvik etmekte ve rHDPE'nin mühendislik uygulamalarındaki potansiyelini incelemektedir (Freudenthaler ve ark., 2022). Bu çalışma, rHDPE'nin mekanik özelliklerini ve çevresel sürdürülebilirliğe katkılarını değerlendirerek, mühendislik uygulamalarındaki rolünü genişletmeyi amaçlamaktadır.

2. MALZEME VE YÖNTEM

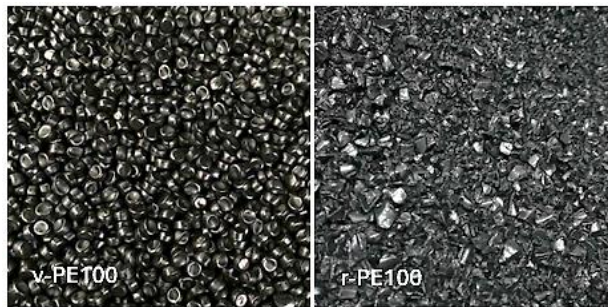
2.1. Malzeme

Bu çalışmada kullanılan malzemeler saf yüksek yoğunluklu polietilen (v-PE100) ve geri dönüştürülmüş (r-PE100) PE100 karışımlarından oluşmaktadır. Deneysel çalışmalar için altı farklı malzeme kompozisyonu hazırlanmıştır. %100 PE100, %80 PE100+ %20 geri dönüştürülmüş PE100, %60 PE100+ %40 geri dönüştürülmüş PE100, %40 PE100+ %60 geri dönüştürülmüş PE100, %20 PE100 + %80 geri dönüştürülmüş PE100 ve son olarak %100 geri dönüştürülmüş PE100 olmak üzere altı farklı oran belirlenmiştir. Bu kompozisyonların detayları Tablo 1'de sunulmuştur.

Tablo 1: Kullanılan Malzeme Kompozisyonları

NUMUNE	v-PE100 (%)	r-PE100*
1	100	0
2	80	20
3	60	40
4	40	60
5	20	80
6	0	100

*Enjeksiyon yöntemiyle üretilmiş aynı tip ürünler geri dönüşüm sürecinde kırılarak ekstrüzyonda tekrar elde edilmiştir.



Şekil 1: v-PE100 ve r-PE100 Granül Yapıları

2.2. Yöntem

Bu çalışmada kullanılan malzemeler, yüksek yoğunluklu polietilen (PE100) ve geri dönüştürülmüş PE100 karışımlarından oluşmaktadır. Çalışmada, %100 PE100 ve farklı oranlarda geri dönüştürülmüş PE100 içeren numuneler hazırlanmıştır. Tablo 1'de kullanılan malzeme kompozisyonları sunulmaktadır. Her bir malzeme kompozisyonu için 10 adet numune plastik enjeksiyon makinasında 40 mm çapında 84 mm boyutunda boru formunda üretilmiştir. Tablo 1'de verilen oranlarda PE100 karışımlar Şekil 2'de gösterilen mekanik karıştırıcı (Xiecheng Marka, XC-HL200KG model) ile homojenize edilmiştir.



Şekil 2: Mekanik Karıştırıcı Görseli

Karışımlar enjeksiyon makinasında (Şekil 3), Tablo 2'de verilen proses şartlarında boru formunda (Ø40x75x4 mm) üretilmiştir (Şekil 4 ve Şekil 5).



Şekil 3: Enjeksiyon Makinesi Görseli (Krauss Maffei 60 Ton)

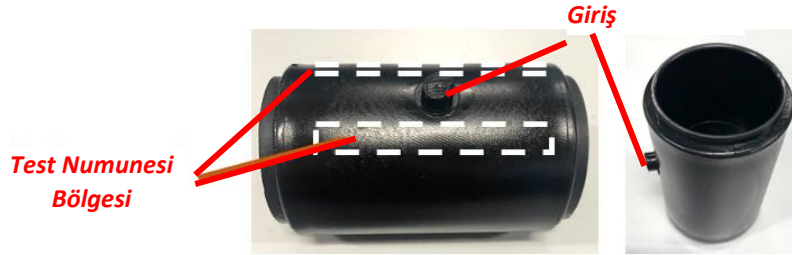
Tablo 2: Proses Parametreleri ve Değerleri

PARAMETRE	BİRİM	DEĞERLER
Enjeksiyon Basıncı	bar	70
Ütüleme Basıncı	bar	65
Enjeksiyon Sıcaklığı	°C	225
Enjeksiyon Hızı	mm/sn	30
Ütüleme Süresi	sn	10
Kalıp Sıcaklığı	°C	45
Çevrim Süresi	sn	55

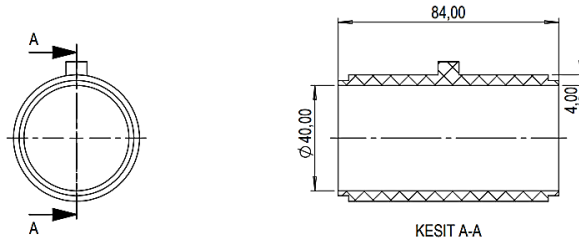
Plastik enjeksiyon yöntemiyle üretilen borulardan test numuneleri alınarak sertlik ve çekme testleri yapılmıştır. İlk denemelerde çekme dayanımında %17,10 ile %29,51 ve Shore D sertlikte %1,53 ile %11,07 oranında düşüş gözlemlenmiştir. Çalışmanın ikinci aşamasında, %20 ve %40 geri dönüştürülmüş PE100 numunelerin proses parametreleri optimize edilmiştir. Bu aşamada enjeksiyon basınçları %7 ve %14 ; ütüleme basınçları ise %15 ve %33 oranlarında artırılmıştır. Diğer parametreler sabit tutulmuştur.

Tablo 3: Optimizasyon Sürecinde Kullanılan İşleme Parametreleri

NUMUNE	v-PE100 (%)	r-PE100 (%)	Enjeksiyon Basıncı (bar)	Ütüleme Basıncı (bar)
2-1	80	20	75	75
2-2	80	20	75	80
2-3	80	20	80	75
2-4	80	20	80	80
3-1	60	40	75	75
3-2	60	40	75	80
3-3	60	40	80	75
3-4	60	40	80	80



Şekil 4: Ürünün Fiziksel Görünüşü ve Test Numunesi Alınan Bölgeler

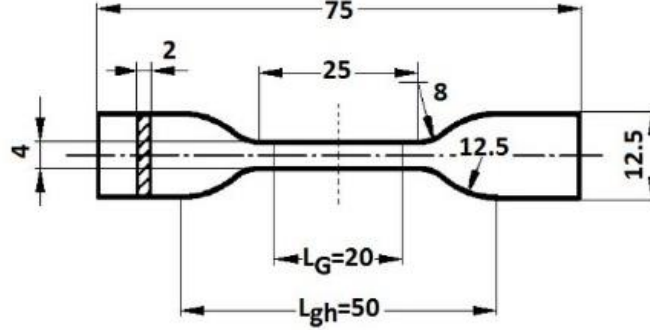


Şekil 5: Ürünün Teknik Resmi

2.2.1. Çekme Testi

Bu çalışmada, üretilen her bir numune grubu için çekme testi, ISO 527-2/5A standardına uygun olarak gerçekleştirilmiştir. Her bir malzeme kompozisyonundan 10 adet boru formundaki numune plastik enjeksiyon makinası kullanılarak üretilmiştir. Bu numuneler, çekme testine tabi tutulmadan önce oda sıcaklığında (23°C) 24 saat boyunca bekletilmiştir. Bu stabilizasyon süreci, malzemelerin homojen bir termal ve mekanik dengeye ulaşmasını sağlamak için kritik bir adımdır. Numuneler Şekil 4'de gösterilen girişin sağ ve solundan standartlara (ISO 527-2/5A) uygun olarak kesilerek hazırlanmıştır (Şekil 6). Çekme testi,

Tinius Olsen test cihazı (Şekil 7) kullanılarak gerçekleştirilmiştir. Test boyunca uygulanan kuvvet ve numunenin uzama miktarı sürekli olarak kaydedilmiştir.



Şekil 6: Çekme Testi numunesi ISO 527-2/5A



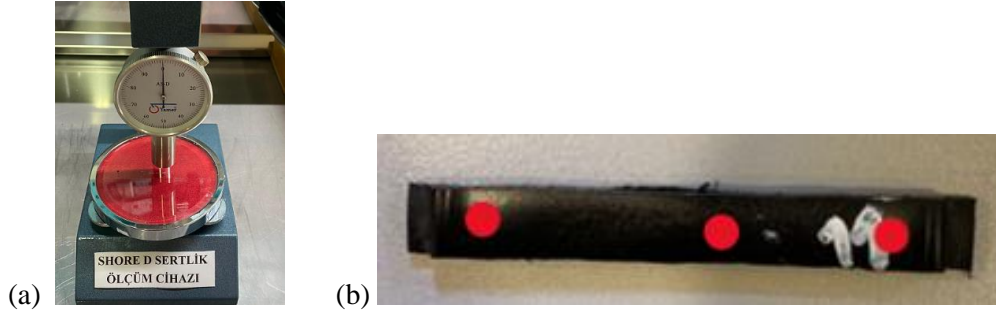
Şekil 7: Tinius Olsen Çekme Test Cihazı ve Numune

Testler, 5 mm/dk sabit hızda gerçekleştirilmiştir. Her bir numune için maksimum çekme kuvveti kaydedilmiştir. Her bir deney altı kez tekrarlanmış ve sonuçlar ortalama değerler olarak raporlanmıştır. Elde edilen veriler, her bir numune grubu için ayrı ayrı değerlendirilmiş ve gruplar arasında karşılaştırmalar yapılmıştır. Saf katkısız PE100 malzemeden enjeksiyonla elde edilmiş numuneler öğütücüden geçirilerek kırılmış ve geri dönüşüm ürünü haline getirilmiştir. Sonrasında saf birincil PE100 ham madde malzemeye %20, %40, %60, %80 ve %100 oranında beş farklı karışım elde edilmiştir. Bu karışımlar enjeksiyonla boru formunda numunelere dönüştürülmüştür. Bu kalıplanan numuneler çalışmada saf birincil PE100 malzemeden elde edilen numuneler ile karşılaştırılmıştır. Çekme dayanımında gözlemlenen değişiklikler Şekil 9’da grafik halinde verilmiştir.

2.2.2. Sertlik Testi

Bu çalışmada, numunelerin sertliği Shore D ile belirlenmiştir (Şekil 8a). Boru formundaki numuneler, Şekil 4’te gösterilen şekilde girişin sağ ve solundan dekapaj yardımıyla kesilerek çekme numunesi olarak çıkarılmıştır. Numuneler çekme testine tabi tutulmadan önce oda

sıcaklığında (23°C) 24 saat boyunca stabilize edilmiştir. Kesilen her bir numune Şekil 8b’de gösterilen kırmızı 3 bölgeden sertlikleri ölçülerek ortalamaları alınmıştır.



Şekil 8: a) ShoreD Sertlik Cihazı (Yamer Marka) b) Ölçüm Alınan Bölgelerin Gösterimi

Sertlik ölçümlerinden elde edilen sonuçlar, numunelerin geri dönüştürülmüş PE100 oranına bağlı olarak karşılaştırılmıştır. Enjeksiyon ve ütüleme basıncı gibi işleme parametrelerinin sertlik üzerindeki etkileri incelenmiştir.

3. BULGULAR VE TARTIŞMA

Çalışmada, farklı geri dönüştürülmüş PE100 oranları ve farklı işleme parametreleri kullanılarak üretilen numunelerin mekanik özellikleri detaylı bir şekilde incelenmiştir. Elde edilen veriler, geri dönüştürülmüş malzeme oranının ve işleme parametrelerinin çekme dayanımı ve sertlik üzerindeki etkilerini ortaya koymaktadır. Aşağıda, her bir mekanik özellik için elde edilen bulgular sunulmakta ve tartışılmaktadır.

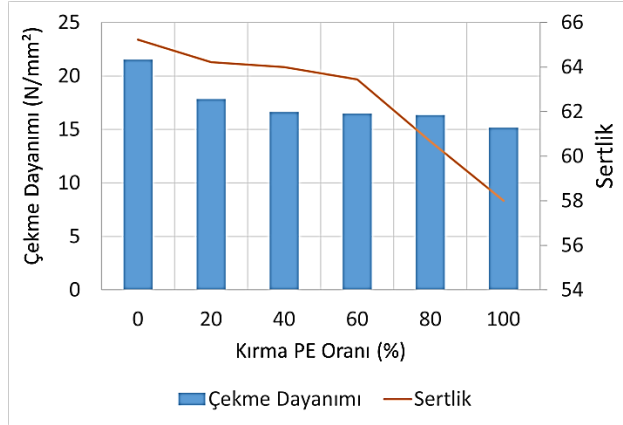
3.1. Çekme Dayanımı ve Sertlik Sonuçları

Bu bölümde, farklı geri dönüştürülmüş PE100 karışımları ve işleme parametreleri altında üretilen numunelerin çekme dayanımı ve sertlik değerleri sunulmuştur. Çalışmanın ilk aşamasında, standart işleme koşulları (Tablo 2) altında üretilen saf birincil %100 PE100 numunelerde en yüksek çekme dayanımı değerleri elde edilmiştir. Ancak, geri dönüştürülmüş PE100 oranı arttıkça, çekme dayanımı değerlerinde ve sertlikte belirgin bir azalma gözlemlenmiştir (Tablo 4).

Tablo 4: İlk Aşama Çekme Dayanımı ve Sertlik Sonuçları

NUMUNE	v-PE100 (%)	r-PE100* (%)	Çekme Dayanımı (N/mm ²)	Çekme dayanımında % azalma	Sertlik Shore D	Sertlikte % azalma
1	100	0	21,52	-	65,22	-
2	80	20	17,84	17,10	64,22	1,53
3	60	40	16,63	22,72	63,00	4,07
4	40	60	16,50	23,33	62,44	4,26
5	20	80	16,34	24,07	60,67	6,98
6	0	100	15,17	29,51	58,00	11,07

Çekme dayanımında geri dönüşüm oranı arttıkça dayanım değerlerinde %29,51’e kadar azalma gözlemlenmiştir. Sertlik değerleri incelendiğinde geri dönüşüm oranı arttıkça sertlik değerlerinde de %11,07’ye kadar bir düşme tespit edilmiştir.



Şekil 9: Farklı PE100 Oranlarına (%) Göre Çekme Dayanımı/Sertlik Grafiği

Çalışmanın ikinci aşamasında geri dönüşüm malzemelerindeki çekme dayanımı ve sertlikte görülen azalmanın önüne geçmek için proses şartlarında değişime gidilmiştir. Tablo 3'deki proses şartlarında üretilen numunelerin enjeksiyon ve ütleme basıncı, malzeme mekanik değerlerine olumlu yönde artış gösterdiği görülmüştür (Tablo 5). Proses şartlarındaki basınç değerlerinin artışı mekanik davranışlara pozitif yönde artış gösterdiği farklı çalışmalarda belirtilmiştir (Lamtai ve ark., 2024; Demirer ve Güney, 2018). Tablo 5'de ikinci aşama çalışmadaki geri dönüşümlü %20 ve %40 oranlarındaki numunelerin farklı enjeksiyon ve ütleme basınçlarındaki elde edilen çekme dayanımı ve sertlik değerleri gösterilmiştir.

Tablo 5: İkinci Aşama Sertlik Sonuçları Tablosu

NUMUNE	v-PE100 (%)	r-PE100 (%)	Enjeksiyon Basıncı (bar)	Ütleme Basıncı (bar)	Çekme Dayanımı (N/mm ²)	Sertlik (ShoreD)
1	100	0	70	65	21,52	65,22
2-1	80	20	75	75	19,07	64,50
2-2	80	20	75	80	19,98	64,80
2-3	80	20	80	75	19,11	63,90
2-4	80	20	80	80	19,80	64,01
3-1	60	40	75	75	16,08	61,00
3-2	60	40	75	80	17,38	62,50
3-3	60	40	80	75	18,73	63,10
3-4	60	40	80	80	18,87	63,30

* Koyu renkle vurgulanan değerler, elde edilen en yüksek çekme dayanımı ve sertlik sonuçlarını temsil etmektedir.

Geri dönüştürülmüş PE100 oranının artmasıyla birlikte, numunelerin çekme dayanımı ve sertlik değerlerinde belirgin bir düşüş gözlemlenmiştir. Çalışmada %100 PE100 içeren numunelerin ortalama sertlik değeri 65,22 Shore D iken, %80 geri dönüştürülmüş PE100 içeren numunelerde 60,67 Shore D'ye düşmüştür. Aynı durum çekme dayanımı içinde geçerlidir.

Bu durum, geri dönüştürülmüş malzemenin moleküler yapısında meydana gelen olası zincir kesilmeleri ve yapısal bozulmalarla açıklanabilir. Bu bulgular, literatürde geri dönüştürülmüş polimerlerin yapısal bozulmaları ve bu bozulmaların mekanik performans üzerindeki

etkileriyle ilgili yapılan çalışmalarla tutarlıdır. Örneğin, Schyns ve Shaver (2020), geri dönüştürülmüş polimerlerde gözlemlenen zincir kesilmelerinin malzemenin sertlik ve çekme dayanımı değerlerinde azalmaya neden olduğunu vurgulamaktadır. Malyuta (2023) ise geri dönüştürülmüş HDPE'nin mekanik performansında, özellikle çekme dayanımında, benzer olumsuz etkiler gözlemlenmiştir.

4. SONUÇLAR

Bu çalışmada, beş farklı oranda geri dönüştürülmüş PE100 malzemelerinin, mekanik özelliklerini iyileştirmek için iki aşamalı bir çalışma yapılmıştır. Plastik enjeksiyon yöntemiyle üretilen numunelerin proses parametrelerinden en etkili olan enjeksiyon ve ütüleme basınçları oransal olarak artırılmış ve mekanik özelliklerden çekme dayanımı ve sertlik değerleri üzerindeki etkileri belirgin olarak ortaya konulmaya çalışılmıştır.

- Geri dönüştürülmüş PE100 numunelerinde sabit proses şartlarında geri dönüşüm oranı arttıkça dayanım değerlerinde %29,51'e kadar azalma; sertlik değerlerinde %11,07'ye kadar bir düşme tespit edilmiştir.
- Proses şartlarından enjeksiyon ve ütüleme basıncının artırılarak gerçekleştirilerek %20 ve %40 geri dönüştürülmüş PE100 numunelerde sırasıyla çekme dayanımında %11,99 ve %13,47 oranında artış tespit edilmiştir.
- Enjeksiyon ve ütüleme basıncının artırılarak gerçekleştirilerek %20 ve %40 geri dönüştürülmüş PE100 numunelerde sırasıyla sertlik değerlerinde %0,9 ve %0,48 oranında çekme dayanımına paralel artış belirlenmiştir.
- Bu sonuçlar, geri dönüştürülmüş PE100 malzemelerin mühendislik uygulamalarında bilhassa düşük oranlarda yapılan geri dönüşümlü ürünlerde etkili sonuç alabileceğimizi göstermektedir.

KAYNAKÇA

- Alzerreca, M., Paris, M., Boyron, O., Orditz, D., Louarn, G., & Correc, O. (2015). Mechanical properties and molecular structures of virgin and recycled HDPE polymers used in gravity sewer systems. *Polymer Testing*, 46, 1-8. <https://doi.org/10.1016/j.polymertesting.2015.06.012>
- Demirer A., Güney Z. H., (2018). Enjeksiyonla Şekillendirilmiş ABS Kompozit Malzemenin Birleşme İzi Özelliklerinin İncelenmesi, The Examination of Weld Line Properties In Injection Molded ABS Composites, *Current Academic Studies In Engineering Sciences- Mühendislik Bilimlerinde Güncel Akademik Çalışmalar*, Volume /Cilt:II, Bölüm:Mechanical and Manufacturing Engineering, Makine ve İmalat Mühendisliği, s:1123-1135, ISBN:978-9940-540-51-7, www.ivpe.me, Ivpe- Cetinje, Montenegro. Cetinje.

- Frank, A., Berger, I. J., Messiha, M., Ek, C.-G., Schuler, N., Storheil, J.-M., ... & Pinter, G. (2018). Slow crack growth resistance of non-virgin polymers. In Proceedings of the 19th Plastic Pipes Conference, PPXIX, Las Vegas, Nevada, September 24-26, 2018.
- Freudenthaler, P. J., Fischer, J., Liu, Y., & Lang, R. W. (2022). Short- and long-term performance of pipe compounds containing polyethylene post-consumer recyclates from packaging waste. *Polymers*, 14(8), 1581. <https://doi.org/10.3390/polym14081581>
- Kharmoudi, H., Lamtai, A., Elkoun, S., Robert, M., & Diez, C. (2024). Effect of additives on thermal degradation and crack propagation properties of recycled polyethylene blends. *Polymers*, 16 (2060). <https://doi.org/10.3390/polym16142060>
- Lamtai, A., Elkoun, S., Kharmoudi, H., Robert, M., & Diez, C. (2024). Optimization of an industrial recycling line: The effect of processing parameters on mechanical properties of recycled polyethylene (PE) blends. *Waste*, 2(2), 186–200. <https://doi.org/10.3390/waste2020011>
- Lang, R. W., Bradler, P. R., Fischer, J., Poehlmann, D., Schmidt, S., & Niehoff, A. (2016). Quality and performance assessment of in-plant and post-use PE recyclates for pipe applications. Paper presented at the 18th Plastic Pipes Conference, Berlin, Germany.
- Malyuta, D. A. I. (2023). Talk dolgulu geri dönüştürülmüş HDPE'nin mühendislik uygulamaları için mekanik özelliklerinin deneysel değerlendirmesi (Montana Eyalet Üniversitesi, Doktora Tezi).
- Schyns, Z. O. G., & Shaver, M. P. (2020). Mechanical recycling of packaging plastics: A review. *Macromolecular Rapid Communications*, 42(3), 2000415. <https://doi.org/10.1002/marc.202000415>

**SOLENOİD VALF KOMPONENTLERİNİN TASARIM OPTİMİZASYONU İLE
DEBİ KARAKTERİSTİĞİNİN İYİLEŞTİRİLMESİ**
IMPROVING FLOW CHARACTERISTICS THROUGH DESIGN OPTIMIZATION OF
SOLENOID VALVE COMPONENTS

Kasım KARATAŞ

Makine Yüksek Mühendisi, E.C.A. Valf Sanayii A.Ş., Msc. Mechanical Engineer, E.C.A. Valf Industry
ORCID NO: 0000-0002-3520-3399

Emin Yiğit UMUR

Makine Mühendisi, E.C.A. Valf Sanayii A.Ş., Mechanical Engineer, E.C.A. Valf Industry
ORCID NO: 0009-0001-5000-5841

Cevat Emre ÖZKAN

Ege Üniversitesi, Mühendislik Fakültesi Makine Mühendisliği, *Ege University, Engineering Faculty,
Department of Mechanical engineering*
ORCID NO: 0009-0003-0564-0859

Hasan ERTUĞRUL

Ege Üniversitesi, Mühendislik Fakültesi Makine Mühendisliği, *Ege University, Engineering Faculty,
Department of Mechanical engineering*
ORCID NO: 0009-0008-0257-6106

ÖZET

Solenoid valfler, elektrikle kontrol edilen ve hızlı açılma/kapanma süreleri sayesinde otomasyon sistemlerinde tercih edilen elemanlardır. Soğutma sistemlerinde yüksek basınç koşullarında çalışan bu valfler, evaporatör, kompresör ve kondenser giriş-çıkış noktalarında soğutkanın kontrollü geçişini sağlayarak soğutma seviyesini anlık olarak düzenler. Soğutkanın sıvıdan gaz haline ve gazdan sıvı haline dönüşüm süreçlerinde ortaya çıkan yüksek basınçlar, valfler gibi mekanik bileşenler üzerinde büyük yükler oluşturur, bu da bu bileşenlerin tasarımında yüksek dayanıklılık ve mukavemet gerektirdiği anlamına gelir. Mukavemetli parçaların tasarımı iç parçaların tasarımı akışkanın geçişini engelleyebilir ve soğutma kapasitesini direkt olarak etkileyen akış katsayısını düşürebilmektedir.

Bu çalışmada, solenoid valflerin iç bileşenlerinin tasarım değişikliklerinin debi performansı üzerindeki etkileri araştırılmıştır. Valf gövdesi, diyafram ve delikli sac gibi parçaların tasarımındaki modifikasyonlar ile debi (Kv) değerlerinin iyileştirilmesi amaçlanmıştır. Bu değişikliklerin akış performansını nasıl etkilediğini belirlemek için Hesaplamalı Akışkanlar Dinamiği (CFD) analizleri yapılmış ve çeşitli tasarımlar üzerindeki akışkan hareketi detaylı bir şekilde değerlendirilmiştir. CFD sonuçları, farklı tasarım alternatiflerinin debi performansını nasıl artırdığını ortaya koymuştur. Valf tasarımı genellikle kontrol, yük kaybı,

kavitasyon, regülasyon ve açma/kapama moment özellikleri ile değerlendirilir. Akış katsayılarının (Kv) belirlenmesi ve karşılaştırılması amacıyla, valflerin basınç farkına bağlı olarak hesaplamalar yapılmıştır. Kv, metrik birimlerde, 16°C sıcaklıktaki suyun valf boyunca 1 bar basınç düşüşü ile metre-küp/saat [m³/h] cinsinden akış debisini ifade eder. Tasarım optimizasyonları, basınç kaybının yüksek olduğu ve akışı kısıtlayan geçiş alanlarına odaklanmıştır. Ansys Workbench ile gerçekleştirilen akış analizleri ve E.C.A Valf Sanayii A.Ş. bünyesinde yapılan Kv testleri, tasarım değişikliklerinin Kv değerlerinde belirgin iyileşmeler sağladığını doğrulamıştır. Bu bulgular, optimize edilmiş tasarımların akış performansındaki artışın deneysel olarak da desteklendiğini göstermektedir.

Anahtar kelimeler: Solenoid Valfler, Akış Katsayısı (Kv), Tasarım Optimizasyonu, Hesaplamalı Akışkanlar Dinamiği (CFD).

ABSTRACT

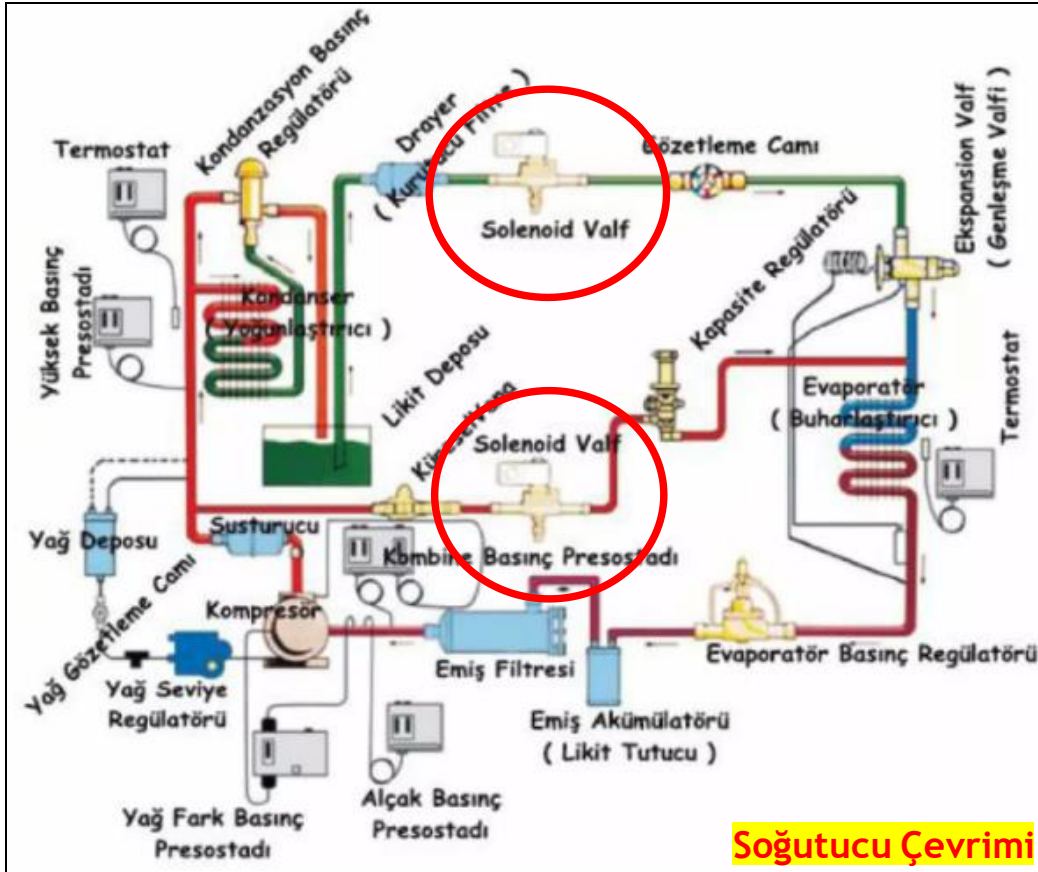
Solenoid valves are components preferred in automation systems due to their electric control and rapid opening/closing times. These valves, which operate under high pressure conditions in cooling systems, manage the controlled flow of refrigerants at the evaporator, compressor, and condenser inlet and outlet points, adjusting the cooling level in real-time. The high pressures that occur during the phase transitions of refrigerants from liquid to gas and vice versa impose significant loads on mechanical components such as valves, necessitating high durability and strength in their design. The design of robust parts can potentially obstruct fluid flow and reduce the flow coefficient, which directly affects cooling capacity.

In this study, the impact of design modifications on the flow performance of internal components of solenoid valves was investigated. Modifications in the valve body, diaphragm, and perforated plate components aimed to improve the flow coefficient (Kv) values. To determine how these changes affect flow performance, Computational Fluid Dynamics (CFD) analyses were performed, and the fluid movement in various designs was thoroughly evaluated. The CFD results demonstrated how different design alternatives could enhance flow performance. Valve design is typically assessed based on control, pressure loss, cavitation, regulation, and opening/closing moment characteristics. To identify and compare flow coefficients, calculations based on pressure differentials in the valves were conducted. Kv is defined as the flow rate in cubic meters per hour [m³/h] of water at 16°C, with a pressure drop of 1 bar across the valve. Design optimizations focused on areas with significant pressure loss and flow restrictions. Flow analyses conducted using Ansys Workbench and Kv testing performed at E.C.A. Valf Sanayii A.Ş. confirmed that design modifications resulted in significant improvements in Kv values. These findings indicate that the increased flow performance of the optimized designs is also supported experimentally.

Keywords: Solenoid Valves, Flow Coefficient (Kv), Design Optimization, Computational Fluid Dynamics (CFD)

GİRİŞ

Valfler, akışkanların basıncını düzenlemek, akışı durdurmak veya ters akışı engellemek gibi önemli işlevler üstlenen cihazlardır. Farklı akışkan türlerini güvenli bir şekilde kontrol etmek için kullanılırlar; bu akışkanlar arasında katılar, sıvılar, gazlar ve gaz-buhar karışımları yer alabilir. Valflerin boyutları, evlerde kullanılan küçük örneklerden, endüstriyel uygulamalarda tercih edilen büyük boyutlara kadar çeşitlilik göstermektedir.



Şekil 1. Solenoid valflerin soğutma sisteminde kullanımı

Soğutma sistemlerinde sistemin kritik noktalarında anlık akış kontrolü sağlayan diyafram pilot solenoid valfler, akış kontrol sistemlerinde kritik bir rol oynar. Otomasyon sistemlerinde kullanımı yaygın ve kaçınılmaz olan bu valflerin akışkan geçirme kapasitesi de sistem verimine direkt olarak etki etmektedir. Bu nedenle, diyafram pilot solenoid valflerin doğru tasarımı ve analizi, sistemlerin performansını artırmak ve kaçakları engellemek açısından elzemdir.

Literatürde, valf tasarımının başarısını belirleyen en önemli faktörlerden biri, valfin doğru bir şekilde tanımlanmasıdır. Açık ve kapalı konumları belirleyen unsurlar arasında diyafram ve pilot mekanizmaları bulunur. Bu tür valfler genellikle sadece iki konumda çalışır ve belirli bir açılma yüzdesine sahiptir. Vana akış karakteristiğini anlamak için akış analizleri yapmak zorunludur. Yapılan araştırmalarda, akış katsayısının (Cv) valf seçiminde önemli bir kriter olduğu vurgulanmıştır. Globe valflerin tasarımında Cv değerini elde etmek için

gerçekleştirilen akış analizleri, piston açılma yüzdelerinin akış üzerindeki etkisini incelemiştir.



Şekil 2. Diyaframli Soğutma solenoid valfler.

Araştırma, valfin açılmasıyla birlikte fark basıncının ve akış hızının düştüğünü göstermiştir; ayrıca açılma yüzdesi arttıkça Cv değerinin yükseldiği gözlemlenmiştir, (Praveen ve Pathan, 2015). Kalke ve arkadaşları tarafından yapılan başka bir çalışmada, globe vanalarda akış karakteristiğini belirlemek ve basınç kayıplarını azaltarak debiyi artırmak amaçlanmıştır. Mevcut tasarım analiz edilerek türbülans oluşturan bölgeler tespit edilmiş ve yeni tasarımda bu bölgelerin giderilmesi hedeflenmiştir. Elde edilen bulgular, yeni tasarımda kütleli debide belirgin bir artış sağlandığını göstermektedir (Kalke vd.,2020). Hesaplamalı akışkanlar dinamiği (HAD) yöntemi, akış analizlerinde yaygın olarak kullanılmaktadır. HAD yöntemi ile vanalardaki akışın gözlemlenmesi ve performans tahmininin yapılabileceği gösterilmiştir. Bu çalışmada, stop vanalarının modellenmesi ve simülasyonu ele alınmıştır. Piston tasarımına odaklanarak, düşük akışlı vanaların performansını artırma hedeflenmiştir (Yang vd. 2011). Ağ oluşturma ve uygunluğunu değerlendirme konusunda çeşitli yöntemler mevcuttur. Hareketli ağ kullanılarak bir çek valfin dinamik davranışları tanımlanmış ve açılıp kapanma durumları öngörülmüştür. Çalışmada, dört farklı hareketli ağ modeli karşılaştırılmış ve her bir yöntemin hız profillerinin benzer olduğu gözlemlenmiştir. Ancak, valfin kapalı konumundaki değerlerin gerçek değerleri yansıtmadığı ve daha iyi anlaşılabilmesi için deneysel verilere ihtiyaç duyulduğu vurgulanmıştır (Kim ve Yong, 2021).

Küresel vanalardaki kavitasyon, Yousaf B. (2021) tarafından HAD modellemesi ile sayısal olarak incelenmiş ve deneysel sonuçlarla doğrulanmıştır. Simülasyonlar zaman bağımsız olarak gerçekleştirilmiş ve türbülans modellerinden yararlanılmıştır. K- ϵ ve K- ω modelleri kullanılarak yapılan analizler, K- ϵ türbülans modelinin girdap bölgeleriyle ilgili daha iyi sonuçlar verdiğini göstermiştir. Diyafram pilot solenoid valflerin akış katsayısı (Kv) gibi karakteristik özellikleri, sistem performansı üzerinde doğrudan etkiye sahiptir. Valflerin tasarımında akış katsayısının belirlenmesi genellikle deneysel yöntemlerle yapılmakta, bu süreç maliyetli ve zaman alıcı olabilmektedir. Hesaplamalı akışkanlar dinamiği (CFD) yöntemleri, bu dezavantajları aşmak için güvenilir bir alternatif sunar. Sonuç olarak, soğutma sistemlerinde pilot solenoid valflerin analizi, belirlenen Kv değerlerine ulaşacak şekilde

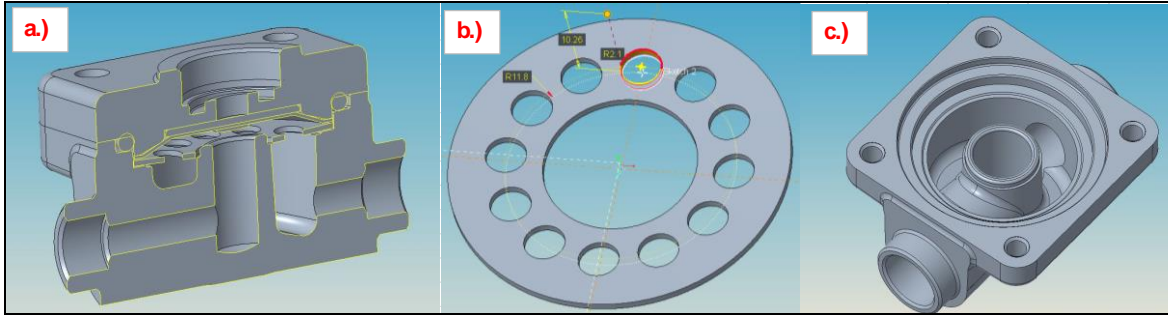
tasarımlar geliřtirmek aısından kritik bir suretir. Kapak, gvde ve diyafram gibi temel bileřenlerde gerekleřtirilen tasarım modifikasyonları, valfin verimliliğini artırarak sistem performansını iyileřtirir. Bu řekilde, enerji verimlilięi saęlanırken, sistemlerin genel gvenilirlięi de artırılmıř olur.

Bu alıřma kapsamında, diyafram pilot solenoid valflerin akıř katsayısını belirlemek iin yarı dinamik bir model geliřtirilmiřtir. Geliřtirilen model zerinden gerekleřtirilen hesaplamalı akıřkanlar dinamięi analizleri, elde edilen optimum deęerlerin deneysel olarak doęrulanmasını amalamaktadır. Yapılan analiz alıřmaları sonucunda, optimum tasarımların prototip retimi gerekleřtirilmiř ve E.C.A Valf Sanayii A.ř. firmasında Kv testleri yapılmıřtır. Bu testler sonucunda Kv deęerinde %10 ile %15 arasında bir iyileřme gzlemlenmiřtir.

YNTEM

Analiz Hazırlıkları ve Mekanik Modelleme

Bu alıřma sırasında rnn benzer tasarımları Solidworks ve PTC Creo ile modellenmiřtir. Kv deęerinin optimizasyonu iin i paralar zerinde revizyonlar yapılmıřtır. Gvde i geiř apı ve delikli sac para llerinde deęiřiklikler yapılarak akıř analizleri gerekleřtirilmiřtir.

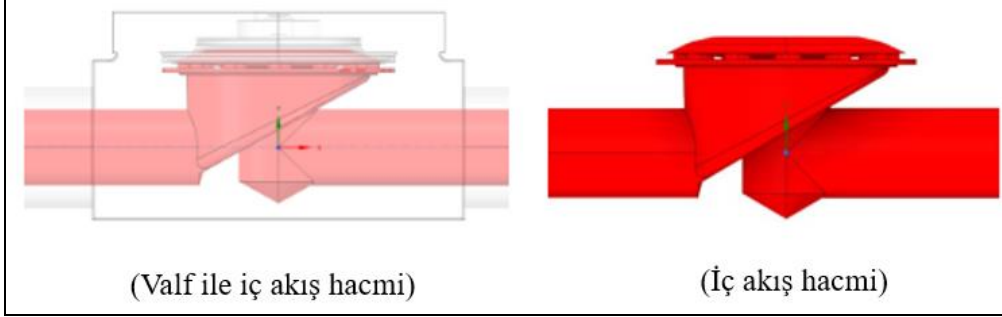


řekil 3. 3D Tasarımlar (a) valfin aık pozisyonundaki montajlanmış grnts, (b) delikli sac para, (c) valf gvdesi.

Akıř Geometrisi ve Modellemesi

Hesaplmalı Akıřkanlar Dinamięi (HAD) analizi, bilgisayar destekli modeller aracılıęıyla akıřkanların hareketlerini ve etkileřimlerini incelemek iin kullanılan bir yntemdir. Bu analizlerde, akıřkanın hareket ettięi geometrinin doęru bir řekilde modellenmesi byk nem tařır. Geometrinin doęruluęu, analizin sonularının gvenilirlięi zerinde doęrudan etkili olabilir. Ancak, akıřkan geen blmlerin modellenmesi ayrıntılı ve karmařık olabilir. Bu durum, analiz sresini ve maliyetini artırabilir. Son olarak, aę yapısı, geometriyi doęru bir řekilde temsil etmekle birlikte analiz iin gerekli detayı saęlayacak řekilde dzenlenmelidir. İ akıř hacmi, bir akıřkanın belirli bir alan veya hacim iindeki hareketini ifade eden bir terimdir. "Fluid domain" olarak adlandırılan bu alan, akıřkanın dinamik davranıřlarını incelemek iin analiz edilen blgedir. Bu alan, sıvı veya gazın akıř zelliklerinin, basın deęiřimlerinin, sıcaklık profillerinin ve trblans etkilerinin deęerlendirilmesine olanak tanır.

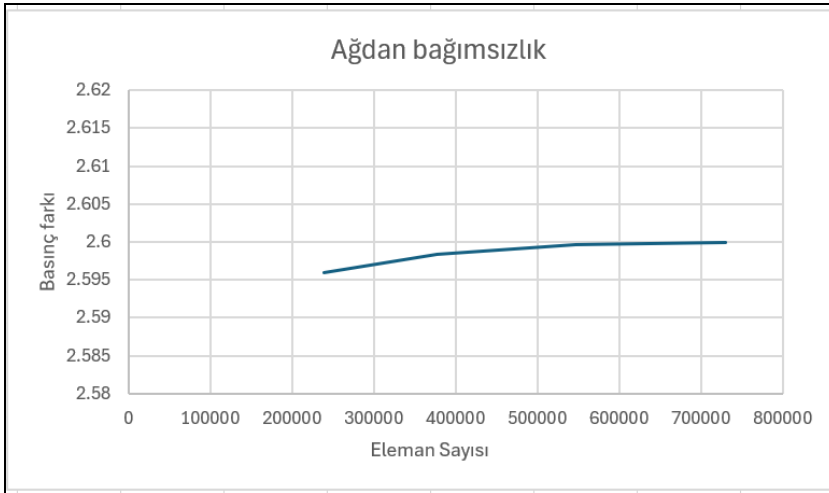
Hesaplamalı akışkanlar dinamiği (CFD) analizlerinde, iç akış hacmi, akışkanın hareketinin simüle edildiği geometrik alanı temsil eder. Bu sayede, akışkanların belirli bir sistem içindeki performansı ve verimliliği hakkında detaylı bilgiler elde edilir.



Şekil 4. İç akış hacmi

Ağdan Bağımsızlık

Akış hacmi analizlerinde, doğru sonuçlar için uygun ağ yapılarının seçimi kritik öneme sahiptir. Yeterli eleman sayısı doğruluk için önemlidir, ancak eleman sayısının artması çözüm süresini de uzatır. Bu nedenle, doğruluk ve çözüm süresi arasında denge sağlanmalıdır. Ağdan bağımsızlık ilkesi, eleman sayısı artırıldığında sonuçların değişmemeye başladığı noktayı ifade eder ve bu nokta, analizlerin doğruluğunu koruyarak süreyi minimize etmek açısından kritiktir. Ayrıca, farklı ağ yapılarına sahip hücrelerin analiz sonuçlarının karşılaştırılması önemlidir. Analizlerimizde giriş ve çıkış basıncını, ardından hesapladığımız Kv değerlerini karşılaştırarak, sonuçların doğruluğunu ve güvenilirliğini değerlendirdik. Bu yaklaşım, farklı ağ yapılarını objektif bir şekilde değerlendirerek en uygun olanını belirlememize olanak tanımıştır.

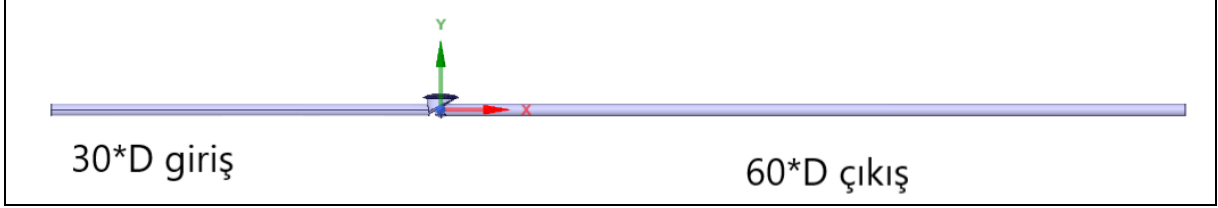


Şekil 5. Ağdan bağımsızlık -Basınç farkına göre

Tamamen Gelişmiş Akış

Tam gelişmiş akış, mühendislik uygulamalarında temel bir kavramdır, çünkü akışkanların belirli bir uzunluk boyunca istikrarlı bir şekilde hareket etmesini ifade eder. Sistemlerin doğru

tasarımı, analizi ve performansının değerlendirilmesi için bu durumun dikkate alınması önemlidir. Bu bağlamda, valf giriş ve çıkış kısımlarındaki akış hacmi için yapılan ilaveler, tam gelişmiş akışın sağlanmasına yönelik bir strateji olarak kullanılmıştır. Özellikle, valfin giriş kısmında çapın 30 katı büyüklüğünde bir alan belirlenirken, çıkış kısmında oluşabilecek türbülansların etkilerini minimize etmek adına çapın 60 katı büyüklüğünde bir alan tercih edilmiştir. Bu yaklaşım, analiz sonuçlarının stabil olmasını sağlamıştır, çünkü akışta homojenlik ve istikrarlılık sağlanarak hesaplamaların güvenilirliği artırılmıştır.



Şekil 6. Giriş ve Çıkış uzunluklarının arttırılması

MATEMATİKSEL MODELLEME

Akışkanlar mekaniğinde temel denklemler kütle, momentum ve enerji korunumuna dayanmaktadır. Momentum denklemleri, Navier-Stokes denklemlerinin temelini oluşturur. Diferansiyel momentum denklemleri, yoğunluk, basınç ve hız gibi akış alanı değişkenleri açısından doğrusal olmayan kısmi diferansiyel denklemler olarak tanımlanır. Akışkan hareketine dair bu denklemlerin türetilmesi sırasında, çözülebilir bir denklem sistemi oluşturulması gerekir; bu durumda, denklem sayıları bilinmeyen bağımlı alanların sayısıyla karşılaştırılır. Akışkan hareketinin temel denklemleri, aşağıdaki korunum yasalarına dayanarak türetilir: Kütle korunumu yasası, Momentum korunumu yasası, Enerji korunumu yasası'dır.

Kütlenin Korunumu

Kütlenin korunumu, akışkanların bir kontrol hacmi içerisindeki kütlenin zamanla nasıl değiştiğini açıklayan matematiksel bir modeldir. Süreklilik denklemi olarak bilinen bu denklemler, kütlenin korunumu ilkesini ifade eder. Sıkıştırılabilir Akışlar için Süreklilik Denklemi:

$$-\frac{\partial \rho}{\partial t} = \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z}$$

Burada, ρ : Yoğunluk, u, v, w : X, Y ve Z yönlerindeki hız bileşenleridir. Sıkıştırılmaz akışlar için süreklilik denklemi:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

Momentumun Korunumu

Momentum korunumu, akışkanların hareketini açıklayan denklemler setidir ve Newton'un ikinci hareket yasasından türetilmiştir. Navier-Stokes denklemleri, bu denklemler arasında yer alır. X-Momentum Denklemi:

$$\rho \left(\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} \right) = -\frac{\partial p}{\partial x} + \mu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right) + F_x$$

Y-Momentum Denklemi:

$$\rho \left(\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} \right) = -\frac{\partial p}{\partial y} + \mu \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2} \right) + F_y$$

Z-Momentum Denklemi:

$$\rho \left(\frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} \right) = -\frac{\partial p}{\partial z} + \mu \left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} \right) + F_z$$

Burada:

- t: Zaman
- p: Basınç
- μ : Dinamik viskozite

Enerji Korunumu

Enerji korunumu, termodinamiğin birinci yasasına dayanan bir prensiptir. Enerjinin korunumu denklemi, akışkan içerisindeki enerji değişimini modellemek için kullanılır. Enerji Korunumu Denklemi:

$$\rho C_p \left(\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} + w \frac{\partial T}{\partial z} \right) = \Phi + \frac{\partial}{\partial x} \left[k \frac{\partial T}{\partial x} \right] + \frac{\partial}{\partial y} \left[k \frac{\partial T}{\partial y} \right] + \frac{\partial}{\partial z} \left[k \frac{\partial T}{\partial z} \right] + \left(u \frac{\partial p}{\partial x} + v \frac{\partial p}{\partial y} + w \frac{\partial p}{\partial z} \right)$$

Burada:

- C_p : Sabit basınçta özgül ısı
- k: Termal iletkenlik katsayısı
- Φ : Enerji kaynak terimleri

4. Türbülanslı Akış ve Modelleri

Türbülans, akışkanların kaotik bir şekilde hareket etmesi durumunu ifade eder. Bu durum, akışkanların hız ve diğer özelliklerinin zamanla değişkenlik göstermesi anlamına gelir.

Türbülans Modelleri:

1. Reynolds-Ortalamalı Navier-Stokes Denklemleri
2. Türbülans Kapanma Modelleri
 - o Tek Denklem Modeli: Spalart-Allmaras Modeli
 - o İki Denklem Modeli: k-ε ve k-ω Modelleri
3. Büyük Girdap Simülasyonu (LES)
4. Doğrudan Sayısal Simülasyon (DNS)

k-ε Modeli

k-ε modeli, iki denklemlilik bir türbülans modelidir. Bu model, türbülanslı kinetik enerji (k) ve türbülans yayılma hızı (ε) denklemlerinden oluşur. k Denklemi:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho k u_i) = \frac{\partial}{\partial x_j} \left[(\mu + \sigma_k \mu_t) \frac{\partial k}{\partial x_j} \right] + G_k + G_b - \rho \epsilon - Y_m + S_k$$

ε Denklemi:

$$\frac{\partial}{\partial t}(\rho \epsilon) + \frac{\partial}{\partial x_i}(\rho \epsilon u_i) = \frac{\partial}{\partial x_j} \left[(\mu + \sigma_\epsilon \mu_t) \frac{\partial \epsilon}{\partial x_j} \right] + C_1 \epsilon \frac{k}{\epsilon} (G_k + G_3 G_b) - C_2 \rho \frac{\epsilon^2}{k} + S_\epsilon$$

Burada:

- G_k: Türbülanslı kinetik enerjinin üretim hızı
- G_b: Kaldırma etkisiyle oluşan türbülans kinetik enerjisi üretim hızı
- μ_t: Türbülanslı viskozite
- Model sabitleri:

$$C_\epsilon = 0.09, C_{1\epsilon} = 1.44, C_{2\epsilon} = 1.92, \sigma_k = 1.0, \sigma_\epsilon = 1.3$$

Bu denklemler, akışkanların dinamik davranışlarını anlamak ve mühendislik uygulamalarında modellemek için önemlidir. Akışkanlar mekaniğinde bu temel denklemler, çok sayıda uygulama ve hesaplama yöntemine temel oluşturur.

Akış Katsayısı (Kv) Değerinin Tanımlanması

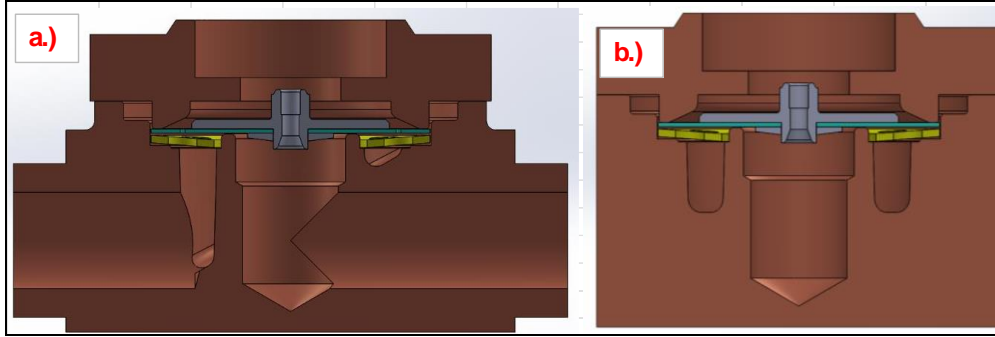
Kv değeri; 20 °C sıcaklıktaki suyun, 1 Bar basınç kaybı ile belirli bir oranda açık vanadan geçen m³/saat cinsinden debisini belirtmektedir, Kv değeri, belirli, sabit tutulan bir doğrultudaki akış sırasında yapılan ölçümlerle tespit edilir. A.B.D'nde kullanılan, eşdeğer Cv değeri de basınç farkı 1.0 psi (0,07 bar) ve akışkan sıcaklığı 60 °F olmak üzere US Galon/dak cinsinden debi olarak tanımlanmıştır (Gürel S., 2003).

$$C_v = 1.117 \times K_v \quad \text{veya} \quad K_v = 0.86 \times C_v$$
$$KV = Q \times \sqrt{\frac{1\text{bar}}{\Delta P} \times \frac{\rho}{1000\text{kg}} \frac{\text{m}^3}{\text{s}}}$$

Şekil 7. Kv değeri hesaplama formülleri

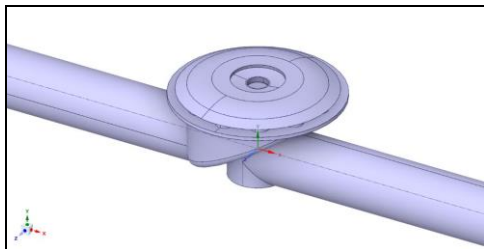
TASARIM VE ANALİZ

Elde ettiğimiz bilgiler doğrultusunda asılı diyaframlı pilot selenoid valflerinin tasarım ve çalışma prensipleri hakkında detaylı bir bilgi edinilmiştir. Pilot selenoid valfin 3 boyutlu modelini oluşturmak için SolidWorks 2022'yi kullanarak tasarımları tamamlanmıştır.



Şekil 8. (a) Tasarım 0'a ait ön düzlem kesiti, (b) Tasarım 0'a ait sağ düzlem kesiti

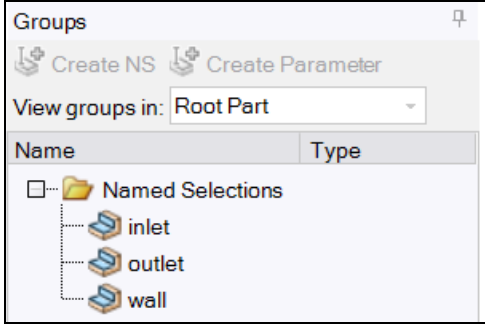
İlk olarak, valfin 3 boyutlu modelinde kapalı pozisyonda durduğunu belirlendi. Sonrasında, valfin üzerindeki diyaframın açık durumda nasıl olacağı SolidWorks 2022 kullanarak çizildi. Yapılan tasarım 0'ı yapılacak olan akış analizinde ince unsurları ortadan kaldırarak akış analizini yapmadan önce tasarım 0 üzerinde düzenlemeler yapılmıştır. Gerekli düzenlemeler tamamlandıktan sonra, SolidWorks programında oluşturulan tasarımı, Ansys'in bilgisayar destekli tasarım programı olan SpaceClaim'e aktarıldı. Bu adımı takiben, Ansys fluent programı akış analizini yaparken akışın hacmini kullandığı için program içinde bulunan "Volume Extract" komutu kullanılarak analiz için kullanılacak olan akış hacmi çıkartılmıştır.



Şekil 9. Tasarım 0'a ait akış hacmi

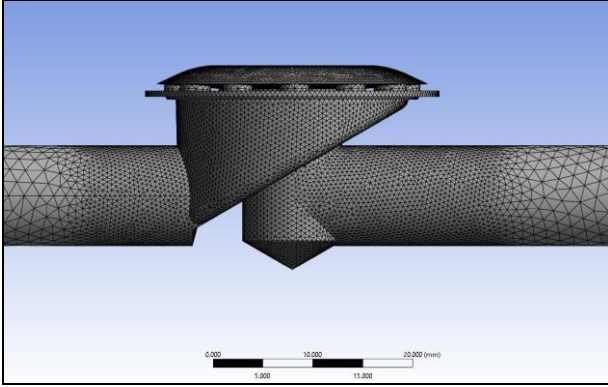
Akış hacmi alındıktan sonra orijinal valf geometrisi fiziksel olaylar için bastırılmıştır. ("Supress for Physics") sınır koşulları belirlenmiştir ve isimlendirilmiştir (valf girişi-inlet, valf

çıkışı outlet, duvarlar-Wall) Sınır koşulları Şekil 10'da gösterilmiştir. Bunlarla beraber analiz yapılacak akış hacmi belirlenmiş ve dosyaya kaydedilmiştir.



Şekil 10. Tasarım 0'a sınır koşullarının adlandırılması

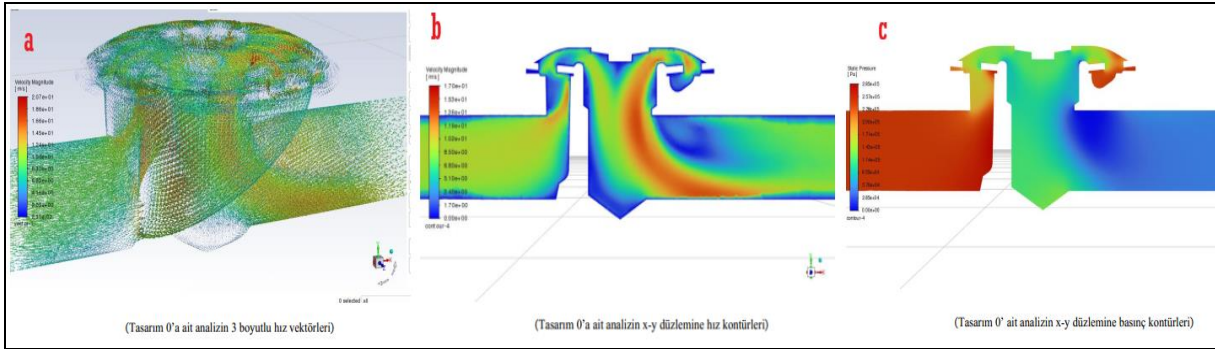
Kaydedilen geometri Ansys'in standart ağ kısmına aktarılmıştır. Burada "Geometry" kısmından valfin gövdesi baskılanmış ve kullanıma kapatılmıştır ("Supress Body"). Aynı kısımda bulunan "Volume" seçeneğinden akışkan olduğu tayin edilmiştir. "Mesh" kısmına gelindiğinde "Physics Preference" seçeneği "CFD" olarak seçilmiştir. Ağ atılırken valfin iç kısmının daha detaylı olması gerektiğine karar verdik bu sebeple uzatılan kısımlar daha kaba bir ağ yapısına sahipken, valfin iç hacim boşluğunun olduğu kısım daha ince ve ayrıntılı bir ağ yapısı elde edilmiştir. Şekil 11 'de akış hacminin ağ yapısı detaylı bir şekilde gösterilmiştir.



Şekil 11. Tasarım 0'a ait akış hacminin ağ yapısı

Analiz süreci, daha az elemanla daha doğru sonuçlar elde etmek ve analiz süresini minimize etmek amacıyla bir ağ yapısı oluşturularak başlatılmıştır. Ağ dosyası, Ansys Fluent yazılımındaki "Setup" bölümüne aktarılmıştır. Burada k-epsilon standart türbülans modeli ve standart duvar fonksiyonları kullanılarak hesaplamalı akışkanlar dinamiği analizi yapılmıştır. Çözücü tipi basınç esaslı olarak ayarlanmış, akış tipi ise zamana bağlı olmayan sürekli akış şeklinde belirlenmiştir. Analizde sıvı su kullanılmış ve sınır koşulları olarak 3 bar giriş basıncı ile atmosferik çıkış basıncı ayarlanmıştır. Çözüm metodu olarak basınç ve hız denklemlerini birlikte çözen "Coupled" yöntemi seçilmiş, türbülans kinetik enerjisi ise ikinci dereceye ayarlanmıştır. Analiz süresince giriş ve çıkış noktalarında basınç ve kütleli debi raporları

oluşturulmuş, hibrit başlatma yöntemi kullanılarak 500 iterasyon sayısı ile analiz gerçekleştirilmiştir. Bu işlemler diğer tasarımlarda da uygulanmıştır.



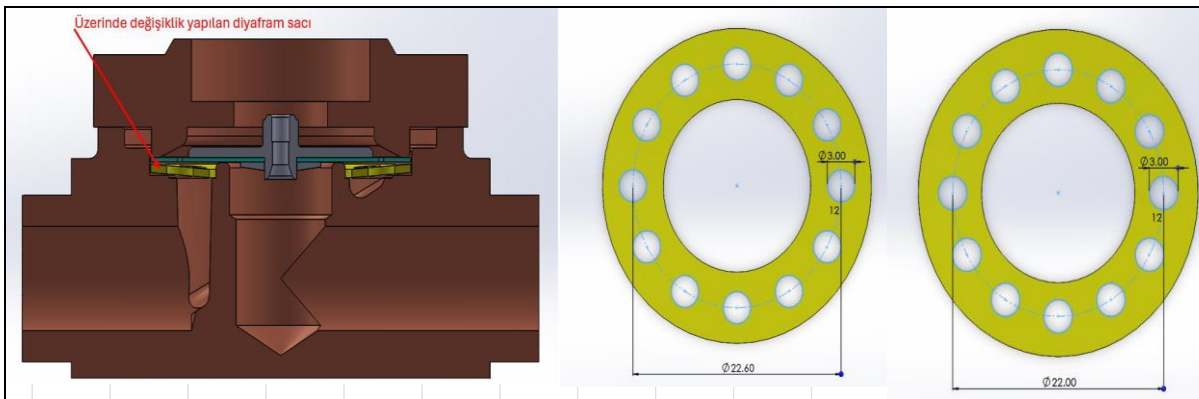
Şekil 12. (a) 3 Boyutlu hız vektörleri, (b) Analizin x-y düzlemine hız kontürleri, (c) Tasarım 0' ait analizin x-y düzlemine basınç kontürleri.

Şekil 12.a'da ilk tasarımın hız vektörleri sunulmuş ve bu vektörlerin akış yönleri incelenmiştir. Bu analiz, akışın dinamiklerini anlamak için önemlidir. Şekil 12.b'de ise ilk tasarımın hız kontürleri gösterilmiştir; bu kontürler, akışın hız dağılımını ve yoğunluğunu görsel olarak temsil ederek tasarımın performansını değerlendirmeye yardımcı olur. Şekil 10.c'de ilk tasarımın basınç kontürleri gösterilmiştir. Tasarım 0 üzerinde gerçekleştirilen akış analizlerinden sonra çizilen hız ve basınç grafiklerini incelenmiştir. Analizler doğrultusunda akışın daha az kayıp daha yüksek verimle nasıl gerçekleştirebileceği konusunda çalışılmıştır.

TASARIM OPTİMİZASYONU

Diyafram Sacında Değişim

Valf üzerindeki akışın hızlandığı ve daralan türbülans bölgesinde, diyafram sacının tasarımında değişiklikler yapıldı. Deliklerin çapı artırılarak hacim genişletildi. Tasarım değişikliklerinin etkileri, giriş ve çıkış basınçları, hacimsel debi ve Kv değerleri Tablo 1'de sunulmuştur. Ana hedef, selenoid valfin debisini artırmaktır. Şekil 13'te diyafram sacının tasarımdaki konumu, ilk tasarımın ölçüleri gösterilmiştir.



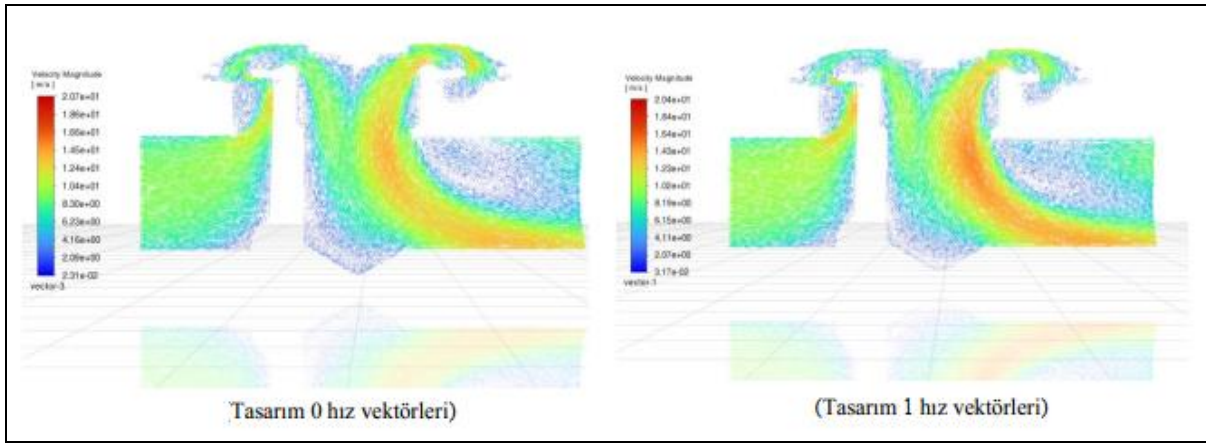
Şekil 13. (a) Tasarım 0 diyafram sacının bulunduğu yer, (b) Tasarım 0 diyafram sacı, (c) Tasarım 3 diyafram sacı

Tablo 1'de farklı tasarımların analiz sonuçlarından yola çıkılarak giriş ve çıkış basınçları ile saniye başına geçen metreküp hacim değerlerini kullanarak Kv değeri hesaplanmıştır.

Tablo 1. Farklı tasarımda Kv hesaplanma tablosu

	Pinlet	Poutlet	m ³ /h	Kv
Tasarım0	2.6512174	0.051586107	2.3082768	1.430344964
Tasarım1	2.6136328	0.056239152	2.42956296	1.517882485
Tasarım2	2.5859726	0.051672694	2.320743816	1.456488235
Tasarım3	2.5651413	0.050782152	2.183318676	1.375663633
Tasarım4	2.5351413	0.056132234	2.291318676	1.453969245
Tasarım5	2.4995206	0.054313264	2.20403934	1.40821926

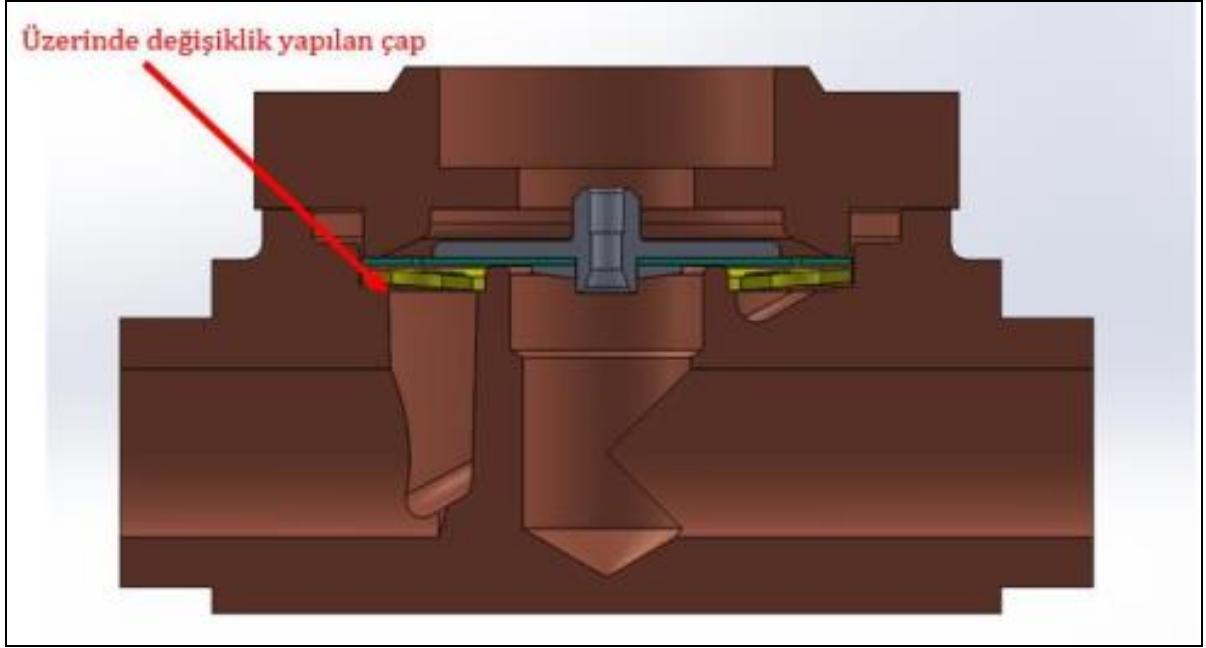
Diyafram çapı 22 mm'ye düşürülerek yeni analizler yapılmıştır. Tablo 1'deki verilerle Kv değeri hesaplandı. Şekil 12'de, delik çapı 3.5 mm ve çap genişliği 22.6 mm koşullarında optimum sonucun alındığı görülmektedir. Ayrıca, Şekil 15'te tasarımın hız vektörleri verilmiştir.



Şekil 15. Tasarım 0 ve Tasarım 1 hız vektörleri

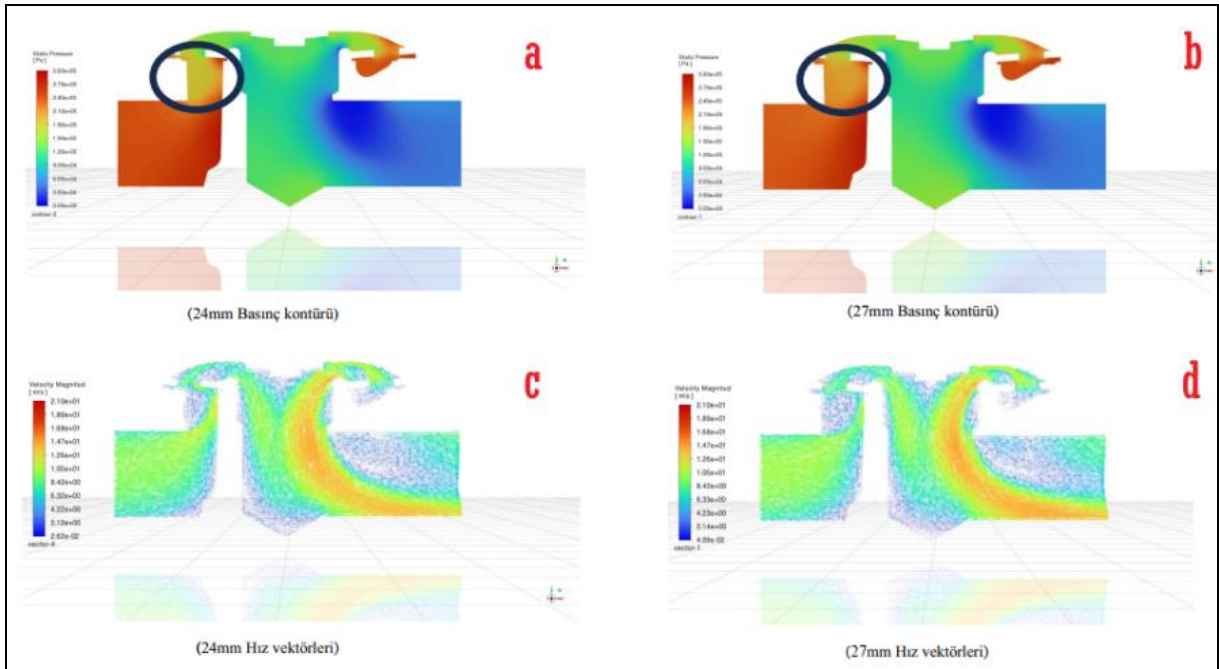
Valfin Çap Boyutunun Değişimi

Tasarımda değişiklik yapılabilecek parçalar incelenmiştir. Önceki saç parçasındaki değişiklikler dikkate alındığında, hacmin artmasının Kv değerini belirli bir noktaya kadar olumlu etkilediği, ancak daha fazla artışın olumsuz sonuçlar doğurduğu gözlemlenmiştir. Bu bağlamda, valf çapının boyutunu değiştirerek Kv değerinde bir artış sağlanabileceği düşünülmüştür. Şekil 16'da, ilk tasarımdaki çap değerinin artırılmasıyla Kv değerinin optimum seviyeye ulaşması hedeflenmiştir.



Şekil 16. Tasarımda değişiklik yapılan çap

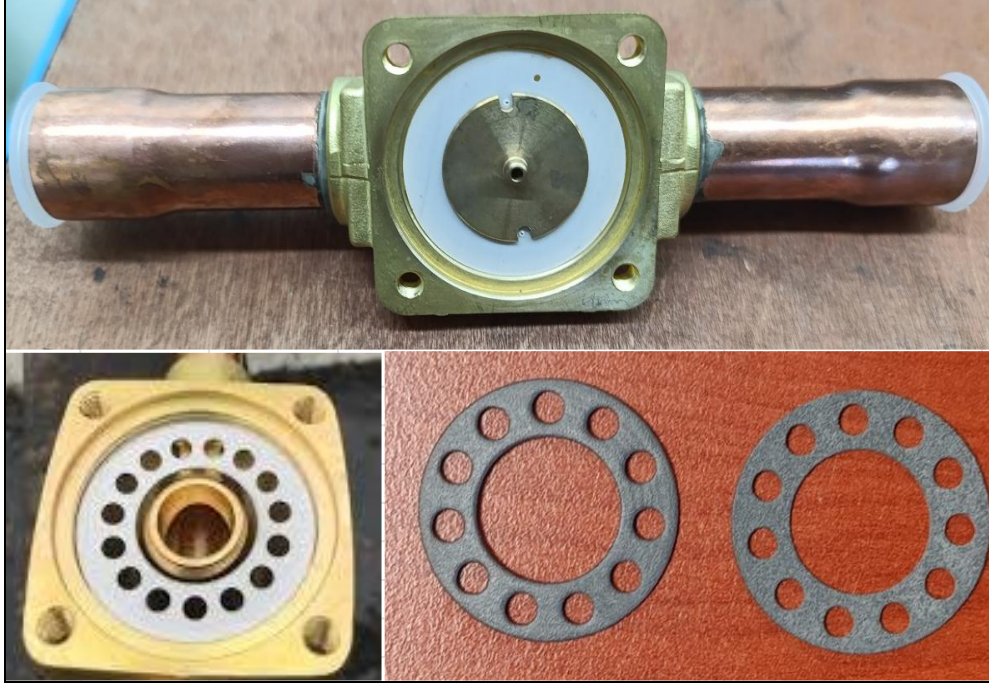
Şekil 17.a'da, çapı 24 mm olan valfin basınç kontürü sunulmuştur. Şekil 17.b'de ise aynı çapta hız vektörleri incelenmiştir. Daha sonra, çapı 27 mm'ye artırılan valf için yapılan değişikliklerle ilgili olarak Şekil 17.c'de 27 mm çapındaki basınç kontürü gösterilmiştir. Şekil 17.d'de de bu çapta hız vektörleri sunulmuştur.



Şekil 17. (a) 24mm Basınç kontürü), (b) 24mm Hız vektörleri), (c) 27mm Basınç kontürü, (d) 27mm Hız vektörleri.

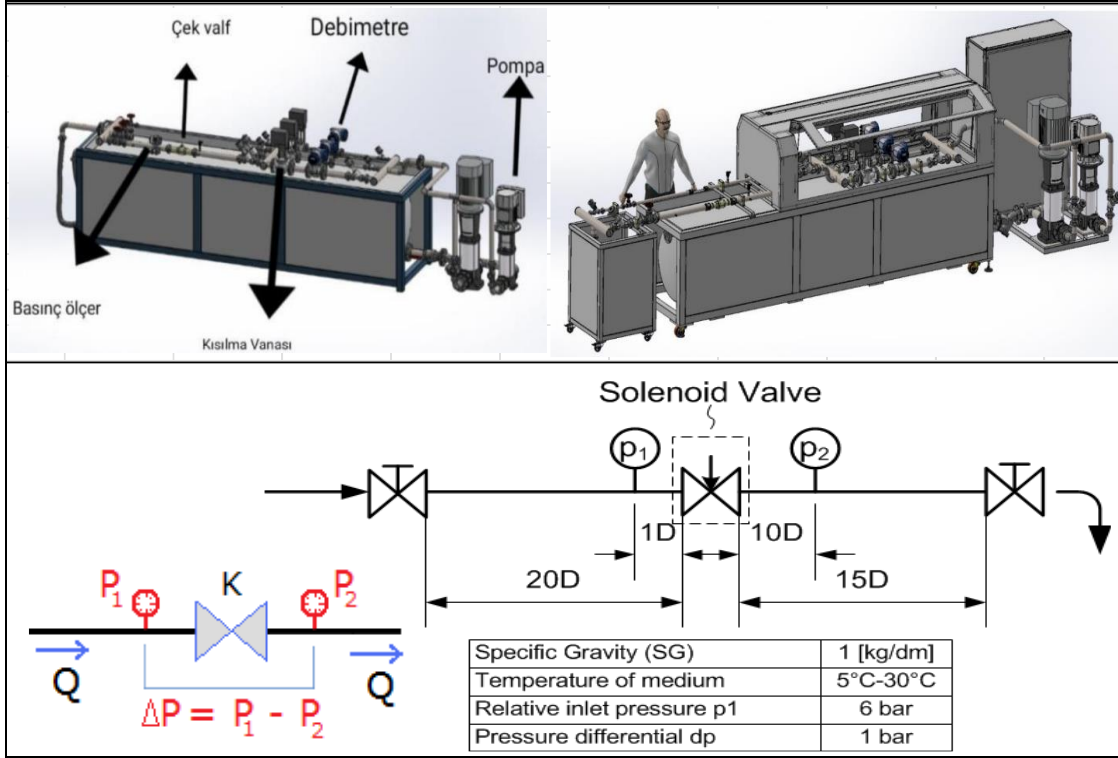
Test ve Deney

Delikli sac parça prototipleri 3D yazıcı ile üretilerek mamüllere montajlanmıştır. Ürünler Kv test cihazında test edilerek Kv değerindeki iyileştirmeler deneysel olarak doğrulanmıştır. Mevcut tasarımın Kv test sonuçları ile optimize tasarımın Kv test sonuçları karşılaştırılmış ve örtüştüğü belirlenmiştir. Testler, E.C.A Valf Sanayii A.Ş. Kv test laboratuvarında gerçekleştirilmiştir.



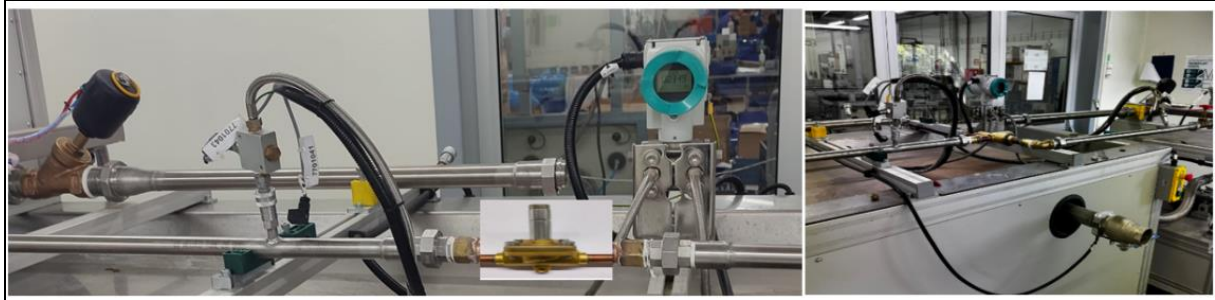
Şekil 18. Delikli Parçaların 3D yazıcıda üretilmesi ve optimize gövdeye montajı

Analiz sonucunda basınç farkları hesaplanmış ve elde edilen veriler ile grafikler kullanılarak tasarımlar arasında Kv değerleri ile karşılaştırmalar yapılmıştır. En verimli ve vana karakteristik değerini artıran tasarım belirlenecek ve iyileştirilmiş ürünler deney düzeneğinde test edilerek gerçek Kv değerleri araştırılacaktır.



Şekil 19. Deneyde Kullanılan Ana Malzemeler ve Deney Düzenegi

Deneyin amacı, çekvalfte oluşan basınç farkını kullanarak Kv katsayısını hesaplamaktır. Deneyde kullanılan ana elemanlar pompa, kısılma vanası, basınç ölçer ve debimetredir. Pompadan gönderilen suyun debisi ve çekvalfe girmeden önceki giriş basıncı debimetre ile ölçülür. İki basınç ölçer kullanılarak fark basıncı elde edilir ve akış ile verilen değer yardımıyla Kv değeri hesaplanır.



Şekil 20. Test ve Deneyler

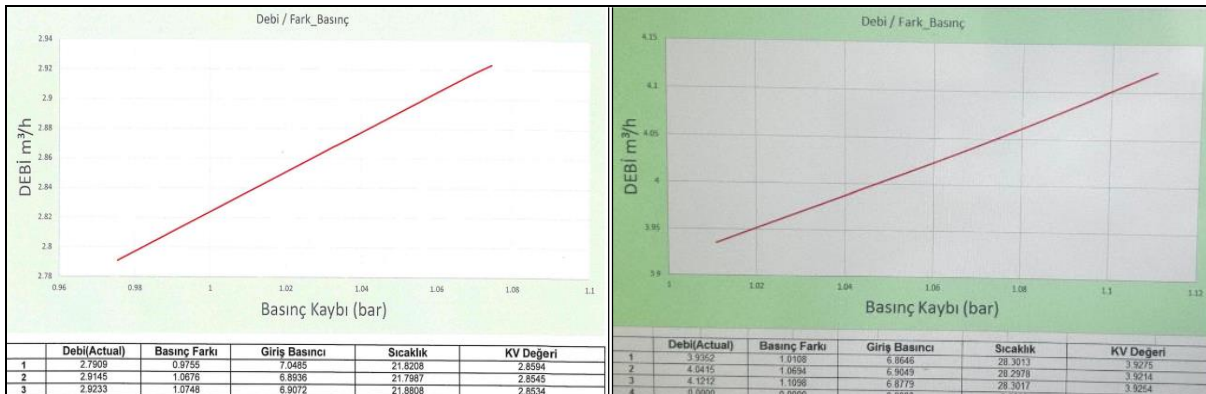
Tablo 2'de analiz sonuçlarından giriş ve çıkış basınçları ile saniye başına geçen metreküp hacim değerlerini kullandık ve çapın bize verilen ilk tasarımdaki değerini (23.3 mm) arttırarak çapın 27 mm 'ye geldiğinde Kv değerinin en yüksek değere çıktığı görüldü ve bu analiz sonuçları yukarıda gösterilmiştir.

Tablo 2. Farklı çaplarda hesaplanan Kv değerleri

	Pinlet	Poutlet	m ³ /h	Kv
çap23.3	2.6512174	0.051586107	2.308277	1.430345
çap24	2.5690191	0.05389107	2.382868	1.501166
çap25	2.5453922	0.056620762	2.459713	1.557761
çap26	2.5305315	0.057446496	2.4964	1.586001
çap27	2.5258922	0.058863821	2.506988	1.594682
çap28	2.5299627	0.062522463	2.502816	1.591895

SONUÇ

Solenoid valfin tasarımında yapılan değişiklikler detaylı olarak açıklanmıştır. İlk olarak sac parçada, ardından klapenin vurduğu çapta değişiklikler gerçekleştirilmiştir. Başlangıçta 3 mm olan delik çapı, önce 3.5 mm (Tasarım 1) ve ardından 4 mm (Tasarım 2) olarak analiz edilmiştir. 3.5 mm çapında yapılan değişikliğin beklenen iyileşmeyi sağladığı belirlenmiştir. Delik çaplarının değiştirilmesi, ana deliğin bulunduğu kısımda üç türbülans bölgesinin küçülmesine yol açmış, bu da akışın daha stabil ve düzenli olmasına katkı sağlamıştır. Diyafram sacında ikinci parametre olarak, delik çaplarının daha düşük bir yörünge çapında yeniden analizi yapılmıştır. Yörünge çapı 22.6 mm'den 22 mm'ye düşürülmüştür. Bu değişiklikler, valf içindeki diğer parçalar sabit kalırken analiz edilmiştir. Yörünge çapının azaltılması, akışta girdap oluşumunu artırmış ve akışkanın yukarı hareketini engellemiştir. Ayrıca, bu değişiklikler hacmi etkilememiş, ancak girişte türbülans artışına neden olmuştur. Artan türbülans, enerji kaybına yol açmış ve Kv değerini düşürmüştür. Gerçekleştirilen altı analiz sonucunda, Tasarım 1 en optimal bulunmuş ve Kv değeri, başlangıç tasarımı (Tasarım 0) ile karşılaştırıldığında %6,12 daha yüksek olduğu belirlenmiştir. İkinci bölümde, delik çapında yapılan değişikliklerle akış hacmini artırma amacı incelenmiştir. 23.3 mm olan delik çapı 28 mm'ye genişletilmiş, ancak bu değişikliklerin Kv üzerinde olumlu bir etkisi olmamıştır. Basınç kontürlerinin incelenmesi, çap arttıkça basınç farkının azaldığını göstermiştir. Özellikle giriş ve çıkışlar arasındaki basınç farkı belirgin şekilde azalırken, hız vektörleri valf duvarlarına çarparak akışı yönlendirmiş ve türbülansın pozitif etki yarattığı gözlemlenmiştir. Yapılan test sonuçları ile %10 değerinde Kv değeri artışı doğrulanmıştır.



Şekil 21. Test Sonuçları

KAYNAKLAR

- Dickenson, T. C. (1999). *Valves, Piping and Pipelines Handbook* (3rd ed.). Elsevier Science, pp. 157-174.
- Gürel, S. (2003). Türk Tesisat Mühendisleri Derneği. Retrieved from <https://www.ttmd.org.tr/PdfDosyalari/Dergi-Eki-26-1-1.pdf> (Accessed: February 12, 2024).
- Kalke, Y. M., Gaurkhede, G. A., & Kawade, H. (2020). Modification and analysis of globe valve using computational fluid dynamics. *Indian Journal of Steam*.
- Kim, K.-Y., Samad, A., & Benini, E. (2019). Design optimization of fluid machinery applied through computational fluid dynamics and numerical optimization. Singapore: John Wiley & Sons.
- Kim, N.-S., & Jeong, Y.-H. (2021). An investigation of pressure build-up effects due to check valve's closing characteristics using dynamic mesh techniques in CFD. *Annals of Nuclear Energy*, 152, 107996.
- Praveen, J. V. S., & Pathan, M. (2015). Flow coefficient analysis for a globe valve using CFD. *International Journal of Science and Research (IJSR)*, 6, 757-763. <https://doi.org/10.21275/ART20178896>
- Smith, P., & Zappe, R. W. (2004). *Valve Selection Handbook: Engineering fundamentals for selecting the right valve design for every industrial flow application*. Elsevier.
- Yang, Q., et al. (2011). Numerical simulation of fluid flow inside the valve. *Procedia Engineering*.
- Yousaf, B., Qaisrani, M. A., Khan, M. I., Sahar, M. S. U., & Tahir, W. (2021). Numerical and experimental analysis of cavitation and flow characteristics in ball valves. *Nonlinear Engineering*. DOI: 10.1515/nleng-2021-0044.
- Kinski, R. (1982). *Uygulamalı Akışkanlar Mekaniği*. McGrawhill Yayınları.
- Kim, Kwang-Yong; Samad, Abdus; BENINI, Ernesto, 2019. Design Optimization of Fluid Machinery: Applying Computational Fluid Dynamics and Numerical Optimization. John Wiley & Sons
- Smith, Peter; Zappe, R. W, 2004. Valve selection handbook: engineering fundamentals for selecting the right valve design for every industrial flow application. Elsevier.
- Lin, Zhe, et al., 2017 . Numerical and experimental studies on hydrodynamic characteristics of sleeve regulating valves. *Flow Measurement and Instrumentation*, 53: 279-285.
- Praveen, J. V. S.; Pathan, Mehboob, 2017. Flow coefficient analysis for a globe valve by using CFD. *Int J Sci Res*, 6: 756-763.
- Tureson, Martin, 2011. Dynamic simulation of check valve using CFD and evaluation of check valve model in RELAP5. Master's Thesis.

İnternet Kaynakları

- https://docplayer.biz.tr/Ani_Genişleme. CC:daralma katsayısı (E.T. 11.11.2022)
- http://bilsenbesergil.blogspot.com/p/blog-page_941.html (E.T. 21.11.2022)
- https://en.wikipedia.org/wiki/Flow_coefficient (E.T. 03.12.2022)

EMNİYETLİ FIRIN MUSLUKLARINDA DEBİ ANALİZİ VE OPTİMİZASYONU
FLOW RATE ANALYSIS AND OPTIMIZATION OF OVEN TAPS WITH SAFETY
DEVICE

Deniz Cura

Makine Yüksek Mühendisi, E.C.A. Valf Sanayii A.Ş., Manisa, Türkiye

ORCID ID: 0000 0002 8633 9181

Emirhan Aşçı

Ege Üniversitesi, Mühendislik Fakültesi Makine Mühendisliği, İzmir Türkiye

ORCID ID: 0009-0003-8250-8456

ÖZET

Gaz yakan cihazlar yemek pişirme, ısınma ve sıcak su elde etme amacıyla kullanılan gaz yakıtlı ürünlerdir. Bu cihazlar günümüzde genel olarak LPG ve doğalgaz (DG) ile kullanılmaktadırlar. Evsel ve endüstriyel ocaklarda gaz geçişini açan/kapan ve geçen gaz miktarını ayarlayan gaz valfleri, fırın musluğu olarak adlandırılmaktadır. Bahsedilen gaz valflerinin kullanıldığı evsel ve endüstriyel ocak ve fırınlarda karşılaşılan problemlerin başında; ateşleme sonrası alevin sönmesi, çakmağın ateşleme yapmaması, ocak gözüne yeterli veya hiç gaz gelmemesi, minimum alev konumunda alevin sönmesi olarak sıralanabilir. Türkiye ve Avrupa’da kullanılan ocakların çoğunda 0° konumunda gaz geçişi kapalı iken, 90° konumunda maksimum alev, 160° konumunda ise minimum alev boyutuna ulaşılmaktadır. Standart 4 gözlü bir set üstü ocakta en az 3 farklı debi de çalışan gaz valfine ihtiyaç duyulmaktadır. Tasarlanıp, üretilen gaz valfleri ister doğalgaz (DG) ister LPG olsun, üreticilerin talep ettikleri debilerde gaz geçişini sağlayan özelliklerde olması önem arz etmektedir. Genel olarak maksimum alev konumunda gaz akışı yüksek debide olduğundan sorun yaşanmaz iken, minimum pozisyonlarda ocak gözüne yeterli gaz gitmediğinden alevin sönmesi karşılaşılabilen bir problemdir.

Bu yüzden minimum konumdaki gaz debisi üretim, test ve montaj aşamasında en çok dikkat edilmesi gereken konuların başında gelmektedir. Bu çalışmada ilgili fırın musluğunun enjektör geçiş çapları üzerinde tasarımsal iyileştirmeler ile üç boyutlu katı modellemeler yapılmıştır. Farklı modeller hesaplamalı akışkanlar dinamiği programına aktarılarak debi analizleri yapılmış olup, debi-enjektör geçiş çapı ilişkisi incelenmiştir. Hesaplamalı akışkanlar dinamiği (HAD) programından elde edilen optimize geçiş çapı değerleri, deneysel çalışmalardan elde edilenden %4 daha küçüktür. Deneysel ve hesaplanan değerler arasındaki %4’lük fark kabul edilebilir seviyededir. Oluşan bu farkın temel sebepleri, HAD analizindeki sabit test koşulları (basınç, sıcaklık, yoğunluk, nem) ve katı modelde akış karakteristiğini olumsuz etkileyecek parça ve kuvvetlerin ihmal edilmesi olarak düşünülmektedir.

Anahtar Kelimeler: Debi, debi analizi, debi optimizasyonu, enjektör, geçiş çapı, fırın musluğu, ocak, LPG, DG

ABSTRACT

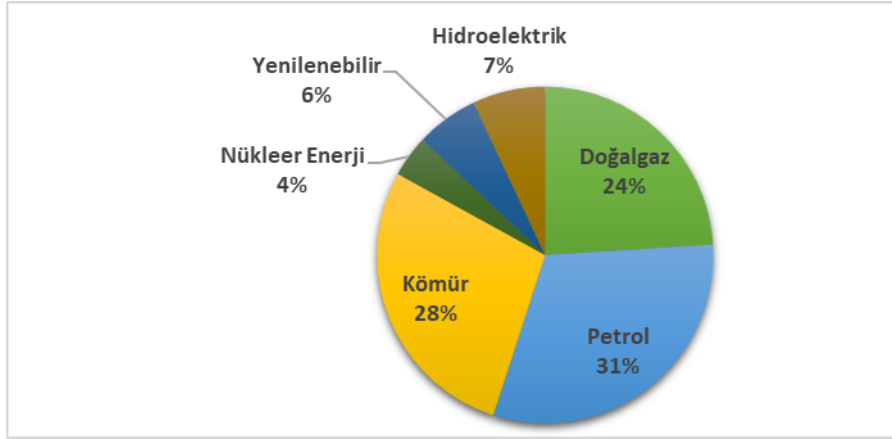
Gas powered devices are generally used for cooking, heating and obtaining hot water appliances. These devices are used LPG and natural gas (NG) as energy source. Gas valves which are used to open/close and adjust gas flow rate of household and industrial ovens, generally known as oven taps. Main problems of mentioned gas valves on household and industrial ovens; blowing off flame after ignition, not providing flame by lighter, inadequate gas flow rate or zero gas flow rate, blowing off flame at minimum position. In Turkey and Europe, most of the gas hobs have these working principal; 0° position means closed while 90° and 160° positions express maximum and minimum flow rates respectively. Generally gas hobs need at least 3 different gas valves with different flow rates. It is really crucial that providing gas flow rate desired by oven producers, whether designed and produced gas valves for LPG or natural gas (NG) as fuel. In general at maximum flow rate position, no problem is observed while at minimum flow rate position, it is observed that blowing of flame due to inadequate gas flow.

For these reasons minimum position of the oven tap is really important in terms of producing, testing and mounting stages. In this study, different 3d models were created as design improvements were done on nozzle transition diameter. Different 3d models were transferred to CFD software and gas flow rate calculations were done. The relationship between flow rate-nozzle transition diameter has been investigated also. Optimized nozzle diameter values from computational fluid dynamics (CFD) software is %4 less than from experimental studies have been reached for desired flow rates. The 4% difference between experimental and calculated values is considered acceptable. It is thought that, the main reasons for this difference; Constant CFD analysis conditions (pressure, temperature, density, moisture), ignored parts and forces which may corrupt the fluid characteristics on 3d model.

Keywords: Flow rate, flow rate analysis, flow rate optimization, nozzle, transition diameter, oven tap, hob, LPG, NG

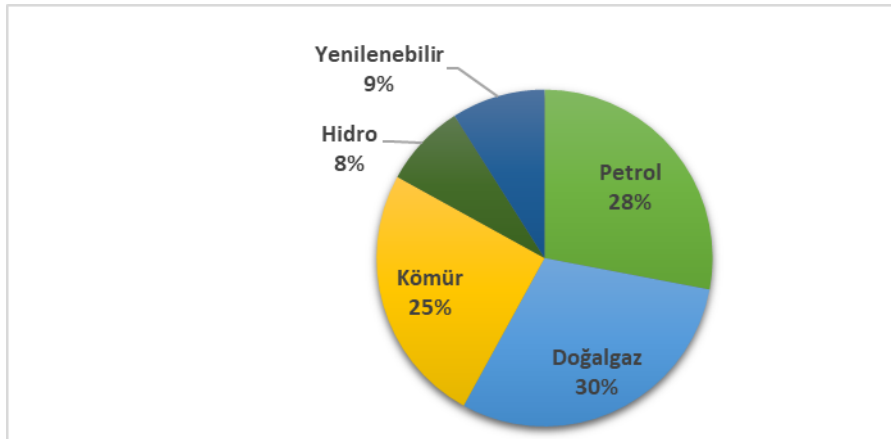
GİRİŞ

Hızlı sanayileşme ve teknolojik gelişmelere bağlı olarak, küresel enerji tüketimi her geçen gün hızla artmaktadır. 2020 yılında kaydedilen küresel enerji tüketimi %5,5 artışla 2021 yılında 595.15 EJ seviyesine ulaşmıştır. (Bp, 2022) Artan bu enerji tüketimi, diğer enerji kaynaklarına oranla daha çok yenilenebilir olmayan petrol, kömür, doğalgaz kaynaklarından karşılanmaktadır. Bahsedilen bu fosil yakıtların büyük ölçüde tüketiminin, gelecekte rezervlerin tükenmesine, küresel ısınma ve iklim değişikliği gibi sorunlara yol açabileceği bilinmektedir. Küresel enerji tüketiminde, kaynak olarak petrol, kömür ve doğalgaz sırasıyla %31, %28 ve %24 ile başta gelmektedir.



Şekil 1: Enerji kaynaklarına göre dünya 2021 enerji tüketimi (Bp, 2022)

Türkiye'deki enerji tüketimi ise 2021 yılında bir önceki yıla göre %6'lık bir artışla 6.83 EJ seviyesine yükselmiştir. Bu tüketim oranında, enerji kaynakları açısından %30 ile doğalgaz ve %28 ile petrol başta gelmektedir. Petrol ve doğalgazın ülkemizdeki tüketimi ise sırasıyla bir önceki yıla göre %2,7 ve %24 artış göstererek en fazla kullanılan 2 enerji kaynağı olmuştur.



Şekil 2: Enerji kaynaklarına göre Türkiye 2021 enerji tüketimi (Bp, 2022)

Tablo 1. Türkiye Enerji Kaynaklarına göre Enerji Tüketimi (Bp, 2022)

Türkiye Enerji Tüketimi 2020-2021			
Enerji Kaynağı	2020 (EJ)	2021 (EJ)	Artış Miktarı (%)
Petrol	1,84	1,89	2,7
Doğalgaz	1,66	2,06	24
Kömür	1,70	1,74	2,4
Nükleer	0	0	0

Hidroelektrik	0,74	0,52	-29
Yenilenebilir	0,50	0,61	22
TOPLAM	6,44	6,83	6

LPG'nin Tanımı

Sıvılaştırılmış petrol gazı olarak da bilinen LPG, ham petrolün damıtılması sırasında elde edilen bütan ve propan gazlarının karışımından oluşmaktadır. Bu gazlar basınç altında, sıvılaştırıldıktan sonra belli oranlarda karıştırılarak veya her birisi saf şekilde kullanıma sunulmaktadır. Ancak günümüzde LPG tabiri ticari olarak %30 propan %70 bütan karışımından oluşan, karışım gaz için kullanılmaktadır. Karışım oranlarının, kullanıldıkları iklime göre değişmekle birlikte, temel fark donma noktalarındaki farklılıktır. (Şaşmaz ve Altıntaş, 2021) LPG konutlarda ısınma, sıcak su ve pişirme amacıyla, sanayide ise ısıtma, ısıl işlem, kurutma, kaynak, kesme, buhar ve elektrik üretiminde verimli ve kolay kullanılabilen bir enerji kaynağıdır. (Önder, 1999)

Doğalgaz'ın Tanımı

Petrol türevlerinden bir diğeri olan doğal gaz: yanıcı, havadan hafif, renksiz ve kokusuz bir gaz olmakla birlikte, Başta metan (CH₄) ve etan (C₂H₆) olmak üzere çeşitli hidrokarbonlardan oluşur. Yer altında, genellikle petrol ile birlikte veya gaz rezervuarlarında bulunur. (Botaş, 2024) Kaynağından çıkarıldığı haliyle herhangi bir işlemde geçmeden kullanılabilen doğal gaz, boru hatları ile veya sıvılaştırılarak tankerlerle taşınır. Doğalgaz konutlarda ısınma, sıcak su ve pişirme amacıyla kullanılabilir. LPG alternatif yakıt olarak doğal gaz yedeklemesinde ve LPG-doğal gaz fiyat dengelemesinde büyük bir yer almaktadır. (Önder, 1999)

LPG ve Doğalgazın Pişirmede Kullanımı

LPG ve doğal gaz, evsel ve endüstriyel ocak ve fırınlarda temel olarak pişirme ve ısıtma amacıyla kullanılmaktadır. Tam boy fırınlı ocakların, ocak kısımlarında, alevin yandığı ve gıdaların tencere gibi pişirme araçları ile üzerine konduğu, beklere giden gaz debisini ayarlayan, gaz geçişini açan/kapatan bu valflere fırın musluğu adı verilmektedir. Genel olarak kumanda mili saat yönü tersine 90° basılarak çevrildiği konumda gaz debisi maksimum olduğundan alev boyu da maksimum olmaktadır. Kumanda Mili +70° daha saat yönü tersine çevrildiği konumda ise gaz debisi minimum olduğundan alev boyu da minimum seviyede olacaktır. Kullanıcı istediği alev boyunu, fırın musluğu milini bir plastik veya metal daire şekilli düğme yardımıyla çevirerek ayarlayabilmektedir.



Şekil 3. Fırın Musluklarının Montaj Görşeli (Copreci,2023)

Fırın Musluklarında Güvenlik

Fırın, ocak gibi gazlı pişirme cihazlarında bek alevinin yemek/su taşması ya da rüzgar gibi bir fizksel sebeple sönmesi durumunda oluşan gaz kaçakları can ve mal kaybına neden olabilmektedir. Bu durumun önüne geçebilmek için fırın muslukları bir emniyet tertibatı ile tasarlanıp, üretilmektedir. Çalışma prensibi temel olarak; bek alevinin sönmesi durumunda gaz geçişini kesmeye, bek alevi algılandığında ise gaz geçişine izin vermeye dayanmaktadır. Teknik açıdan ise çakmak ile ocak ateşlendiğinde termokopul alevin sıcaklığını algılayarak, ısı enerjisi elektrik enerjisine dönüşür, mıknatıs (magnet) olarak adlandırılan emniyet elemanında manyetik alan oluşarak, gaz geçişini mümkün kılar.



Şekil 4. Emniyetli Fırın Musluğu ve Emniyet Tertibatı (E.C.A, 2021)

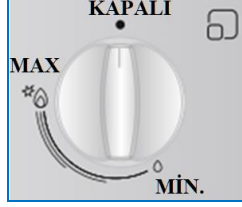
Fırın musluklarının tasarım, test ve kullanım koşulları uluslararası kabul gören EN 13611, EN 1106, EN 125, EN 126 standartlarında belirtilmiştir. Standartlara uygun yapılan üretimler hem evsel hem de endüstriyel son kullanıcı tarafında güvenlik, performans konularında fayda sağlamaktadır.

Fırın Musluklarının Kullanımında Karşılaşılan Sorunlar

Fırın musluklarının, evsel ve endüstriyel ocak/fırınlarda kullanımında karşılaşılan problemlerin başında aşağıda bahsedilenler gelmektedir:

1. Ateşleme sonrası alevin sönmesi
2. Çakmağın ateşleme yapmaması
3. Ocak gözüne yeterli veya hiç gaz gelmemesi
4. Ocak minimum alev konumunda iken alevin sönmesi

Türkiye ve Avrupa’da kullanılan ocakların çoğunda 0° konumunda gaz geçişi kapalı iken, 90° konumunda maksimum gaz geçişi ve maksimum alev boyu, 160° konumunda ise minimum gaz geçişi dolayısıyla minimum alev boyuna ulaşılmaktadır.

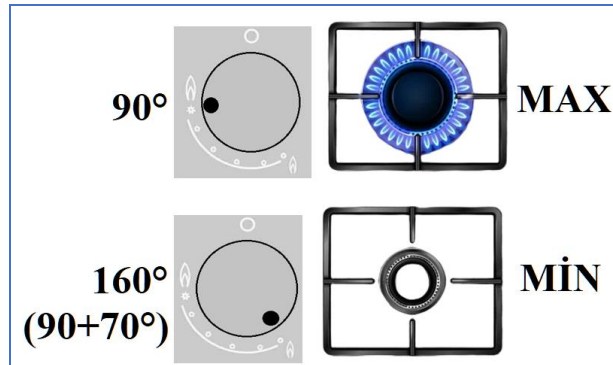


Şekil 5. Ocak Düğmesinin Konumları

Standart 4 gözlü bir set üstü ocakta en az 3 farklı debi de çalışan gaz valfine ihtiyaç duyulmaktadır. Örnek olarak 8.6kW gaz gücü beyan edilen dört gözlü bir ocakta; yardımcı bek:1kW, Vok beki 3.6kW, sol ve sağ normal bek için 2kW şeklinde görülmektedir. (Arçelik, 2023).

Problemin Tanımı

Tasarlanıp, üretilen fırın muslukları ister doğalgaz (DG) ister LPG ile kullanılsın, üreticilerin talep ettikleri debilerde gaz geçişini sağlayan özelliklerde olması önem arz etmektedir. Genel olarak maksimum alev konumunda gaz akışı yüksek debide olduğundan sorun yaşanmaz iken, minimum pozisyonlarda ocak gözüne yeterli gaz gitmediğinden alevin sönmesi sık karşılaşılabilen bir problemdir. Bu yüzden minimum konumdaki gaz debisi üretim, test ve montaj aşamasında en çok dikkat edilmesi gereken konuların başında gelmektedir. Bu da fırın musluklarının minimum debisinin ne olacağına karar veren enjektör (debi düşürücü) adı verilen parçanın doğru ölçülerde tasarlanıp üretilmesi ile sağlanabilir.



Şekil 6. Ocak Alevinin Konumlara Göre Değişimi

YÖNTEM

Bu çalışmada, ocak minimum alev konumunda iken alevin sönmesi problemi üzerine çalışıldı. Üretimi yapılan bir fırın musluğunun, minimum konumdaki gaz debisini belirleyen enjektör (debi düşürücü) adlı parçanın özellikle gaz geçiş yolları tasarımında yapılan değişikliklerin gaz debisine etkisi gözlemlendi. Öncelikle 3 boyutlu tasarım programında fırın musluğunun katı modeli oluşturuldu ardından bu katı model hesaplamalı akışkanlar dinamiği programı

vasıtasıyla akış analizine tabi tutuldu, referans alınan gerçek bir fırın musluğunun debisine ulaşana kadar enjektör tasarım ve geçiş çapı değerleri değiştirilerek analiz tekrarlandı. Son olarak akış analizinden alınan değerler ve fiziki fırın musluğunun laboratuvar ortamında yapılan testlerle elde edilen gaz debisi değerleri kıyaslandı. Öncesinde konu ile ilgili benzer makaleler incelendi.

ARAŞTIRMA VE BULGULAR

Albizuri (2010) “Rotary Valve Arranged In A Multi-Gas Cooker” tasarımında gazın maksimum debisini sınırlamak için volan-mil mekanizmasına dayanan orbital pim kullanmıştır. Aybegüm Numanoğlu ve Orhan Erden (2019) “Ev Tipi Set Üstü Gazlı Ocaklarda Maliyet ve Kalite İyileştirme Amaçlı Bir Değer Mühendisliği Uygulaması” çalışmasında gaz musluklarında pirinç malzeme yerine alüminyum malzemedan üretilmesini sağlayarak ve bek odasında kullanılan alüminyum malzeme miktarının %10 azalmasını sağlayarak tasarım iyileştirmeleri yapmış ve maliyet azalışı gerçekleştirmişlerdir. Aynı zamanda alüminyum kullanım miktarını %10 azaltarak tasarladıkları bek odasıyla mevcut ocaklardaki yanma verimliliğinin %6 üstünde yanma verimliliği gerçekleştirmişlerdir.

Boru İçi Akış

Boru veya kanal içerisinde hareket eden akışkanlar için enerji kayıpları, tasarımda büyük önem arz eder. Bu kayıplar için iki temel etken vardır; yerel kayıplar ve sürtünmeler dolayısıyla oluşan kayıplar. Yerel kayıpların oluşmasında; dirsekler, düğüm noktaları, valfler ve çap değişimleri etkilidir. Sürtünme kayıpları ise akışkanın, boru veya kanal yüzeyinden geçerken oluşacak kayıplardır. Boru veya kanal akış sistemleri için Bernoulli Denklemi, kayıpları analiz etmek için kullanılan en yaygın yöntemdir. Bu denklem şu şekilde yazılır.

$$\frac{V_1^2}{2g} + \frac{P_1}{\gamma} + z_1 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + z_2 + h_s + h_y$$

Burada bulunan h_s sürtünme kayıpları için, h_y yerel kayıplar için atanmış enerji birimleridir. Toplam enerji kaybı için kullanılan formül

$$h_k = \sum h_s + \sum h_y$$

Laminar Ve Türbülanslı Akışlarda Reynolds Sayısı

Yapılan deneylerle Reynolds, laminar akış ile türbülanslı akış geçişinin, akışkanın atalet kuvvetlerinin (FA) viskoz kuvvetlerine (FV) oranı ile bulunabileceğini ortaya koymuştur. Boyutsuz sayı Reynolds Sayısı'nın denklemi de, silindir borular için oluşmuştur; (Recebli ve Özkaymak, 2013)

$$Re = \frac{FA}{F_V} = \frac{U_0 D}{\nu} = \frac{\rho U_0 D}{\mu}$$

$Re \leq 2300$ Laminar Akış

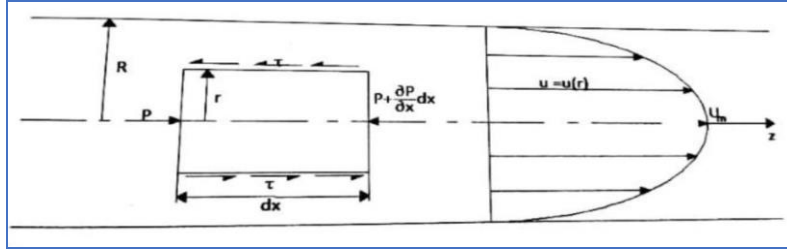
$2300 \leq Re \leq 4000$ Geçiş Akışı

$Re \geq 4000$ Türbülanslı Akış olarak kabul edilmektedir. (Recebli ve Özkaymak, 2013)

Laminar Akış

Boru veya kanal boyunca aksel yönde hareketini sürdüren akışkanın oluşturacağı akım çizgileri sabit hızla hareket eder. Akış hattında gözlemlenen parçacık etrafında oluşacak kuvvetlerin dengesini incelendiğinde akış formülü elde edilir;

$$u = u(r) = -\frac{R^2}{4\mu} \frac{\partial P}{\partial x} \left(1 - \frac{r^2}{R^2}\right)$$



Şekil 8. Laminar Akışın Boru İçinde Oluşturduğu Kuvvetler (Recebli ve Özkaymak, 2013)

Tam gelişmiş laminar akışta orta noktada ($r = 0$) hız maksimum seviyededir. Boru veya kanal kenarlarında hız sıfırdır. Parabolik bir eğri formuna dönüşür. Formül önündeki eksi (-) işareti ise akışın + x yönünde ilerlerken $\partial P/\partial x$ 'ye bağlı olarak basıncın azaldığını göstermektedir. (Recebli ve Özkaymak, 2013)

İki nokta arası basınç denklemi şu şekilde elde edilir; (Aracı ve Kınacı, 2018)

$$\frac{\partial P}{\partial x} = \frac{P_1 - P_2}{L}$$

Laminar akış için maksimum ve minimum değerlerin ortalama hız denklemleri; (Recebli ve Özkaymak, 2013)

$$u(r) = 2U_0 \left(1 - \frac{r^2}{R^2}\right)$$
$$U_0 = \frac{\Delta P D^2}{32\mu L}$$

Türbülanslı Akış

Silindirik boru veya kanallarda $Re \geq 4000$ olan akış türleri için türbülanslı akış tanımlaması yapılır. Türbülanslı akışlar herhangi bir formül veya analitik çözüm yoluyla hesaplanamayan akış titreşimleri oldukları için yaklaşık çözüm yapılır ve bunu yaparken kullanılacak eğriler, bilim insanlarınca deneylerle oluşturulmuş uydurma eğrilerdir. Bunlar için farklı deneysel formüller gerekir. Nikuradse'nin, tam pürüzlü yüzeyler için bağıl pürüzlülüğe bağlı formülü;

$$C_f \approx 0,045 \left(\frac{\varepsilon}{D} \right)^{\frac{1}{3}}$$

Bu pürüzlülük değeri ile Reynolds Sayısı'nı bulmak için;

$$\frac{1}{\sqrt{C_f}} = -3,61 \log \left[\frac{6,9}{Re} + \left(\frac{\varepsilon/D}{3,7} \right)^{1,11} \right]$$

Blasius tam pürüzsüz yüzeyle boru ve kanallar için Reynolds Sayısı'na bağlı bulduğu formüller;

$$10^4 < Re < 5 \cdot 10^4 \text{ için } C_f = 0,079 \cdot Re^{-0,25}$$

$$3 \cdot 10^4 < Re < 10^6 \text{ için } C_f = 0,046 \cdot Re^{-0,2}$$

Cyril F. Colebrook'un pürüzlü ve pürüzsüz boruların içerisinde geçiş bölgesi ve türbülanslı akışların gerçekleştiği deneylerden elde ettiği verilerle oluşturduğu Colebrook denklemi;

$$\frac{1}{\sqrt{f}} = -2 \log \left[\frac{\varepsilon/D}{3,7} + \frac{2,51}{Re \sqrt{f}} \right]$$

ANALİZ

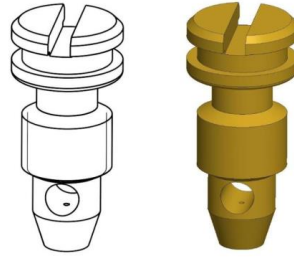
Kabuller

- Analizlerde akış tipi olarak türbülanslı akış seçildi.
- Test sıcaklığı 20°C olarak kabul edildi
- Analiz giriş-çıkış basınç farkı 20 mbar kabul edildi.
- Akışkan olarak EN 1106 standardı gereği hava seçildi.
- Fırın musluğu minimum konumda (Mil 160° saatin tersi yönünde) emniyet tertibatı alevi algılamakta ve gaz geçişine izin verdiği kabul edilmektedir.
- Mamulde herhangi bir kaçağa sebebiyet verecek bir durum olmadığı kabul edildi.

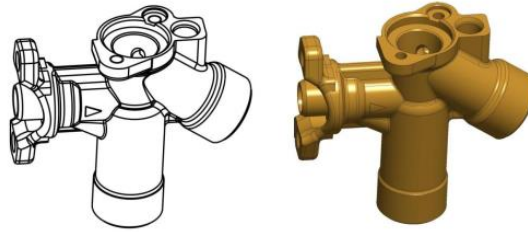
- Analizde mil, yay, conta, emniyet tertibatı ve bunların oluşturacağı direnç ve yay kuvvetleri ihmal edildi.
- Analizde hata almamak adına gövde ve enjektör harici parçalar ihmal edilerek kapalı bir geometri elde edilerek akış geometrisi oluşturuldu.

Katı Modelleme

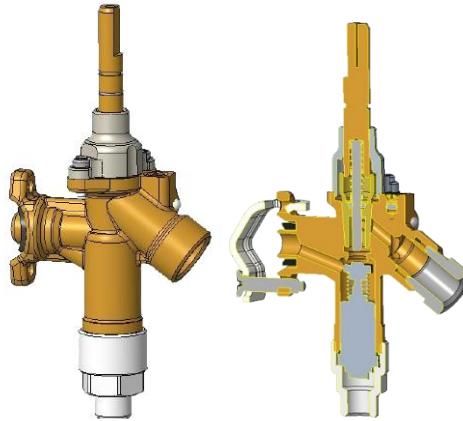
Üç boyutlu katı modelleme programı ile ilgili fırın musluğu gövde ve enjektör başta olmak üzere tasarımları yapıldı ve analiz için uygun hale getirildi.



Şekil 7. Enjektör Tasarımı



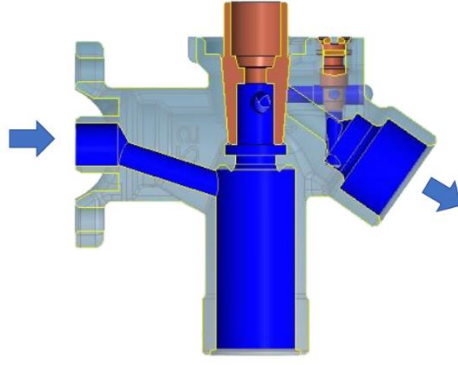
Şekil 8. Gövde Tasarımı



Şekil 9. Komple Fırın Musluğu Tasarımı

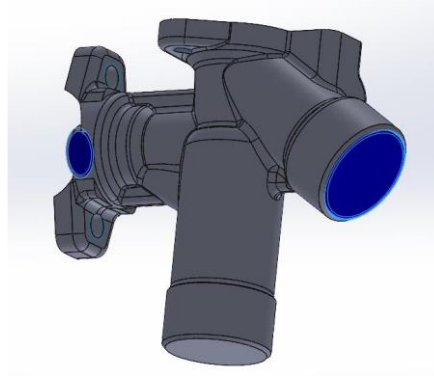
Akış Analizi

Akış Analizi için öncelikle bir akış alanı tanımlandı ve fırın musluğu tek bir parça ve geometride dışta bir boşluk kalmayacak şekilde katı model akış analizine hazırlandı.

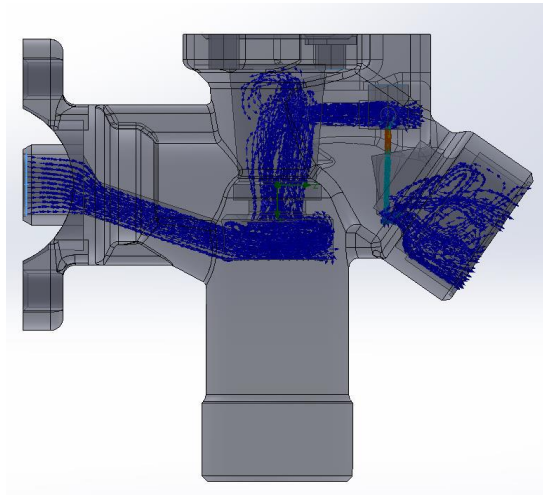


Şekil 10. Gaz Akış Yönü

Giriş ve çıkış sınır koşulları, akış türü, akışkan türü, giriş-çıkış basınç farkı ve test sıcaklık değerleri hesaplamalı akışkanlar dinamiği programına işlendikten sonra, analizlere 0.25mm enjektör gaz geçiş yolu \emptyset değeri ile analize başlandı. Referans debi değerine ulaşana dek analiz tekrarlandı.



Şekil 11. Giriş-Çıkış Sınır Koşullarının Belirlenmesi



Şekil 12. Akış Analizi Simülasyonu

Deneysel Çalışma

Analiz sonuçları ile kıyaslayabilmek için fiziki numuneler debi testine tabi tutuldu. Öncelikle mamullerde iç ve dış sızdırmazlık olup olmadığı kontrol edildi. Kontroller; fırın musluğu girişi açık-çıkışı kapalı ve fırın musluğu tamamen kapalı olacak şekilde 6mbar ve 150mbar hava ile teste tabi tutuldu, kaçak testinden geçen numuneler debi testine tabi tutuldu. Ayrıca emniyet tertibatının çalışıp çalışmadığı da test edildi.

Debi testleri EN 1106 gereği kalibre bir ATEQ debi ölçüm cihazı ile fırın musluğunun girişi cihaza bağlandı ve Mil minimum gaz debisi konumunda iken yaklaşık 20mbar basınçlı hava verilerek minimum konumdaki gaz debisi, akış analizi sonuçları ile kıyaslanmak üzere kaydedildi. Debi değeri kaydedilen fiziki numuneler demonte edilerek enjektör geçiş çapları ölçüldü.



Şekil 13. Deneysel Çalışma

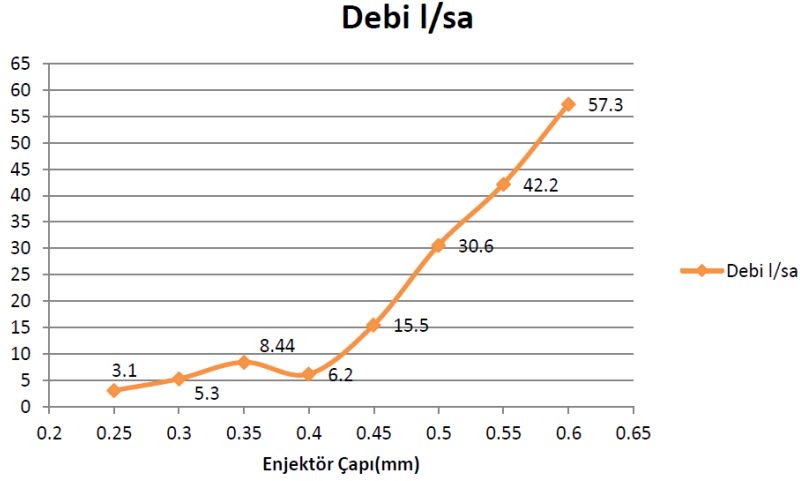
SONUÇ

Analizde hedef debi aralığına (40-45L/sa) 0.55-0.6 mm enjektör geçiş çapı değerleri ile ulaşıldı. Ardından analiz bu değerler arasında tekrarlandı. Ø0.55 mm değeri için hacimsel debi 42,2 l/sa, Ø0.56 mm değeri için hacimsel debi 44,99 l/sa olarak elde edildi. Laboratuvarda testleri yapılan fiziki numunede ise 40-45 L/sa debi aralığında; enjektör geçiş çapı 0,58mm için 45 L/sa olarak ölçüldü. Deneyisel çalışma ile analiz çalışması arasında yaklaşık %3.6'lık bir fark gözlemlendi. Elde edilen bu fark kabul edilebilir sınırdan olmakla birlikte, olası sebepler aşağıda tartışılmıştır.

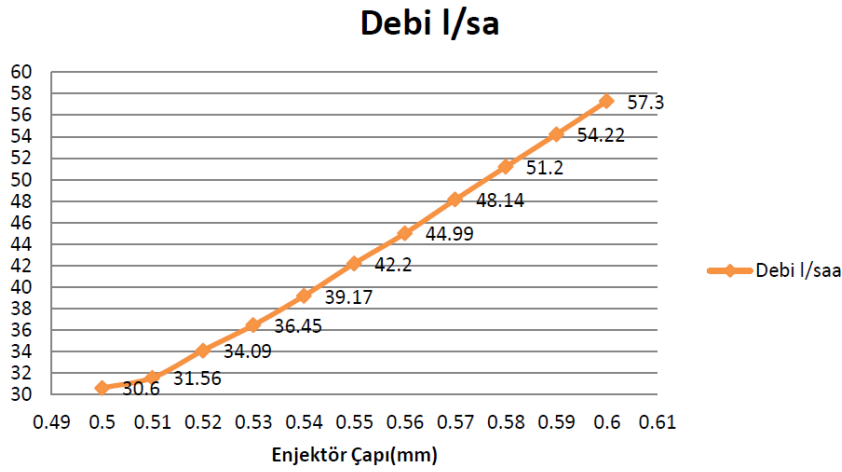
Test Ortamı ve Koşulları: laboratuvar testlerinde kullanılan ortamın sıcaklık, basınç ve nem gibi faktörleri, enjektör performansını etkileyebilir. Akış analizinde sabit kabul edilen faktörler, enjektör çıkışındaki debi miktarını etkileyebilir ve sonuç olarak farklı değerler elde edilebilir.

Operatör Tekniği: Testler sırasında kullanılan teknikler ve operatörün deneyim düzeyi, sonuçları etkileyebilir.

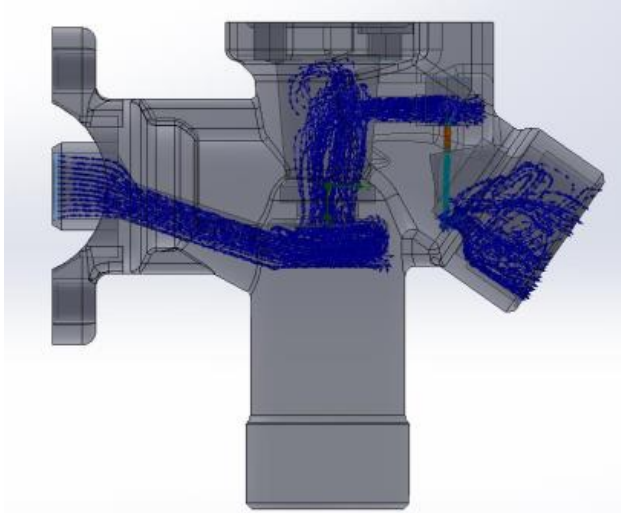
Test Cihazlarının Hassasiyeti ve Doğruluğu: Kullanılan ölçüm cihazlarının hassasiyeti ve doğruluğu, elde edilen sonuçları etkileyebilir. Cihazların kalibrasyonu ve doğru bir şekilde kullanılması, doğru sonuçlar elde etmede kritik öneme sahiptir.



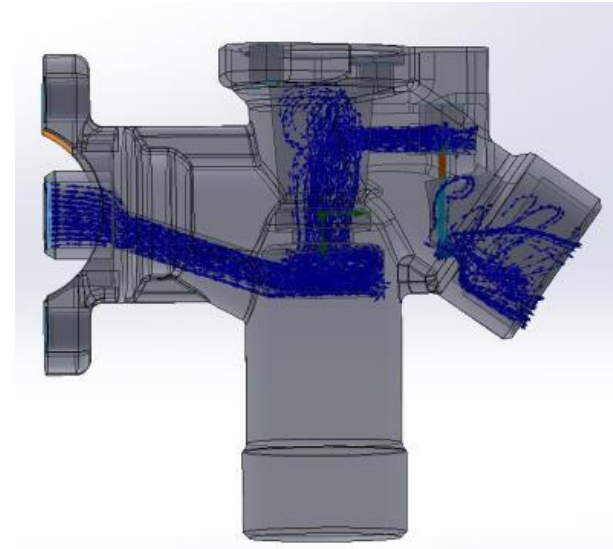
Tablo 2. Analiz Sonucu Debi-Enjektör Çapı İlişkisi



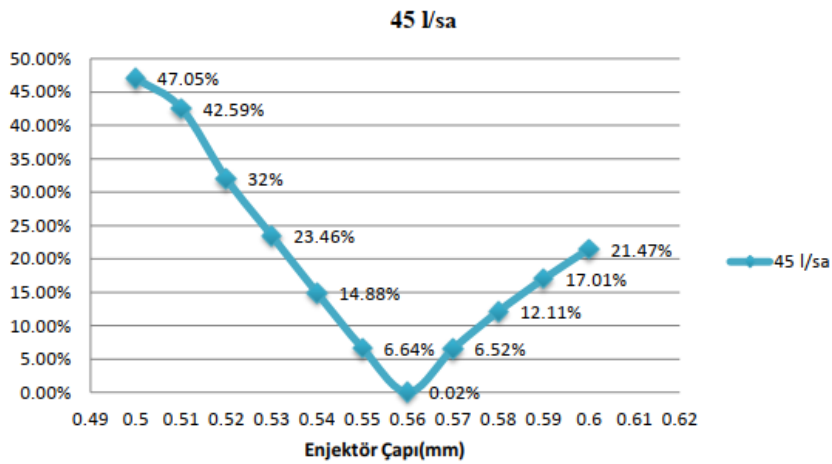
Tablo 3. 0.5-0.6mm Çap Değerine Karşılık Gelen Debi Değerleri



Şekil 14. Enjektör Ø0,55 Valf Akış Analizi



Şekil 15. Enjektör Ø0,56 Valf Akış Analizi



Tablo 4. Debi-Enjektör Çapı Hata Değeri

KAYNAKÇA

- Bp, “Statistical Review of World Energy”, 2022,
<https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energyeconomics/statistical-review/bp-stats-review-2022-full-report.pdf> (Erişim tarihi:15 Ocak 2024).
- Önder, D., 1999, SANAYİ TESİSLERİNDE LPG KULLANIMI VE YAKMA SİSTEMLERİ, IV. Ulusal Tesisat Mühendisliği Kongresi.
- TMMOB Makina Mühendisleri Odası, “Doğal Gazın Konutlarda Güvenli ve Verimli Kullanımı”,
<https://www.mmo.org.tr/sites/default/files/users/izmir/dogalgazbrosur.pdf> (Erişim tarihi: 17 Ocak 2024).
- Arçelik, “Setüstü Ocak Kullanma Kılavuzu” , (2023),
https://download.arcelik.com.tr/download.usagemanuals/24142_185241232_arc.pdf (Erişim tarihi: 17 Ocak 2024)
- Albizuri, I. (2010), Rotary valve arranged in a multi-gas cooker, U.S. Patent No.7,651,330. Washington, DC: U.S. Patent and Trademark Office.
- Numanoğlu, A., Erden, O., 2019, Ev tipi set üstü gazlı ocaklarda maliyet ve kalite iyileştirme amaçlı bir değer mühendisliği uygulaması, Uluslararası Doğu Anadolu Fen Mühendislik ve Tasarım Dergisi, 1(1), 87-98.
- Şaşmaz, E., Altıntaş, A., 2021, Gaz ve Tüp Valflerinin Tanıtımı Ve Çalışma Sistemi, Mühendis ve Makina Güncel, sf. 43.
- Kırkgöz, S., 2013, Akışkanlar Mekaniği, Birsen Yayınevi, İstanbul, sf. 303-304.
- University of Sydney, 2005, Aerospace
http://wwwmdp.eng.cam.ac.uk/web/library/enginfo/aerothermal_dvd_only/aero/fprops/pipeflow/node8.html (Erişim Tarihi: 15 Mart 2024)
- Recebli, Z., Özkaymak, M., 2013, Akışkanlar Mekaniği, Seçkin Yayınevi, sf. 175-200.
- Aracı, S., Kınacı, Ö. K., 2018, Boru içi akışlarda basınç kaybının sayısal hesabı,Gemi ve Deniz Teknolojisi, (211), 39-60.
- Paulo, R., 2024, A Note on the Moody Diagram, Fluids, 9(4), 98.
- BOTAŞ, “Doğalgaz nedir” <https://botas.gov.tr/Sayfa/dogal-gaz-nedir/249>) (Erişim tarihi: 19 Nisan 2024).
- E.C.A, Dik Tip Emniyetli Fırın Musluğu, 2021 <https://eca.com.tr/dik-tip-emniyetli-firin-muslugu-2> (Erişim Tarihi: 23 Nisan 2024)
- Copreci, Gaz Ürünleri Kataloğu, 2023
https://www.copreci.com/download/catalogos/Copreci_gas_cooking.pdf (Erişim Tarihi 19 Mayıs 2024)

A REVIEW OF THE ENVIRONMENTAL SUSTAINABILITY OF BIOFUELS

S. SANTHOSH KUMAR

Lecturer & Research Scholar, Mechanical Engineering, St. Joseph University in Tanzania, Dar es salaam,
Tanzania

J. Ajith kings

Prof. Dr., St. Xaviers Catholic College of Engineering, Nagercoil, India

ABSTRACT

Fuels are increasingly promoted as a low-carbon alternative to fossil fuels due to their potential to reduce greenhouse gas (GHG) emissions and mitigate climate change impacts from transportation. However, their expanded use raises concerns about possible unintended environmental consequences. Life cycle assessment (LCA) studies have examined the climate and environmental impacts of biofuels, but their findings often vary significantly. This paper aims to review and analyze the latest evidence to provide clearer insights into the environmental impacts of different liquid biofuels.

The review underscores that LCA outcomes are highly situational and influenced by factors such as feedstock type, production methods, data variations, and methodological choices. Despite these variations, evidence indicates that first-generation biofuels generally have lower GHG emissions than fossil fuels, provided there is no land-use change (LUC). However, the GHG reductions for most feedstocks fall short of the savings targets set by the EU Renewable Energy Directive (RED). Conversely, second-generation biofuels tend to offer greater emission reduction potential, again assuming no LUC. Currently, third-generation biofuels are not a feasible option as their GHG emissions exceed those of fossil fuels.

Furthermore, studies suggest that while biofuels can reduce GHG emissions, these reductions often come with trade-offs, including impacts on acidification, eutrophication, water usage, and biodiversity loss. The paper also investigates key methodological issues and sources of uncertainty in biofuel LCAs and provides recommendations to address these challenges.

Keywords: Biofuel, Green House, Feedstock, Emission Reduction.

**EFFECT OF GRAPHENE NANOPLATES (GNPS) ON THE ENHANCEMENT OF
TENSILE PROPERTIES OF THE HYBRID KEVLAR/BASALT FIBER
REINFORCED EPOXY BASED COMPOSITES**

Atban R. Abdo

Ministry of Industry and Minerals, The State Company for Textile Industries and Leather Cotton Factory,
Anbar/Iraq

Ömer Yavuz BOZKURT

Department of Mechanical Engineering, Faculty of Engineering, Gaziantep University, Gaziantep, Turkey.

ABSTRACT

The objectives of this study are to achieve improvement in the tensile properties of the polymer composite by including different GnPs content ratios 1wt. %, 2wt.% and 3wt. % GnPs contents were used in production additives within the polymer matrix. This study used the sequence stacking of hybrid fiber from Kevlar and basalt fiber the sequence was (K5B10K5) and experimented with tensile polymer composites. The SEM micrographs showed a good indication of particle dispersion within the polymer matrix. The tensile values were changed and improved after the inclusion of nanoparticles. The addition of GnPs nanoparticles in a hybrid composite significantly improved the tensile properties that addition of GnPs particles at the small contents (1 wt. %) slightly increased the tensile strength and modulus by 14 % and 19.5 % respectively. excessive GnPs loading created a reverse effect on the tensile strength and modulus with a decreasing trend, and this was attributed to the poor load transferring from particles to the matrix as a result of agglomeration effects.

Keywords: Tensile strength, Basalt fiber, Kevlar fiber, GnPs nanoparticles.

**INFLUENCE OF CARBON FIBER-REINFORCED EPOXY-BASED HYBRID
KEVLAR/CARBON FIBER NANOTUBE (MWCNT) ON THE IMPROVEMENT OF
TENSILE PROPERTIES**

Bahjat Hardan Sulaiman

University of Anbar, Renewable Energy and Research Center, Ramadi, Anbar, Iraq.

Ahmet Erkliğ

Faculty of Engineering, Mechanical Engineering Department, Gaziantep University, Gaziantep, Turkey.

ABSTRACT

The goal of this study is to improve the polymer composite's tensile qualities by utilizing additives that contain varying ratios of MWCNTs 0.1, 0.25, and 0.5 weight percent in the polymer matrix during manufacture. This work experimented with tensile polymer composites and used the sequence stacking of hybrid fiber from Kevlar and carbon fiber, which was (K5C10K5). A clear picture of particle dispersion inside the polymer matrix was provided by the SEM micrographs. After the nanoparticles were added, the tensile values were altered and improved. When MWCNT nanoparticles are added to a hybrid composite, the tensile properties of the material are greatly improved. Tensile strength and modulus are increased by 14.2% and 7.8%, respectively, when MWCNT particles are added in small amounts (0.1 weight percent). On the other hand, high MWCNT loading had a negative trending effect on the modulus and tensile strength, which was explained by the insufficient load transmission from the particles to the matrix due to agglomeration effects.

Keywords: Tensile strength, Carbon fiber, Kevlar fiber, MWCNT nanoparticles.

**HOW CROSS CONTAMINATION CAN INFLUENCE THE QUALITY OF
IRRIGATION WATER? – CASE STUDY OF THANA REZERVOIR IN ALBANIA**

Erdona Demiraj

Dr., Agriculture University of Tirana, Department of Environment and Natural Resources, ALBANIA

Irena Duka

Dr., Agriculture University of Tirana, Department of Environment and Natural Resources, ALBANIA

Ervin Doçaj

MSc., GFA Consulting Group, ALBANIA

Ferdi Brahushi

Dr., Agriculture University of Tirana, Department of Environment and Natural Resources, ALBANIA

Seit Shallari

Dr., Agriculture University of Tirana, Department of Environment and Natural Resources, ALBANIA

ABSTRACT

Urban cross-contamination affects irrigation water used in agricultural lowlands by introducing pollutants such as nutrients, heavy metals, and pathogens from urban runoff and sewage, compromising water quality and crop health. The largest artificial reservoir built in Albania for the irrigation of the Myzeqe field is the Thana reservoir, covering an area of 5.9 km². In response to the requirements of the Nitrates Directive (91/676/EEC) and the need to preserve food quality, this study aims to assess the amount of nutrients introduced through irrigation and evaluate the risk of toxicity from metals (B, Cd, Zn, Pb, As, Cu, Cr, Co) resulting from urban pollution of irrigation water. In the first phase, questionnaires were conducted with local farmers, while the second phase a monitoring program where undertake to assess water quality parameters (nutrients and toxicity) used for irrigation. According to the survey results, farmers expressed a strong need for continuous training on water quality parameters and their role in food safety. However, the extension service is absent in some areas. The findings indicate that nitrogen levels in the water contribute 12-22 kg/ha per vegetative cycle. Regarding metal toxicity, no values were found to exceed the limits set by FAO. The need for futher study about farmer behavior and soil quality and adsorbation capacity will be an added value for future strategies.

Keywords: Thana Reservoir, Nitrates, Heavy Metals, Irrigation water, Cross contamination.

INTRODUCTION

The continuous increase of nitrate leaching and toxic heavy metals from urban water to agricultural irrigation systems poses a significant threat to the contamination of soil, groundwater, crop and all food chain, and it requires immediate attention (Abbasi and Sepaskhah, 2023). In the study conducted by Keskin, 2010, nitrate (NO_3) pollution was detected in groundwater from agricultural areas, where high levels of heavy metals like B, Pb, Hg, and Se were also observed. Other trace elements such as Cr, Mn, Fe, Cu, and Zn were found in slightly elevated concentrations, likely due to fertilizers and pesticides. Monitoring of the Ganga River (2009–2014) in West Bengal, India, revealed higher nitrate and trace element concentrations, particularly during dry seasons. Nitrate levels were elevated, and heavy metals like Fe, Mn, Zn, and Pb were detected in over 90% of samples, with manganese exceeding limits in 60% of cases, affecting irrigation suitability (Mandal *et al.*, 2019). In central Thessaly, Greece, groundwater quality has degraded due to intensive agriculture, excessive irrigation, and fertilizer use with high nitrate (31.7–299 mg/L) and heavy metal concentrations, such as NO_2 and NH_4 , make shallow aquifers unsuitable for human use (Stamatis *et al.*, 2011). In the study done by Goher *et al.*, 2014 for the Ismailia Canal in Egypt, that provides water for drinking and irrigation the results indices reveal significant heavy metal contamination largely due to industrial waste and may affect the crops that may be irrigated. Thana, situated in central Albania, is the country's largest reservoir with a surface area of 5.9 km². It is connected to the Devoll River through a recharge canal and is primarily used for irrigating the western lowlands of Myzeqe which represent almost 25% of the agricultural production of the entire country (Doko and Rroço, 2010). The water from this reservoir is distributed through a network of irrigation canals to irrigate approximately 30,000 hectares of farmland in the Myzeqe region. The irrigation network is also misused by residents and businesses to illegally discharge polluted water and urban waste, increasing the risk of contamination with pathogens, macronutrients, and toxic elements. Some farmers, however, use small basins (50-70 m²) to naturally filter the water before it is pumped into the drip irrigation systems in their greenhouses. The aim of this study was to periodically monitor key physical and chemical parameters, including macronutrients (NO_3^- ; P/PO_4^{3-}), toxic elements (B, Cd, Zn, Pb, As, Cu, Cr, Co), and electrical conductivity (EC), which is particularly important for farmers. Previous studies have indicated that the reservoir has a high EC level due to its origin from sedimentary formations.

MATERIALS AND METHOD

The monitoring program spanned from June to September, with samples taken monthly at four monitoring stations, as detailed in Table 1. The sampling stations as indicated in the table 1, were selected with the assumption that water quality would be influenced by major impacts from point-source pollution, especially untreated urban wastewater, as well as diffuse pollution, mainly resulting from agricultural practices as it is displayed in Figure 1. Four water samples (pursuant the preselected sampling stations) were taken in four month, namely

June, July, August, September of 2024 to determine the following parameters (Temperature, pH, EC, NO_3^- , P/PO_4^{3-} , B, Cd, Zn, Pb, As, Cu, Cr, Co). Samples were taken with plastic bottles of 1 L volume, at a depth of about 20 cm below the water surface. The bottles were stocked in freezer boxes at about 4°C during the transport, and were taken to the laboratory where they were placed in the refrigerator for further analysis. Parameters such as temperature (Temp. $^\circ\text{C}$), pH, EC (electrical conductivity), were measured in situ using a Multi 3510 IDS Portable Meters. Analysis of the mineral forms of nitrogen and phosphorus (NO_3^- and P/PO_4^{3-}) were conducted based on Photometer Method with PALINTEST. Determination of orthophosphate was performed according to the ammonium molybdate spectrometric method specified in standard ISO 6878:2004 and for the determination of heavy metals (Cd, Zn, Pb, As, Cu, Cr, Co in $\mu\text{g/L}$) was used a Flame Atomic Absorption Spectrometer type AA350. Boron was determined using the UV-Vis Spectrophotometric method with the Curcumin Complex, as described by (Setyawati 2019). The collected data were used to generate charts utilizing JUMP SAS 11 software.

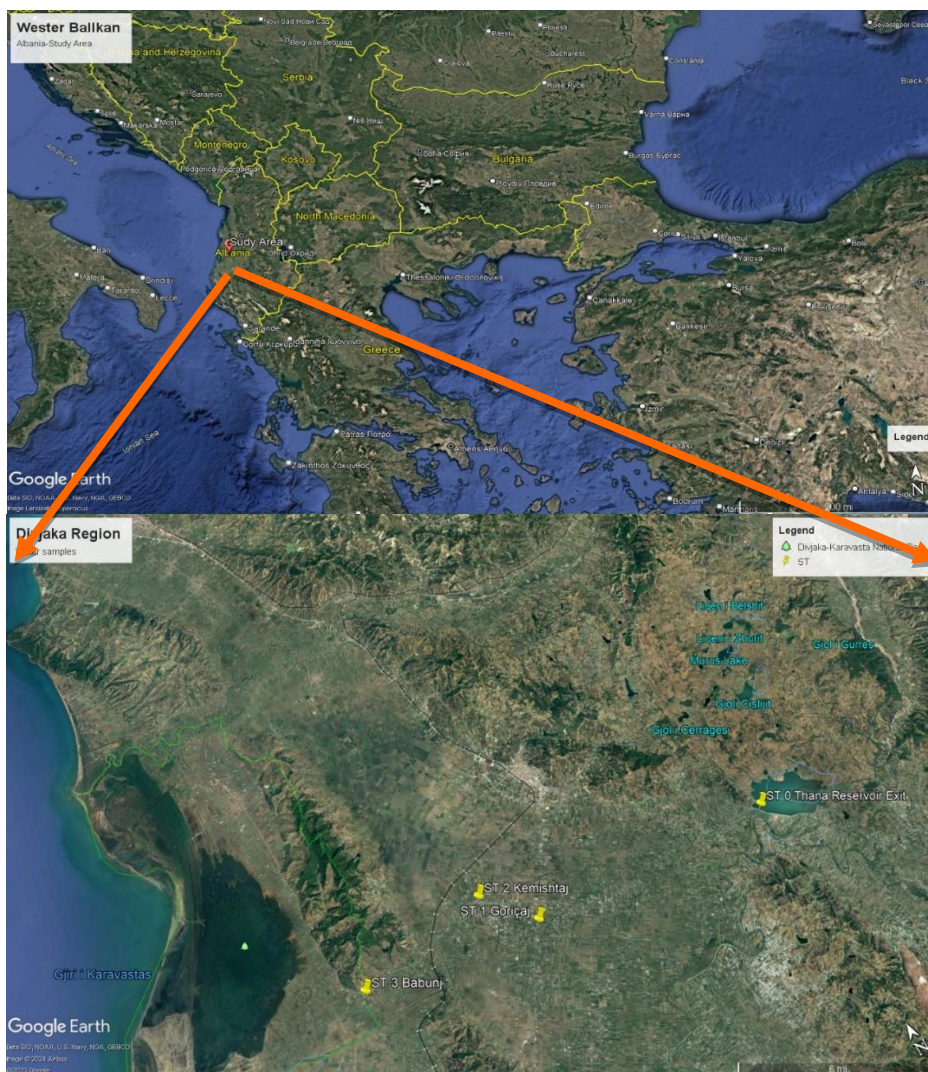


Figure 1. Map of Divjaka (study area) with the sampling stations location. (Source: Google Earth).

Table 1. Sample stations Coordinates.

Stations	Latitude	Longitude
St ₀ : Thana Reservoir Exit	40°51'51.55"N	19°49'19.71"E
St ₁ : Goriçaj	40°52'13.04"N	19°39'26.99"E
St ₂ : Këmishtaj-Mërtish	40°53'37.13"N	19°37'57.66"E
St ₃ : Babunj	40°52'53.09"N	19°32'44.53"E

RESULTS AND DISCUSSION

Temperature plays a crucial role in assessing water quality, as it triggers or influences various reactions. The results show notable temperature variations across the sampling months and monitoring stations. At St₀ (Thana Reservoir Exit), the temperature remained relatively stable, rising from 27.3°C in June to 30.1°C in July and 31.1°C in September. At St₁ (Goriçaj), more pronounced changes were observed, with temperatures increasing from 24.7°C in June to 29.5°C in July and 30.5°C in September. In St₂ (Këmishtaj), temperature fluctuations were minor, ranging from 24.3°C in June to 27.9°C in July and 28.9°C in September. At St₃ (Babunj), noticeable changes occurred, with temperatures rising from 24.5°C in June to 29°C in July and 30°C in September. As shown by the first sampling, the temperatures across all locations generally fall within FAO's recommended limits, where the acceptable range is between 22°C and 28°C.

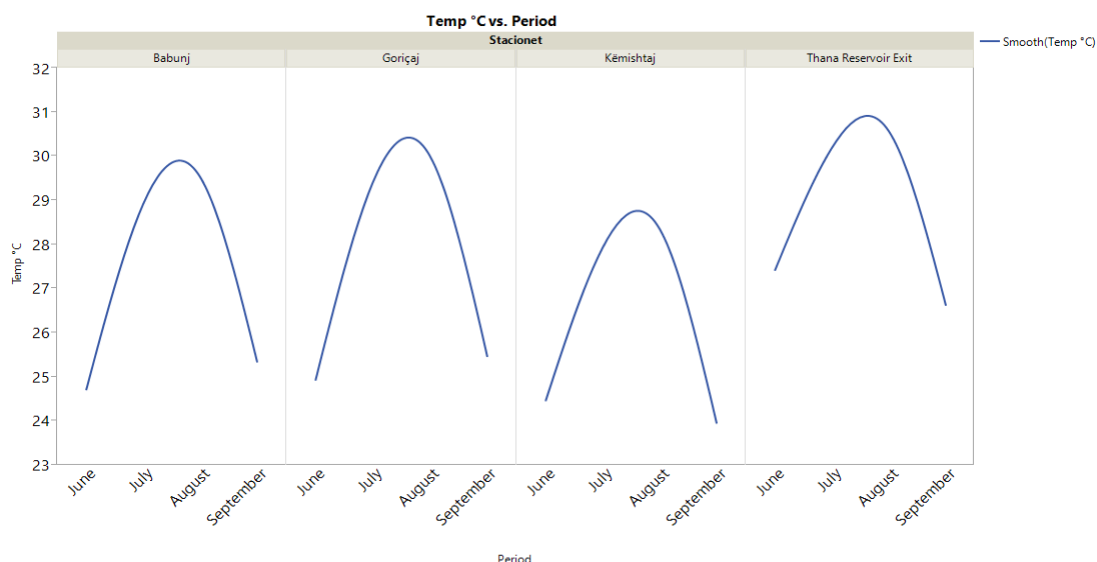


Figure 2. Water temperature during the irrigation water monitoring program.

According to the FAO, the normal pH range for irrigation water is between 6.5 and 8.4. Although low pH levels are uncommon in the Thana Reservoir, they can lead to increased

corrosion of the irrigation system when they do occur. A pH higher than 8.5 is typically due to elevated bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) levels, which contribute to alkalinity. Based on the results, the pH levels are within the acceptable range. The lowest pH value was recorded in Këmishtaj during the third sampling in August, while the highest was at the reservoir outlet.

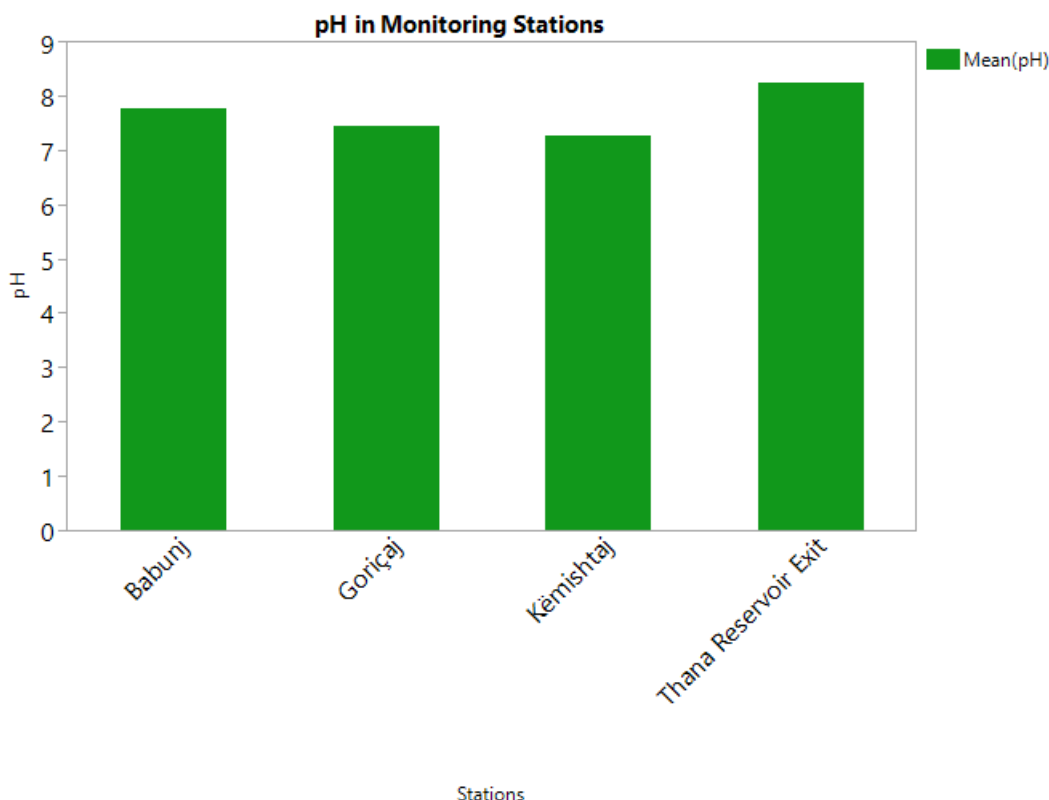


Figure 3. Water pH during the irrigation water monitoring program.

Based on the data presented in the table and illustrated in the graph above, we compared our findings with the FAO standard of 5 - 30 mg/L. The initial concentration in first Sampling exceeds the lower level FAO guideline for NO_3^- , which is 5 mg/L, indicating a relatively high level of nitrate. The subsequent samples show a decline in concentration, suggesting that the water quality improves as it moves away from the Thana Reservoir Exit. The concentrations in Goriçaj remain below the lower level of FAO guideline, indicating acceptable levels of NO_3^- . The fluctuations observed between Sampling 1 and Sampling 2 might suggest seasonal influences or localized sources of nitrate input. NO_3^- levels in Këmishtaj also fall within the acceptable range according to FAO guidelines. The increase from Sampling 1 to Sampling 2 may indicate agricultural runoff or other contributions, but overall the concentrations remain manageable. Similar to Këmishtaj, the concentrations in Babunj are within the acceptable range, reflecting stable water quality. The slight increase observed across the samples may be attributed to local agricultural activities.

The concentrations of orthophosphate in Thana Reservoir Exit are consistently low, well below the FAO guideline for acceptable levels (typically around 0-2 mg/L or lower for most

water bodies). This indicates good water quality with respect to phosphate levels. The phosphate concentration in Goriçaj shows a notable increase in Sampling 1 (0.15 mg/L), which may indicate localized pollution or runoff effects. While Sampling 1 and Sampling 3 remain below the guideline, the spike in Sampling 2 suggests further investigation may be warranted to identify sources of increased phosphates. Këmishtaj presents significantly elevated phosphate levels, with all samples exceeding typical acceptable limits. This indicates potential eutrophication risks, suggesting that nutrient loading in this area is a concern and could lead to algal blooms or other ecological issues. Babunj also shows low phosphate levels, similar to Thana Reservoir Exit. The concentrations are within acceptable ranges, indicating good water quality with respect to orthophosphates.

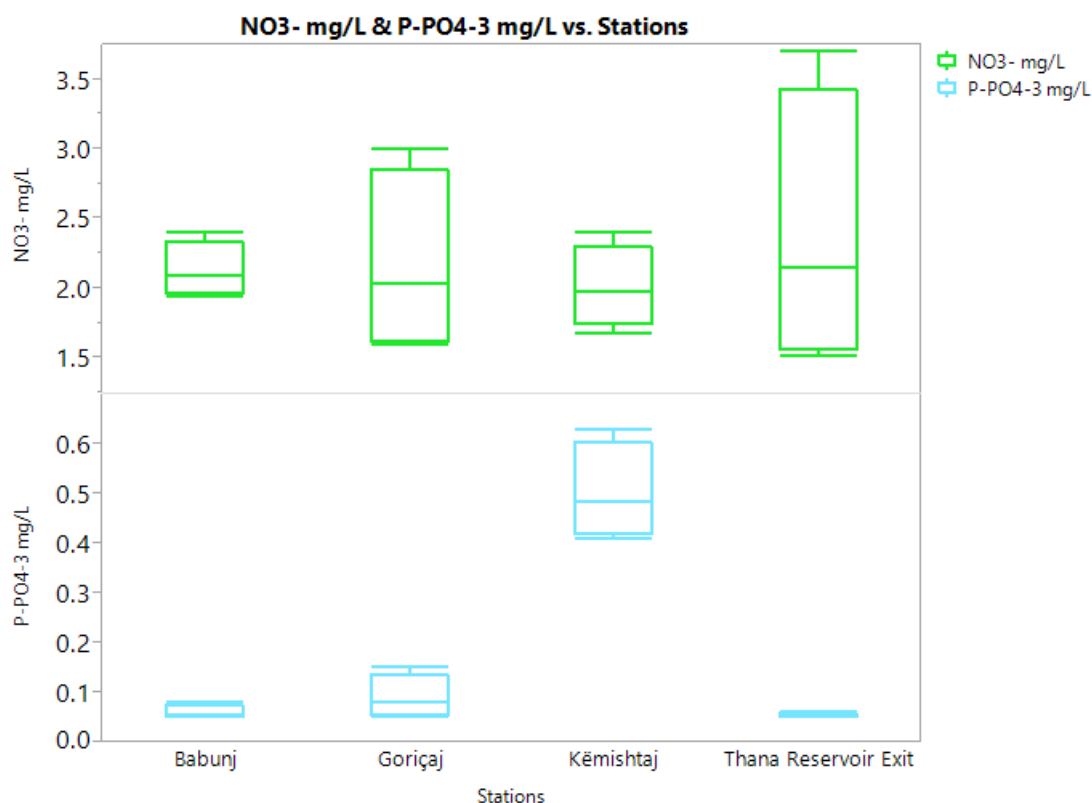


Figure 4. Nitrate and orthophosphate concentrations (mg/L) in water during the irrigation monitoring program.

Electrical conductivity (EC) is an important indicator of salt levels in water. It reflects the concentration of salts, and based on the results obtained in the field using the in situ method, it is observed that the EC level in the first sample taken in June was average and not harmful to plants. The data shown in Figure 5 indicate that at Thana Reservoir Exit, EC was 539 $\mu\text{S}/\text{cm}$; at Goriçaj, EC was 675 $\mu\text{S}/\text{cm}$; at Këmishtaj, EC was 677 $\mu\text{S}/\text{cm}$; and at Babunj, EC was 695 $\mu\text{S}/\text{cm}$. In the second sampling, significant changes were observed in the EC concentration, which is directly influenced by temperature. During this month, the temperatures were higher, leading to an increase in the concentration of salts in the water. The results were: at St0, EC = 803 $\mu\text{S}/\text{cm}$; at St1, EC = 1265 $\mu\text{S}/\text{cm}$, where a significant increase is observed compared to

the first sampling; at St2, EC = 1229 $\mu\text{S}/\text{cm}$; and at St3, EC = 1195 $\mu\text{S}/\text{cm}$. These data from the second sampling provide important information regarding the EC concentrations in irrigation water, indicating noticeable changes. This suggests that the water has a high salt content, but it remains within acceptable levels compare to FAO. In the third sampling, the results were almost similar, with a slight decrease of EC concentration, resulting from the rainfall that occurred in the area, which helped to wash the soil. At St0, EC = 812 $\mu\text{S}/\text{cm}$, showing a slight increase from the second sampling; at St1, EC = 1198 $\mu\text{S}/\text{cm}$, indicating a small change; at St2, EC = 1217 $\mu\text{S}/\text{cm}$; and at St3, EC = 967 $\mu\text{S}/\text{cm}$. In the fourth sampling period during the September the EC content in each station were in the following range: St0, EC = 827 $\mu\text{S}/\text{cm}$, St1, EC = 1005 $\mu\text{S}/\text{cm}$, indicating a small change; at St2, EC = 907 $\mu\text{S}/\text{cm}$; and at St3, EC = 771 $\mu\text{S}/\text{cm}$.

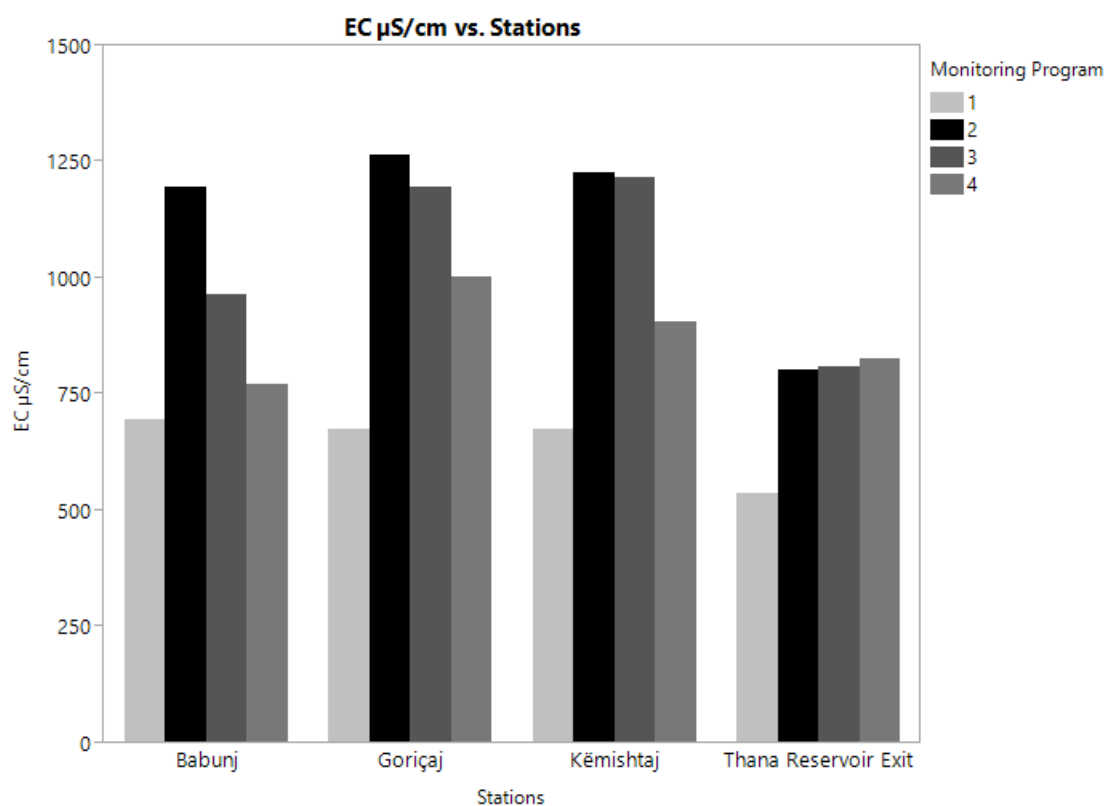


Figure 5. Electrical conductivity (EC in $\mu\text{S}/\text{cm}$) of the water during the irrigation monitoring program.

The concentrations of Boron are shown in Figure 6, were at Thana Reservoir Exit in Sampling 1 (0.97 mg/L) and Sampling 3 (0.67 mg/L) exceed the FAO guideline, indicating a potential concern. Sampling 2 (0.35 mg/L) and Sampling 4 (0.4 mg/L) are within safe limits. In Goriçaj the measured values of Sampling 1 (0.57 mg/L), Sampling 2 (0.76 mg/L), sampling 3 (0.76 mg/L), and sampling 4 (0.61 mg/L) show that Sampling 2 and sampling 3 exceed the FAO guideline, which suggests that the levels are concerning, while Sampling 1 and sampling 4 remain safe. In Këmishtaj Sampling 1 (0.62 mg/L) and Sampling 4 (0.54 mg/L) are within safe limits. however, sampling 2 (0.85 mg/L) and Sampling 3 (1.01 mg/L) exceed the FAO

guideline, indicating a significant concern for these Samples. In Babunj all measurements (Sampling 1 at 1.8 mg/L, Sampling 2 at 0.67 mg/L, sampling 3 at 0.93 mg/L, and Sampling 4 at 0.46 mg/L) indicate that Sampling 1 and Sampling 3 exceed the lower value of FAO guideline, showing potential risk, while Sampling 2 and Sampling 4 are within the safe range.

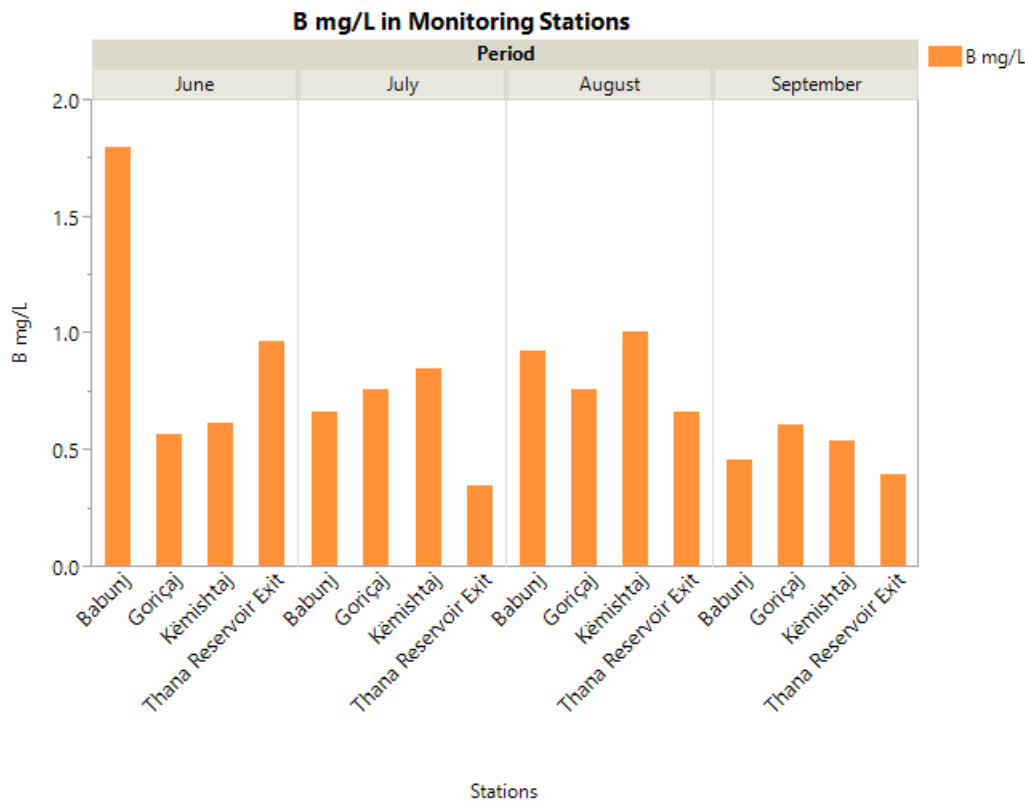


Figure 6. Boron concentration (mg/L) in the water during the irrigation monitoring program.

Based on the data provided for heavy metals in water samples and the FAO guidelines, all samples exhibit the arsenic concentrations of 10 µg/L, which is well below the FAO guideline. This suggests that arsenic levels are safe and do not pose an immediate threat. Lead concentrations are consistently under the FAO guideline, although some samples (such as Sampling 3 and Sampling 4 from Thana Reservoir Exit and Goriçaj) are comparatively elevated. According to the guidelines, there are no immediate concerns regarding lead contamination. The cadmium levels in all samples are significantly below the FAO guideline, signifying that these levels are safe and not a matter of concern. All chromium measurements are considerably lower than the FAO guideline, indicating that there is no notable chromium contamination in the water samples. Each sample's cobalt concentration is well below the FAO guideline, reflecting safe levels of this metal in the water. Copper levels in all results are significantly under the FAO guideline, confirming their safety. Zinc levels are also well below the FAO guideline, indicating no significant zinc contamination. Overall, the results demonstrate that the concentrations of heavy metals in the water samples reach the safe limits established by FAO guidelines for arsenic, lead, cadmium, chromium, cobalt, copper, and zinc. Although there are variations in lead levels, they consistently remain below the

acceptable threshold, indicating minimal immediate health risks associated with these heavy metals. Ongoing monitoring is advised to maintain water quality safety.

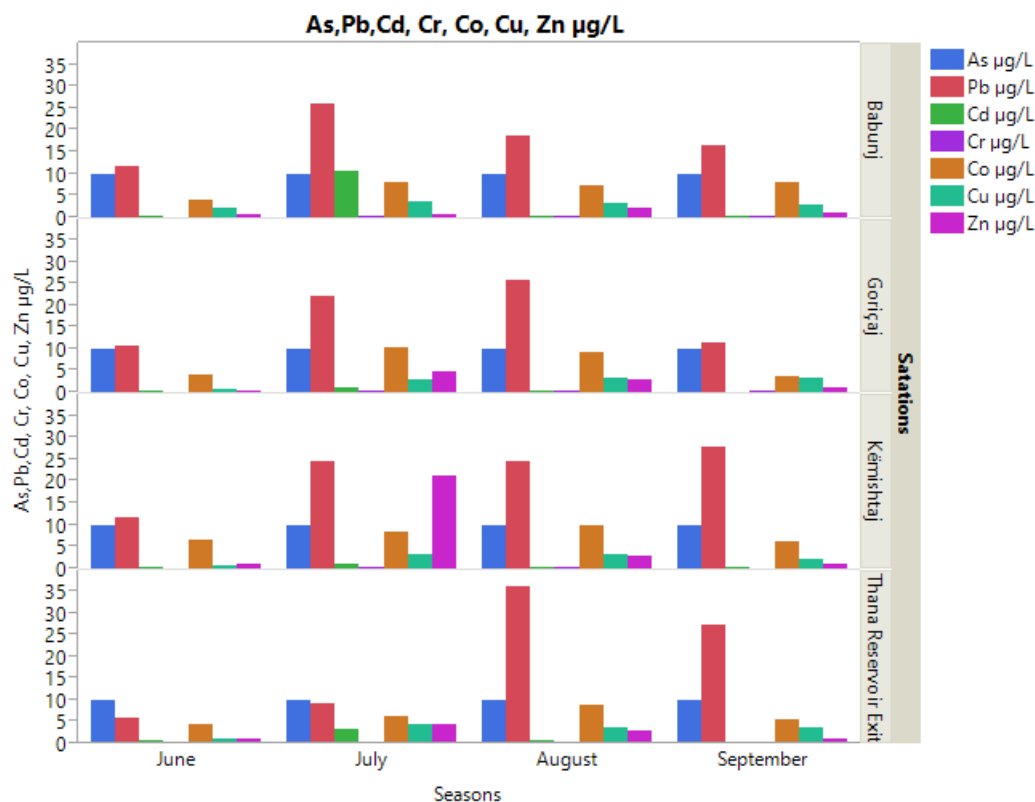


Figure 7. Heavy metals concentration ($\mu\text{g/L}$) in the water during the irrigation monitoring program.

The nitrate levels show some variability across the different sampling points as displayed in figure 8. The highest recorded nitrate concentration is 22.80 kg/ha in the second Sampling 2, indicating a significant presence of nitrates in that location. The lowest concentration is 12.16 kg/ha in Sampling 3 from the second set of samples, suggesting that some areas have lower nitrate levels. The values for Sampling 2 consistently show higher nitrate levels, especially noted in the second Sampling 2 sample (22.80 kg/ha). This could indicate a potential source of nitrate input or accumulation in that area. The concentrations in Sampling 1 across the three sampling events vary, with the highest being 18.24 kg/ha in the second set, while the other samples (Sampling 3 and Sampling 4) remain fairly stable around 15 kg/ha. Most of the nitrate values fall between 12.16 kg/ha and 22.80 kg/ha, which suggests a moderate level of nitrate presence in the samples. Monitoring these levels is crucial, especially in agricultural settings, as elevated nitrate concentrations can have implications for crop health and water quality. High nitrate levels can indicate nutrient-rich soils, which may be beneficial for agricultural productivity but can also lead to issues such as leaching into water bodies, resulting in eutrophication.

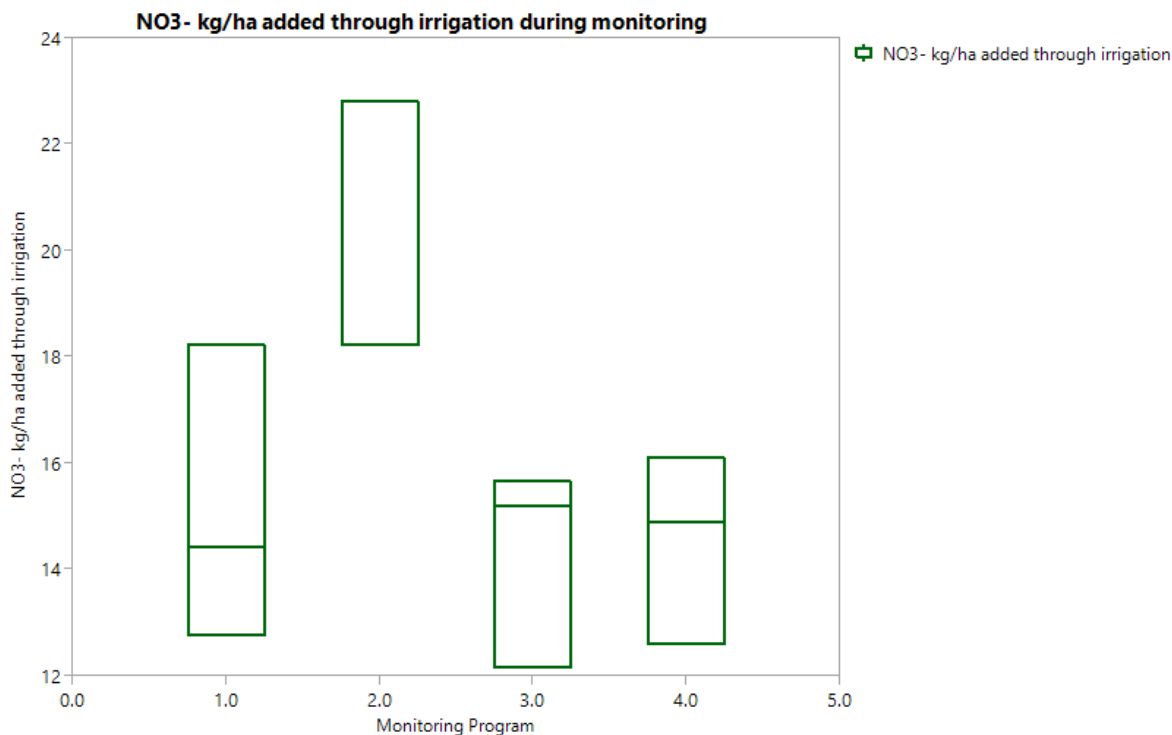


Figure 8. The amount of nitrates (NO_3^- in kg/ha) added through irrigation from June - September 2024.

CONCLUSION

The findings of this study underscore the pressing issue of water quality in agricultural irrigation systems, particularly concerning nitrate leaching and heavy metal contamination. The analysis conducted across various monitoring stations revealed notable fluctuations in water quality parameters, including temperature, pH, nitrate concentrations, electrical conductivity, and the presence of toxic elements such as boron, cadmium, and lead. The elevated levels of nitrates, especially during the dry months, raise significant concerns about their potential effects on crop health and environmental integrity. Particularly alarming is the detection of heavy metals exceeding safety thresholds in certain samples, suggesting contamination from urban wastewater and agricultural runoff. These findings align with previous studies indicating widespread contamination of groundwater and surface water resources due to anthropogenic activities, highlighting an urgent need for improved water management practices. While the majority of heavy metal concentrations remained within acceptable limits set by FAO guidelines, the study identified specific areas where levels were elevated, necessitating continuous monitoring and potential remedial measures. The use of small basins by some farmers to filter water prior to irrigation offers a promising strategy for mitigating contamination risks; however, broader interventions are required to ensure sustainable agricultural practices and protect food safety. Overall, this study calls for increased awareness and proactive measures among stakeholders, including policymakers, farmers, and researchers, to address the dual challenges of nutrient and heavy metal pollution.

in irrigation systems. Implementing robust monitoring frameworks and sustainable agricultural practices can safeguard water quality and ensure the long-term viability of agricultural production in the Myzeqe region and similar agricultural areas globally.

REFERENCES

- Abbasi, M.R., Sepaskhah, A.R. (2023). Nitrogen leaching and groundwater N contamination risk in saffron/wheat intercropping under different irrigation and soil fertilizers regimes. *Sci Rep* 13, 6587.
- Adrian, D., Evan, Rr. (2010). State of Water Quality of Thana Reservoir and Its Influence on *Irrigated Soils*. BALWOIS, Ohrid, Republic of Macedonia, 25- 29 May 2010.
- Ekemen Keskin, T.(2010). Nitrate and heavy metal pollution resulting from agricultural activity: a case study from Eskipazar (Karabuk, Turkey). *Environ Earth Sci*, 61, 703–721.
- Food and Agriculture Organization of the United Nations Rome, 1985.
- Mandal, S.K., Dutta, S.K., Pramanik, S. (2019). Assessment of river water quality for agricultural irrigation. *Int. J. Environ. Sci. Technol.*, 16, 451–462.
- Mohamed E. Goher, Ali M. Hassan, Ibrahim A. Abdel-Moniem, Ayman H. Fahmy, Seliem M. El-sayed, (2014). Evaluation of surface water quality and heavy metal indices of Ismailia Canal, Nile River, Egypt, *Egyptian Journal of Aquatic Research*, 40, 3, 225–233.
- Setyawati, A. (2020). Analysis Methods Verification of Boron in River Water Using the Uv-Vis Spectrophotometer with Curcumin Complex as Alternative Practical Educations. *IJCER (International Journal of Chemistry Education Research)*, 3, 60–65.
- Stamatis, G., Parpodis, K., Filintas, A. (2011). Groundwater quality, nitrate pollution and irrigation environmental management in the Neogene sediments of an agricultural region in central Thessaly (Greece). *Environ Earth Sci*, 64, 1081–1105.

INNOVATIVE ADAPTIVE FUZZY STRATEGY FOR DTC IN DUAL STAR INDUCTION MOTORS

Rahma BELKAID

Department of Electrical Engineering, Faculty of Technology, University of Batna2

Lamia YOUB

Department of Electrical Engineering, Faculty of Technology, University of Batna2

Farid NACERI

Department of Electrical Engineering, Faculty of Technology, University of Batna2

ABSTRACT

This article presents a novel approach to the direct torque control (DTC) of the dual-star induction motor (DSIM). Based on Lyapunov's theory, the strategy combines two recent and promising techniques: fuzzy logic control and adaptive control. The aim is to optimize the gains of the PI speed regulator and ensure the stability of the drive system. A simulation study in a Matlab/Simulink environment convincingly demonstrates the effectiveness and robustness of this DTC strategy with the adaptive fuzzy controller, even in the face of parametric variations.

Keywords: Dual star induction motor (DSIM), Direct torque control (DTC), PI speed controller, Fuzzy logic, Adaptive control, Matlab/Simulink simulation.

INTRODUCTION

The Double Star Induction Motor (DSIM) is a key component in high-power applications and loads requiring speed control. This research is significant as it focuses on the control of DSIM, a topic of great interest in the field. Typical applications of wound rotor or slip ring induction motors include crushers, piston pumps, cranes, and hoists [1].

The research and development of DSIM has led to a significant advancement in the electrical supply, reducing current and torque ripples, enhancing reliability, and minimizing rotor losses. The direct torque control (DTC) technique, a significant milestone in this evolution, emerged in the second half of the 1980s. Patented by Manfred Depenbrock and further refined by Isao Takahashi and Toshihiko Noguchi, this technique stands as a competitive alternative to traditional methods. Its key feature is the decoupling of flux and torque through the orientation of the magnetic flux.

Direct torque control DTC consists of directly controlling the closing or opening of the inverter switches from the calculated error values of the stator flux and torque at the hysteresis controller levels

to give the vector representing the stator flux the direction determined by the setpoint values. A suitable machine model must be used to know the electromagnetic state of the motor and determine the control of the inverter switches. From measurements of the direct voltage at the inverter input and the stator currents, the model gives the real stator flux of the machine, the real torque it develops, and its rotation speed at each moment. Shaft speed measurement is unnecessary, which is a great advantage of these methods.

The state of these quantities allows us to define the stator voltage vector to be applied to the machine to best maintain the torque and the flux in their hysteresis bands.

Fuzzy logic is an approach used in artificial intelligence based on “values or degrees of truth”. This so-called versatile logic admits the possibility of partial truths located between the two extremes 0 and 1. Fuzzy logic was formulated by the mathematician Lotfi Zadeh in the 1960s as part of his research on the understanding of natural language by computer. It allows a more faithful representation of human cognitive abilities. In this way, designing and developing artificial intelligence functionalities for complex tasks is essential. It, therefore, relies on qualitative variables to model nonlinear systems [3], [13].

Adaptive control [5] is another way to solve the control problem; it avoids the requirement of explicit knowledge of the system dynamics, which is not always possible, and reduces the influences of unknown parameters. The main attraction of this strategy results from the fact that it must make it possible to maintain the near-optimal performance of a system whose parameters vary slowly over time by dealing with the gap between the desired performance index and that which is measured. in the real system and adjusts a controller to eliminate this deviation. However, to maintain consistent execution in the presence of real uncertainties, the use of adaptive control is, in most cases, unavoidable. Fuzzy adaptive control has been the subject of intensive research over the past decade.

The objective of this study is to use an adaptive fuzzy control approach based on the Lyapunov theory. This method does not require any structural, parametric, or experimental information on the variation of the PI-fuzzy regulation gains. The adaptation system is based on stability theory and is used to approximate gains, ensure the stability of machine control in real-time, and provide more satisfactory performance and robustness to machine parameter variations.

RESULTS AND DISCUSSION

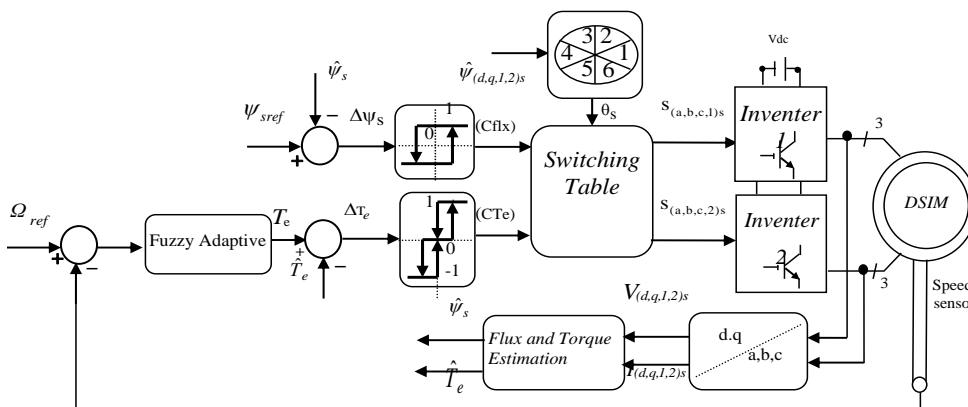


Figure 1. DTC of DSIM

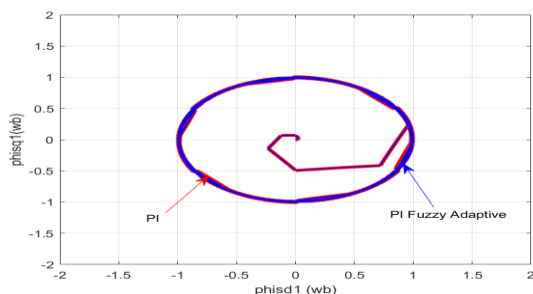


Figure 2. Stator flux trajectory in stator (1) of two controllers

To validate the effectiveness of our training system in terms of the different operating systems, we carried out the simulation using Matlab Simulink. We have noticed that Figure 3 shows the speed adjustment performance of the double-star asynchronous machine for a set point of 100 rad/s with a variation in the load. The speed follows the reference speed despite the presence of load disturbances. The response with pi fuzzy adaptive time is around 0.1s. Overshoot is zero.

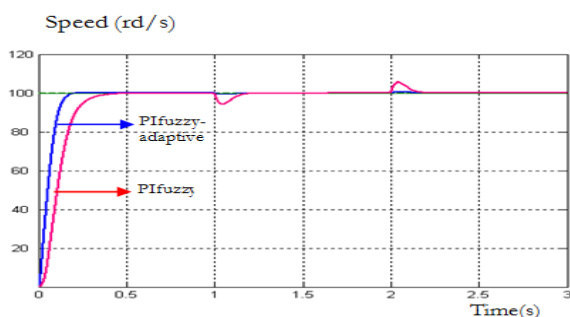


Figure 3. Dynamic speed response.

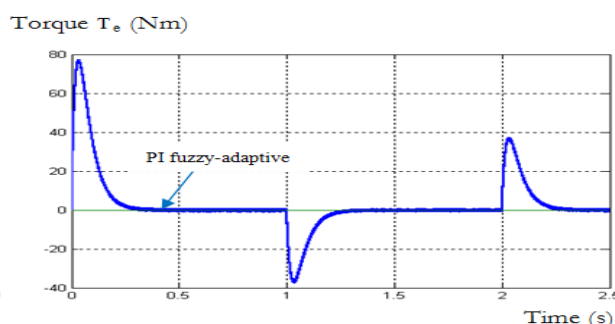


Figure 4. Dynamic response of electromagnetic torque

The torque with pi fuzzy adaptive judiciously follows its set reference and shows slight overruns at the moments of load applications in Figure 4.

Figure 5 shows that the phase current maintains a sinusoidal shape and reacts to the setpoint load.

Figure 6 displays the shape of the curves of the components of the direct rotor fluxes, where it clearly appears follows his reference. However, we note that the coefficients, $k_f < k_r$, have values of 0.2 and 0.35, respectively, of the initial values.

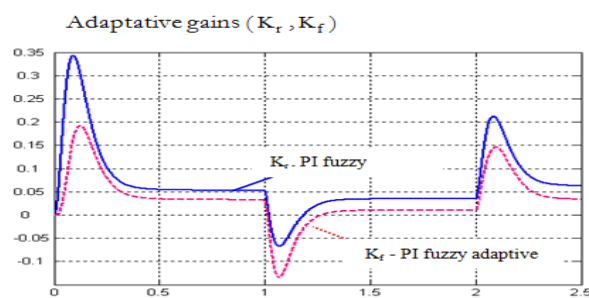
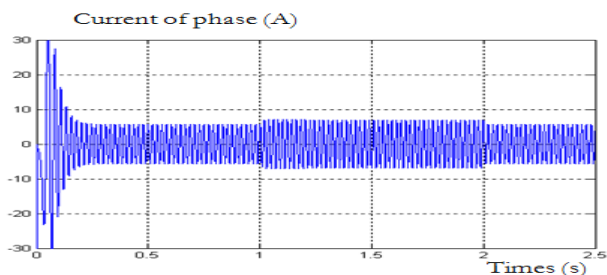


Figure 5. The current of phase. Figure

6. Evolution of fuzzy adaptive gains K_r , K_f .

By applying an inversion of the direction of rotation of -100 rd/s between time $t = 1$ s and 2 s, we note that the speed follows its setpoint without showing ripples and overrun. Also, the inversion time is satisfactory

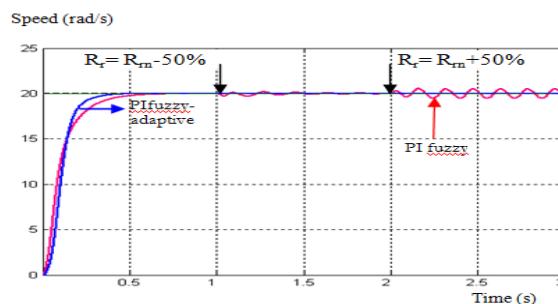
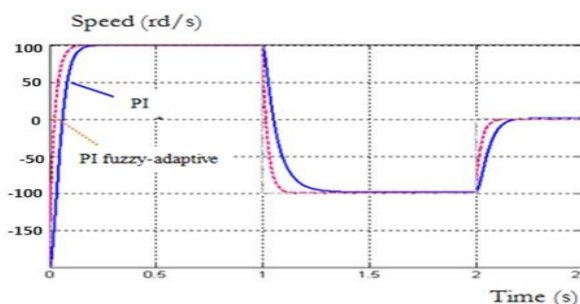


Figure 7. Dynamic response of speed reversal.

Figure 8. Dynamic speed response.

It appears, following the different results obtained, that the performance of the speed adjustment by the application of the adaptive control with the control stability is very satisfactory, To demonstrate the adaptability of the proposed control scheme concerning parametric variations, we introduce parametric variations on the rotor resistance, The resistance is increased by -50% , and then the resistance is decreased by 50% The responses obtained are shown in Figure 8 , We clearly notice that this parametric variation did not affect the low-speed tuning performance, which proves the efficiency of the used control algorithm.

CONCLUSION

The objective that we set ourselves in our work is to improve the performance of the control of the double star asynchronous motor by reducing each time the disadvantages to which it is subject. We use direct control of the DTC torque by a conventional PI speed regulator and integrate the DTC control with a fuzzy adaptive structure.

The work presented is devoted to controlling the double-star asynchronous machine, which presents a very complex system of equations to study because of the coupling between electromagnetic torque and flux. Hence, the equation system needs to be simplified using the Concordia transformation. We then modeled the voltage inverter controlled by a vector PWM. Then, we developed the principle of direct control of the couple.

The synthesis of classical regulators is then discussed. Different simulation tests have shown the effectiveness of this method from the point of view of decoupling between the main quantities of the asynchronous motor, namely the electromagnetic torque and the flux, to achieve a control compatible with that of a DC motor with separate excitation. These tests allow us to better understand the behavior of the double-star asynchronous machine in the presence of disturbances of different natures (electrical or mechanical). From these results, we can clearly see that traditional PI regulators are insufficient to meet the required performance requirements. They are subject to deterioration of performance in the presence of parametric variations. Therefore, the use of modern control is more than necessary. For this, we used a fuzzy logic regulator, which is based on the exploitation of human expertise which we integrated into a more stable control, which in this case, adaptive control, to replace the classic PI regulator in the DTC control, which realizes the speed response in a short time and ensures judicious

disturbance rejection and provides speed inversion without overshoot and rigorous robustness in the face of a variation of the DTC's sensitive parameter, which is the machine's stator resistance. We also suggest that, for future work perspectives, an in-depth study be carried out on implementing a new generation of so-called type-2 fuzzy systems, allowing better consideration of uncertainties.

Finally, the experimental validation of the methods studied in digital simulation during a real-time hardware implementation is the only alternative that allows the shortcomings of the mathematical modeling of the double-star asynchronous machine to be highlighted.

REFERENCES

- [1] OJO O, WU Z. Speed control of a dual stator winding induction machine [J]. APEC second Annual IEEE Applied Power Electronics Conference and Exposition, 2007.
- [2] PIEŃKOWSKI K. Analysis and control of dual stator winding induction motor [J]. Archives of Electrical Engineering, 2012, 61(3): 421 –438. DOI: 10.2478/v10171-012-0033-z.
- [3] LAAMAYAD T, NACERI F, BELKACEM S. A fuzzy sliding mode strategy for control of the dual star induction machine [J]. Journal of Electrical Engineering, 2013, 13(3):

- [4] ZHAO Y, LIPO T A. Space vector PWM control of dual three-phase induction machine using vector space decomposition [J]. IEEE Trans Ind Appl, 1995, 31(5): 1100–1108. DOI: 10.1109/28.464525
- [5] YOUB L, BELKACEM S, NACERI F, CERNAT M, PESQUER L G, Design of an adaptive fuzzy control system for dual star induction motor drives [J]. Advances in Electrical and Computer Engineering, 2018, 18(3): 37–44.
- [6] PREMKUMAR K, MANIKANDAN B. Speed control of brushless DC motor using bat algorithm optimized adaptive neuro-fuzzy inference system [J]. Applied Soft Computing, 2015, 32(2): 403–419. DOI: 10.1007/s00170-016-9092-
- [7] SWAGAT P, KANUNGOB DEBIPRASANNA D. A hybrid self-tuned fuzzy controller for Indirect for indirect vector controlled induction generator [C]// India conference (INDICON), 2012 Annual IEEE.
- [8] GÜZELKAYA M, EKSIN I, YESIL E. Self-tuning of PID-type fuzzy logic controller coefficients via relative rate observer [J]. Engineering Applications of Artificial Intelligence, 2003, 16: 227–236.
- [9] QIAO W Z, MIZUMOTO M. PID type fuzzy controller and parameters adaptive method [J]. Fuzzy Sets and Systems, 1996, 78(2): 23–35. DOI: 10.1016/0165-0114(95)00115-8.
- [10] DENG Wu, ZHAO Hui-mnin, LIU Jing-jing, YAN Xiao-lin, LI Yuan-yuan, YIN Li-feng, DING Chuan-hua. An improved CACO algorithm based on adaptive method and multivariant strategies [J]. Soft Computing, 2015, 19(3).
- [11] LAZREG M H, BENTAALLAH A. Speed sensorless vector control of double star induction machine using reduced order observer and MRAS estimator [C]. 6th International Conference on Electrical Engineering (ICEE). Boumerdes, Algeria: ICEE, 2017: 111–118. DOI: 10.1109/ICEE-B.2017.8192150.
- [12] LEKHCHINE S, BAHI T, SOUFI Y. Indirect rotor field oriented control based on fuzzy logic controlled double star induction machine [J]. Electrical Power and Energy Systems, 2014, 57: 206–211.
- [13] G. Boukhalifa, S. Belkacem, A. Chikhi, S. Benaggoune, Genetic algorithm and particle swarm optimization tuned fuzzy PID controller on direct torque control of dual star induction motor, Journal of central south univ. 26(7) (2019) 1886–1896.
- [14] G. Boukhalifa, S. Belkacem, A. Chikhi, S. Benaggoune, Direct torque control of dual star induction motor using a fuzzy-PSO hybrid approach, Applied Computing and Informatics. (2018).
- [15] T. Laamayad, F. Naceri, S. Belkacem, A fuzzy sliding mode strategy for control of the dual star induction machine. Journal of Electrical Engineering. 13 (3) (2013) 216–223
- [16] G. Boukhalifa, S. Belkacem, A. Chikhi, M. Bouhental, Fuzzy-second order sliding mode control optimized by genetic algorithm Applied in direct torque

control of dual star induction motor, Journal of central south univ. 29(12) (2022) 3974–3985

[17] M. Mareli, B. Twala, An adaptive Cuckoo search algorithm for optimisation, Applied Computing and Informatics. (14) (2018) 107-115.

[18] G. Boukhalfa, S. Belkacem, A. Chikhi, S. Benaggoune, Genetic algorithm and particle swarm optimization tuned fuzzy PID controller on direct torque control of dual star induction motor, Journal of central south univ. 26(7) (2019) 1886–1896.

**MACHINE LEARNING BASED STAFF CHURN SCORING MODELS FOR THE IT
INDUSTRY**

Gökay DAĞDAŞ

Mr., Inveon, Director of Customer Operations

ORCID ID: 0009-0007-7341-0907

Batuhan TAŞKAPI

Mr., Inveon, Department of Director of Customer Operations

ORCID ID: 0009-0005-3965-5981

Zehra Sude SARI

MSc Student, Inveon, Department of Data Science

ORCID ID: 0000-0002-0341-6488

M. Fatih AKAY

Prof. Dr., Çukurova University, Dept. of Computer Engineering

ORCID ID: 0000-0003-0780-0679

ABSTRACT

The Information Technology (IT) sector is a dynamic field where technological advancements progress rapidly, and innovations constantly emerge. This dynamism increases the turnover rate of experienced staff in the IT sector. The churn of experienced staff is a critical factor that leads to a decline in service quality and a reduction in the company's market share. Therefore, businesses need to develop accurate workforce plans and minimize turnover rates by taking the necessary strategic actions. In this context, staff churn scoring stands out as an important tool for effective workforce planning. The aim of this study is to develop staff churn scoring models using machine learning-based methods for the IT sector. To achieve this, models have been developed using Categorical Boosting (CatBoost), Light Gradient Boosting Machine (LightGBM), and Convolutional Neural Network (CNN). The dataset containing detailed staff information has been taken from Inveon. To address the class imbalance in the dataset, sample augmentation (oversampling) has been performed using the Synthetic Minority Over-sampling Technique (SMOTE). By applying SMOTE on the dataset, 125 additional rows of data have been generated, resulting in a dataset containing a total of 458 rows and balanced data. 10-fold cross validation has been implemented during the model development phase. The performance of the staff scoring models has been evaluated using F1 Score, Accuracy, Precision, and Sensitivity, which are well-known metrics for classification problems. It has been observed that the CatBoost-based model demonstrates superior performance. The LightGBM-based model exhibits lower performance compared to that of other models.

Keywords: Staff Churn, Machine Learning, Synthetic Minority Over-sampling Technique

1. INTRODUCTION

The IT sector is a broad and dynamic field where numerous innovations emerge and rapid developments occur. With the significant growth it has experienced in recent years, this sector has become one of the foundational pillars of the global economy. This expansion has led to a substantial increase in the number of companies operating within the sector and the staff they hire. The most valuable assets of companies in the IT sector are experienced and skilled staff with technological expertise. However, the dynamic nature of the sector necessitates swift adaptation to innovations, which, in turn, contributes to a higher rate of staff turnover.

Staff turnover is one of the most critical challenges facing the IT sector. High turnover rates force companies to continually allocate resources and time to recruitment and training processes. Moreover, the loss of qualified and experienced staff reduce the quality of services provided by these companies, leading to decreased customer satisfaction, an increased risk of losing clients, and ultimately, a decline in market share.

In this context, it is crucial for companies to predict staff churn in order to maintain productivity and sustain their competitive advantage. Staff churn scoring emerges as a strategic tool that enables companies to predict which staffs are most likely to leave within a certain period. Such predictions allow companies to take proactive measures to mitigate potential negative outcomes by identifying staffs at risk of leaving. High accuracy in staff churn predictions helps companies enhance customer satisfaction and, consequently, achieve higher profit margins.

The aim of this study is to develop staff churn scoring models using machine learning-based methods for the IT sector. To achieve this, models have been developed using CatBoost, LightGBM and CNN. 10-fold cross validation has been implemented to the developed models.

This study is organized as follows: Section 2 covers relevant literature. The dataset has been described in Section 3. The methodology is presented in Section 4. Section 5 presents results and discussion. Section 6 concludes the paper.

2. LITERATURE REVIEW

They proposed an Artificial Intelligence (AI) based solution to predict employee attrition. Data was collected from various sources, such as the Human Resources Management System, Working Pulse Surveys, and Yammer, to serve as input to the model. AI models, including Decision Tree (DT), Support Vector Machine (SVM), Random Forest (RF), and Natural Language Processing (NLP), were employed. The model was trained to estimate the risk of employee attrition in real-time with an accuracy of approximately 95% (Agarwal et al., 2023). They reviewed the use of machine learning techniques for predicting employee churn over the past decade. Between 2012 and April 2023, 52 studies were analyzed, revealing that the RF technique, primarily based on supervised learning, was the most commonly used method (Akasheh et al., 2024). In another study aimed at predicting employee churn, the Chi-squared

Automatic Interaction Detector (CHAID) machine learning algorithm was used to predict retail employee churn using real-time data. The performance evaluation of CHAID was based on metrics such as Accuracy, the Confusion Matrix, CHAID Decision Tree, and the Area Under the Curve (Chaudhary et al., 2023). They proposed an integrated approach to addressing employee churn. In this study, all employees were categorized using a combination of machine learning algorithms and Multi-Criteria Decision Making (MCDM) techniques. Techniques such as the Technique for Order of Preference by Similarity to Ideal Solution and the Analytical Hierarchy Process (AHP) were combined. Seven machine learning algorithms were applied to predict staff churn, with the results indicating that RF provided the highest accuracy (Chowdhury et al., 2023). Researchers introduced a model to predict the likelihood of staff churn in a business. Logistic Regression (LR), RF, and Extreme Gradient Boosting (XGBoost) were used to build the prediction models, and the best-performing models were combined using a stacking algorithm. The results demonstrated that the proposed model achieved a higher accuracy rate (Chung et al., 2023). They presented a model for estimating sales staff churn, utilizing techniques such as LR, K-Nearest Neighbor (KNN), Naive Bayes (NB), DT, SVM, XGBoost, and RF. The results indicated that RF outperformed other techniques in predicting salesperson churn (Comert et al., 2023). In another study aimed at predicting employee churn in a company, LR, KNN, SVM, RF, and DT were used, resulting in an LR accuracy of 88.09% (Gupta et al., 2023). Researchers investigated the causes of employee attrition using three datasets. They predicted employee attrition using multiple machine learning and deep learning algorithms, evaluating their performance using various metrics. The best-performing methods were Deep Random Forest for the HR Dataset from Kaggle, and Neural Network for the International Business Machines Corporation and Adesso datasets, with F1 scores of 0.972, 0.642, and 0.853, respectively (Gurler et al., 2023). They aimed to predict employee churn using machine learning. In this context, CatBoost, LightGBM, and XGBoost methods were compared to determine which employees are more likely to leave their organization. The K-Fold approach was used to split the dataset into training and testing data (Kakulapati and Subhani., 2023). A framework has been presented that emphasizes the adoption of genetic algorithms to address imbalanced classification and optimize the model. In this study, the SMOTE technique was used for unbalanced data, creating a framework that integrates XGBoost with genetic algorithm-based parameter optimization. The results showed that the combination of genetic algorithms with SMOTE and optimization achieved promising results (Konar et al., 2023). Researchers sought to predict whether an employee would leave or stay in their job, using supervised classification and machine learning algorithms to identify reasons for employee churn (Lalitha et al., 2023). They proposed a prediction model using machine learning to forecast staff churn. In this model, feature selection was conducted using Pearson Correlation methods, and it combined techniques such as RF, LR, DT, XGBoost, and KNN. The results indicated that RF performed better than other models in terms of accuracy in predicting staff churn (Musanga et al., 2023). Lastly, they used machine learning algorithms to predict the likelihood of employee churn.

Using a real company dataset, they examined the impact of different features (such as age, gender, working hours, performance, etc.) on employee churn. The results indicated that machine learning algorithms achieved high accuracy rates, potentially assisting companies in reducing employee churn (Shaik et al., 2023).

3. DATASET

The dataset containing detailed staff information has been taken from Inveon. To address the class imbalance in the dataset, oversampling has been performed using the SMOTE algorithm. By applying SMOTE on the dataset, 125 additional rows of data have been generated, resulting in a dataset containing a total of 458 rows and balanced data. The attributes of the dataset are listed in Table 1.

Table 1. Attributes in the dataset

Attributes	Description
Staff Name and Surname	Staff's full name
Department	Department in which the staff works
Level	Staff's level
Role	Staff's role
Title	Staff's title
Manager Name	Name of the staff's supervisor
Date of Birth	Staff's date of birth
Gender	Staff's gender
Date of Employment	Staff's date of hire
Last Update Date	Date of last data update
Marital Status	Staff's marital status
Educational Background	Staff's educational background
Graduated Program	Department from which the staff graduated
Graduated University	University from which the staff graduated
Graduate Postgraduate Program (Optional)	Undergraduate program from which the staff graduated
Graduate Postgraduate University (Optional)	University of the undergraduate program from which the staff graduated
R&D Scope	Information on whether the staff is part of the R&D
Pre-Inveon Work Experience	Staff's previous experience before joining Inveon
Departure Code (Low-High)	Reason for departure from the previous company (subcategories: primary and secondary reasons)
Factors Creating Attraction Effect (Low-High)	Reason for moving to another company (subcategories: primary and secondary reasons)
Difficulty in Filling the Importance Place	Difficulty in filling the position upon staff's departure
Worked at Inveon for more than 1, 2, or 3 Years? (0: Did not work, 1: Worked)	Information on whether the staff has worked at Inveon for 1, 2, or more than 3 years

4. METHODOLOGY

This study utilized the Python programming language to achieve significant analytical advancements. Data manipulation has been conducted using the Numpy and Pandas libraries,

while data visualization was carried out with the Matplotlib library. For the modeling process, the Scikit-learn, PyTorch, and TensorFlow libraries have been employed.

4.1 Categorical Boosting

An open-source machine learning method built on Gradient Boosting is called Catboost. Its quick learning curve, capacity for handling text, categorical, and numeric data, Graphics Processing Unit support, and visualization choices set it apart from other approaches. It also has the ability to code category data and empty data without necessitating an additional coding step during data preparation. With the help of the model's integrated tools for managing categorical features, CatBoost's parameters were adjusted. Moreover, the features included in the final model were repeatedly improved using CatBoost's feature importance scores (Hasan et al., 2024).

4.2 Light Gradient Boosting Machine

The gradient boosting framework LightGBM uses tree-based learning methods, which are thought to be incredibly computationally powerful. It is regarded as a quick processing algorithm. LightGBM grows vertically, which implies it grows leaf-wise, whereas other algorithms grow horizontally, forming trees (Ke et al., 2017).

4.3 Convolutional Neural Network

CNN is a popular deep learning technique. CNN was used for text classification, sentiment analysis in NLP, and extracting deep semantic features. Studies have shown that CNN has better results than traditional machine learning methods. Although CNNs have been proven to perform well, a classification model that uses only CNNs cannot learn contextual dependency and structural information (Xue et al., 2019).

5. RESULTS AND DISCUSSION

Staff churn scoring models have been developed using CatBoost, LightGBM and CNN. 10-fold cross validation has been implemented during the model development phase. Hyperparameter values of the staff churn scoring models developed using CatBoost, LightGBM and CNN are given in Table 2.

Table 2. Hyperparameter values of staff churn scoring models

Algorithm	Parameters	Values
CatBoost	Iterations	250
	Learning_rate	0.3
	Max_depth	None
LightGBM	Num_leaves	50
	Learning_rate	0.1
	Max_depth	None
CNN	Layer_size	1
	Neurons	64
	Filter_size	3
	Epochs	200

	Batch_size	32
	Optimizer	Adam
	Learning_rate	0.001
	Hidden_layers_activation_function	Relu
	Output_activation	Sigmoid

The complexity matrices of the staff churn scoring models developed with CatBoost, LightGNM and CNN are given in Figures 1 to 3.

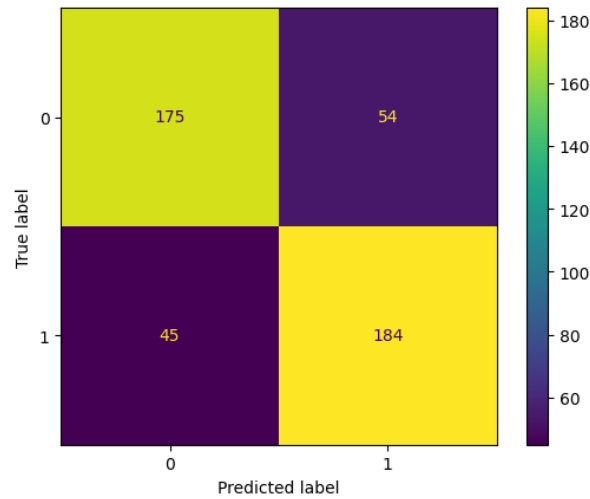


Figure 1. Confusion matrix obtained with CatBoost

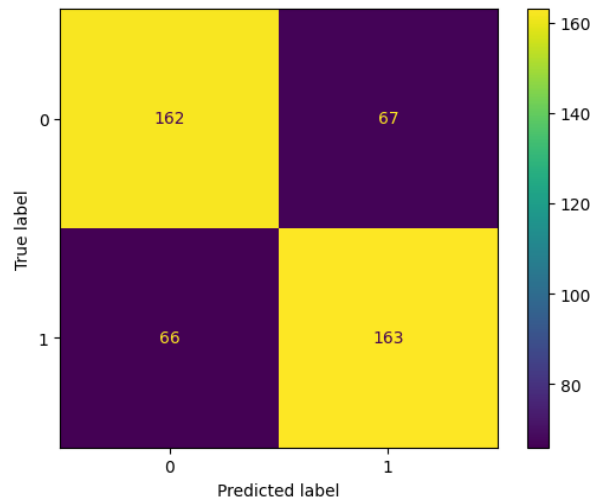


Figure 2. Confusion matrix obtained with LightGBM

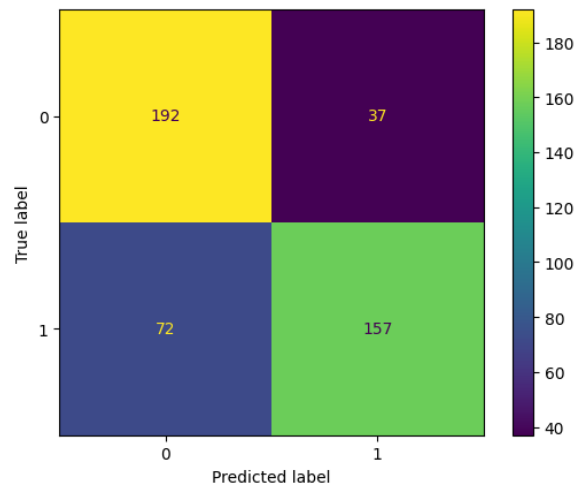


Figure 3. Confusion matrix obtained with CNN

The comparison of Precision, Recall, F1-Score and Accuracy values of the results obtained with the staff churn scoring models developed using CatBoost, LightGBM and CNN are given in Table 3.

Table 3. Precision, Recall, F1-Score and Accuracy values of staff churn scoring models

Algorithms	Precision	Recall	F1-Score	Accuracy
CatBoost	0.77	0.80	0.79	0.78
LightGBM	0.71	0.71	0.71	0.71
CNN	0.81	0.69	0.74	0.76

Based on the results,

- The LightGBM model reached a value of 0.71 in all metrics, which revealed that the model was consistent but less effective than other models. In order to increase the performance of this model, its settings need to be reviewed and improved.
- The CNN model achieved the highest value in the Precision metric with 0.81, however it showed a lower performance in the Recall metric with 0.69 compared to other models. In this context, it is observed that the model has a high false negative rate.
- An analysis of the results obtained from the developed models revealed that CatBoost-based models outperformed those based on LightGBM and CNN across all three error metrics.

6. CONCLUSION

The information technology sector is rapidly developing and increasingly facing a competitive environment. In this competitive landscape, businesses must take various strategic steps to stand out. In this context, addressing staff loss, one of the most significant challenges in the information technology sector, is of great importance. Unpredictable staff churns lead to serious difficulties for companies. In this study, staff churn scoring models have been

developed using machine learning-based methods, including CatBoost, LightGBM, and CNN. The developed scoring models have been evaluated with Precision, Recall, F1-Score and Accuracy. The results revealed that the CatBoost method exhibited superior prediction performance.

REFERENCES

- Agarwal, S., Bhardwaj, C., Gatkamani, G., Gururaj, R., Darapaneni, N., & Paduri, A. R. (2023, June). AI Based Employee Attrition Prediction Tool. In International Conference on Multi-disciplinary Trends in Artificial Intelligence (pp. 580-588). Cham: Springer Nature Switzerland.
- Al Akasheh, M., Malik, E. F., Hujran, O., & Zaki, N. (2023). A Decade of Research on Data Mining Techniques for Predicting Employee Turnover: A Systematic Literature Review. *Expert Systems with Applications*, 121794.
- Chaudhary, M., Gaur, L., & Chakrabarti, A. (2023). Who's Next: Evaluating Employee Churn in Retail using Machine Learning algorithm CHAID. *Journal of Survey in Fisheries Sciences*, 339-351.
- Chowdhury, S. J., Mahi, M. I., Saimon, S. A., Urme, A. N., & Nabil, R. H. (2023, January). An Integrated Approach of MCDM Methods and Machine Learning Algorithms for Employees' Churn Prediction. In 2023 3rd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST) (pp. 68-73). IEEE.
- Chung, D., Yun, J., Lee, J., & Jeon, Y. (2023). Predictive model of employee attrition based on stacking ensemble learning. *Expert Systems with Applications*, 215, 119364.
- Cömert, G. D., Özcan, T., & Kaya, T. (2022, October). Salesperson Churn Prediction with Machine Learning Approaches in the Retail Industry. In The International Symposium for Production Research (pp. 25-31). Cham: Springer International Publishing.
- G. Ke, Q. Meng, T. Finley, T. Wang, W. Chen, W. Ma and T. Liu, LightGBM: A Highly Efficient Gradient Boosting Decision Tree, NIPS, 2017.
- Gupta, S., Bhardwaj, G., Arora, M., Rani, R., Bansal, P., & Kumar, R. (2023, March). Employee Attrition Prediction in Industries using Machine Learning Algorithms. In 2023 10th International Conference on Computing for Sustainable Global Development (INDIACom) (pp. 945-950). IEEE.
- Gurler, K., Pak, B. K., & Gungor, V. C. (2023, June). Deep Learning Based Employee Attrition Prediction. In IFIP International Conference on Artificial Intelligence Applications and Innovations (pp. 57-68). Cham: Springer Nature Switzerland.
- Hasan, B., Shaikh, S. A., Khaliq, A., & Nadeem, G. (2024). Data-Driven Decision-Making: Accurate Customer Churn Prediction with Cat-Boost. *The Asian Bulletin of Big Data Management*, 4(02), Science-4.
- Kakulapati, V., & Subhani, S. (2023). Predictive Analytics of Employee Attrition using K-Fold Methodologies. *IJ Mathematical Sciences and Computing*, 1, 23-36.

- Konar, K., Das, S., & Das, S. (2023, January). Employee attrition prediction for imbalanced data using genetic algorithm-based parameter optimization of XGB Classifier. In 2023 International Conference on Computer, Electrical & Communication Engineering (ICCECE) (pp. 1-6). IEEE.
- Lalitha, V., Prithiv, R. S., & Lokesh, P. (2023). A Novel Analysis of Employee Attrition Rate by Maneuvering Machine Learning. In *Advances in Science and Technology* (Vol. 124, pp. 469-477). Trans Tech Publications Ltd.
- Musanga, V., & Chibaya, C. (2023, May). A Predictive Model to Forecast Employee Churn for HR Analytics. In *Proceedings of NEMISA Digital Skills Conference* (Vol. 5, pp. 17-30).
- Shaik, S., Kumar, P. S., Reddy, S. V., Reddy, K., & Bhutada, S. (2023). Machine learning based employee attrition predicting. *Asian Journal of Research in Computer Science*, 15(3), 34-39.
- Xue, X., Feng, J., Gao, Y., Liu, M., Zhang, W., Sun, X., ... & Guo, S. (2019). Convolutional recurrent neural networks with a self-attention mechanism for personnel performance prediction. *Entropy*, 21(12), 1227.

**DIKEY EKSENLI RÜZGÂR TÜRBİNLERİNDE STEPPED AIRFOIL YAPISININ
AERODİNAMİK PERFORMANSA ETKİSİNİN DENEYSEL İNCELENMESİ**
EXPERIMENTAL INVESTIGATION OF THE EFFECT OF STEPPED AIRFOIL DESIGN
ON THE AERODYNAMIC PERFORMANCE OF VERTICAL AXIS WIND TURBINES

Ömer Uçar

Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi, Havacılık ve Uzay Mühendisliği Bölümü
Adana Alparslan Türkeş Science and Technology University, Aerospace Engineering Department

ORCID ID: 0009-0006-3725-3142

Erhan Tok

Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi, Havacılık ve Uzay Mühendisliği Bölümü
Adana Alparslan Türkeş Science and Technology University, Aerospace Engineering Department

ORCID ID: 0009-0001-1240-6986

Fatih Can Ölmez

Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi, Havacılık ve Uzay Mühendisliği Bölümü
Adana Alparslan Türkeş Science and Technology University, Aerospace Engineering Department

ORCID ID: 0009-0006-9345-9735

Hürrem Akbıyık

Asist. Prof. Dr., Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi, Havacılık ve Uzay Mühendisliği
Bölümü

Asist. Prof. Dr., Adana Alparslan Türkeş Science and Technology University, Aerospace Engineering
Department

ORCID ID: 0000-0002-1880-052X

ÖZET

Son yıllarda fosil yakıtların hızla tükenmesi ve küresel ısınmanın hızla artması sebebiyle yenilenebilir enerji kaynakları üzerine araştırmalar giderek artmaktadır. Bu yenilenebilir enerji kaynaklarından birisi de rüzgâr enerjisidir. Eksen açısından incelendiğinde, rüzgâr türbinleri dikey ve yatay olmak üzere ikiye ayrılmaktadır. Bu çalışmada, H tipi rüzgâr türbini kanatları üzerinde basamak kanat profili tasarımları gerçekleştirilmiştir. Baz kanat olan NACA 0015 ve dairesel yapıdan eliptik yapıya dönüşen 13 kanat ile birlikte toplam 14 farklı tasarıma sahip kanat modeli rüzgâr tüneli testlerine tabi tutulmuştur. 60000 Reynolds sayısı ve -18° ile $+18^\circ$ derece hücum açısı aralığında kanatlar rüzgâr tüneline testlere tabi tutulmuştur. Aerodinamik performansı en yüksek 5 kanat için akış görselleştirme testleri gerçekleştirilmiştir. Bu kanatlar arasında en yüksek aerodinamik performansa sahip kanat seçilmiştir. Bu çalışma ile H tipi dikey eksenli rüzgâr türbinlerin kanatlarına yönelik bir çalışma gerçekleştirilmiş olup bu alanda yapılan çalışmalara katkıda bulunulmuştur.

Anahtar kelimeler: Rüzgâr Türbini, Kaldırma Katsayısı, Sürüklenme Katsayısı, Aerodinamik Performans, TiO_2 Temelli Yüzey Yağ Görüntüleme

ABSTRACT

In recent years, research on renewable energy sources has been increasing due to the rapid depletion of fossil fuels and the rapid increase in global warming. Wind energy is one of these renewable energy sources. In terms of axis, wind turbines are divided into two types as vertical and horizontal. In this study, step airfoil designs were applied to H-type wind turbine blades. Total of blade models with 14 different designs, including the base blade NACA 0015 and 13 blades modified from circular to elliptical, were experimented to wind tunnel tests. At a Reynolds number of 60000 and attack angles between -18° and $+18^\circ$, the airfoils were tested in the wind tunnel. Flow visualization tests were performed for b2 airfoil model with the higher aerodynamic performance than that of other models. The airfoil with the highest aerodynamic performance was selected among these airfoils. In this study, a study on H-type vertical axis wind turbine airfoils has been carried out and contributed to the studies in this field.

Keywords: Wind Turbine, Lift Coefficient, Drag Coefficient, Aerodynamic Performance, TiO₂ Based Surface Oil Flow Visualization

INTRODUCTION

The need for energy has a vital importance for human life. In the world, energy consumption is increasing day by day (Kaya et al., 2018). Figure 1 clearly shows the increase in energy consumption of countries, including Turkey, over the years.

Country	2013	2014	2017	The Total Ratio in 2017
China	2903.9	2970.3	3014.0	22.9
ABD	2271.7	2300.5	2280.6	17.3
India	626.0	666.2	700.5	5.3
Russia	688.0	689.8	666.8	5.1
Japan	465.8	453.9	448.5	3.4
Canada	335.0	335.5	329.9	2.5
Germany	325.8	311.9	320.6	2.4
Brazil	290.0	297.6	292.8	2.2
South Korea	270.9	273.1	276.9	2.1
Iran	247.6	260.8	267.2	2.0
Saudi Arabia	237.4	252.4	264.0	2.0
France	247.4	237.5	239.0	1.8
Indonesia	175.0	188.3	195.6	1.5
UK	201.4	188.9	191.2	1.5
Mexico	188.9	190.0	185.0	1.4
Italy	155.7	146.8	151.7	1.2
Spain	134.2	132.1	134.4	1.0
Australia	130.7	129.9	131.4	1.0
Türkiye	120.3	123.9	126.9	1.0
Thailand	120.3	123.4	124.9	0.9
TOTAL	12873.1	13020.6	13147.3	100

Figure 1. Ranking of primary energy consumption in the world (2013-2017) [Kaya et al., (2018)]

Energy consumption in our country is increasing day by day (Korkmaz et al., 2012). Among the energy sources, fossil fuels are mostly used to meet our energy needs (Çıtak et al., 2016). However, when fossil fuels are used, they cause an increase in greenhouse gas emissions on a global scale as seen in Figure 2. Since fossil resources release harmful gases into the atmosphere and cause global warming, the amount of energy obtained from renewable energy sources has increased and investments in this field have increased (Bayraç et al., 2017).

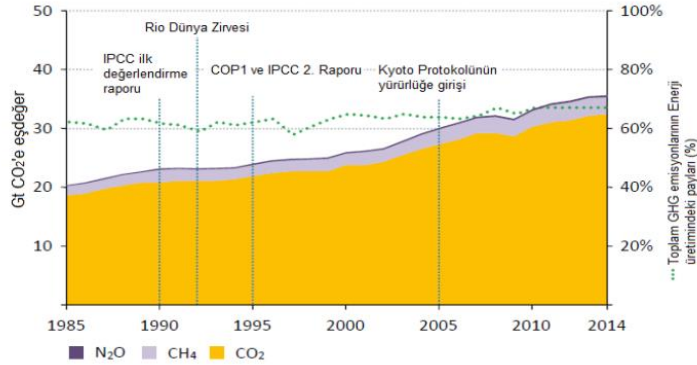


Figure 9. Greenhouse gas emission distribution on a global scale [Güner et al. (2017)]

The importance given to these renewable energy sources in the world is also valid in our country. Our country has great potential for various energy sources, especially wind energy. Among these energy types, wind energy has a large share (Bekar et al., 2020). In order to utilize wind energy more, there are various studies. Radhika et al. (2018) found that the lift force acting on the airfoil increases as the angle of attack increases on the NACA 0012 with stepped design.

In the experimental study conducted by Witherspoon et al. (1996), flow visualizations of the step structure with various angles and lengths on the upper surface of the NACA0012 wing were performed. As a result of these visualizations, comments were made on the vortices formed on the airfoils and the advantages of stepfoil structures were mentioned. Mishriky et al. (2016) conducted a numerical study on a NACA 2412 wing design to observe the effect of the step structure on the aerodynamic forces depending on the location. Acarer (2017), investigated the effect of the step structure on the aerodynamic effect and energy storage in the darrieus vertical axis wind turbine blade. Iddou et al. (2024), investigated the effects of Kline and Fogleman airfoils on darrieus type wind turbines. As a result of this numerical study at different locations and at different angles, extensive findings have been obtained. These studies are mainly focused on aerodynamic and structural elements of turbines. Wind turbines are divided into vertical and horizontal according to their axis. Vertical axis wind turbines are divided into various types such as Darrieus, Savonius and H type (Elibüyük et al., 2014). In their study, the designs of the airfoil used in H-type vertical axis wind turbines has been modified in order to maximize the benefit from the wind. In this field, there were many studies focused on the stepped airfoil to improve the performance. This stepped airfoil geometry, shown in Figure 3, was firstly proposed by Kline and Fogleman (1985).

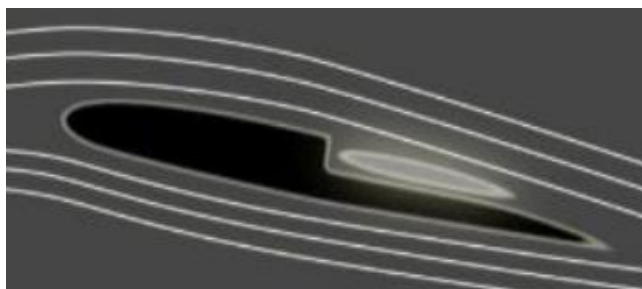


Figure 10 Vortex attached to a KFM2 Airfoil [Karunakaran (2013)]

In the design process, the base model is chosen as a NACA0015 airfoil, the chord length was determined as 14 cm and the wing span as 57 cm. The ratio of the distance of the circular structure from the leading edge of the airfoil to the rear of the airfoil was determined as 46% as a result of various literature studies. With various angles and diameter lengths of these circular structures, 13 different wing designs were presented.

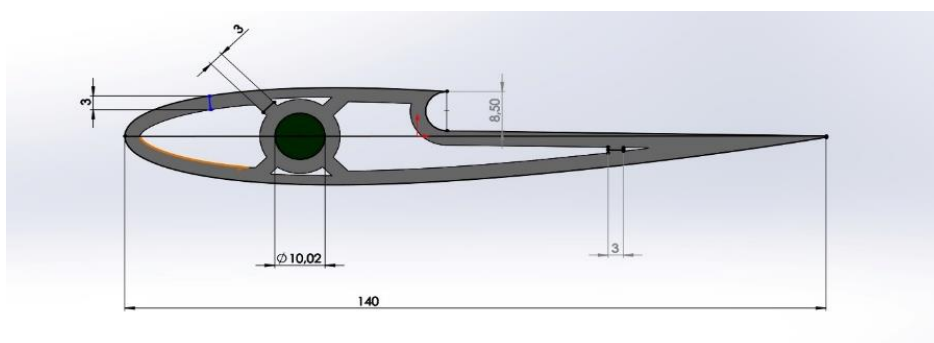


Figure 11. Airfoil dimensions with circular step structure

METHODS

14 different airfoil models were designed by using a CAD program and produced by using a 3D printer.

Table 1. Step-structured model types with various angles and diameters based on NACA 0015 airfoil

Geometric Shape	Ratio of Geometric Shape	Angle of a Geometric Shape	Schematic Name of Geometric Shape
NACA 0015	-	-	
Circle	%100	0°	a
Ellipse	%75	30°	b3
Ellipse	%75	20°	b2
Ellipse	%75	10°	b1
Ellipse	%75	0°	b
Ellipse	%50	30°	c3

Ellipse	%50	20°	c2
Ellipse	%50	10°	c1
Ellipse	%50	0°	c
Ellipse	%25	30°	d3
Ellipse	%25	20°	d2
Ellipse	%25	10°	d1
Ellipse	%25	0°	d

In Table 1, the diameter and angle characteristics of the step structures of 14 different airfoil models are given together with their schematic names. Figures from 5 to 11 show the stepped geometrical modification on the NACA 0015 airfoil.

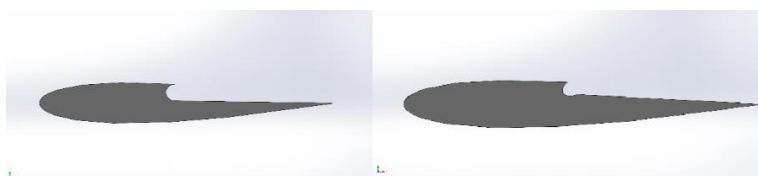


Figure 5. Geometric shape-a, Geometric shape-b3

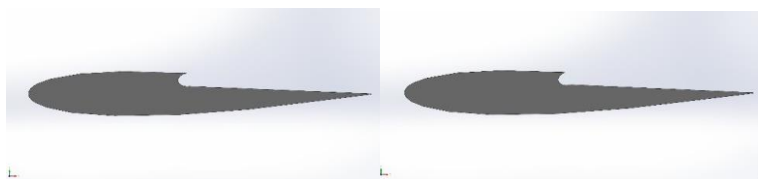


Figure 6. Geometric shape-b2, Geometric shape-b1

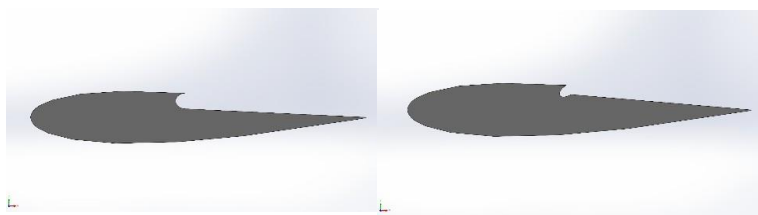


Figure 7. Geometric shape-b, Geometric shape-c3

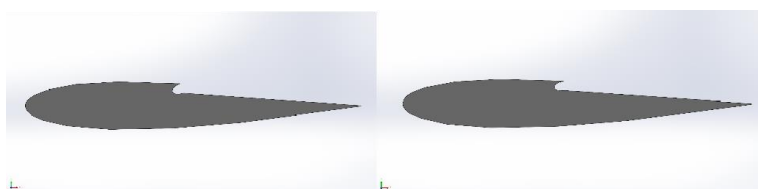


Figure 8. Geometric shape-c2 Geometric shape-c1

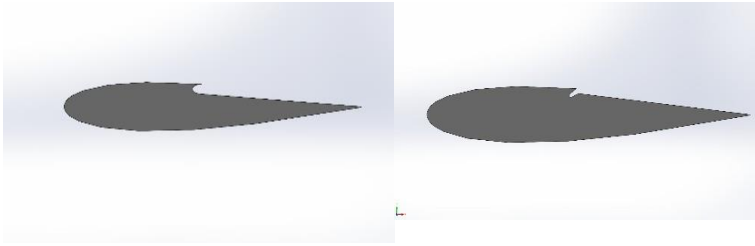


Figure 9. Geometric shape-c, Geometric shape-d3

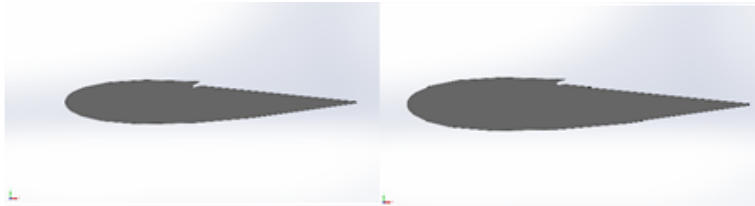


Figure 10. Geometric shape-d2, Geometric shape-d1

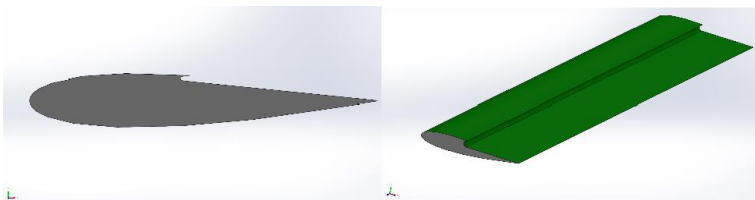


Figure 11. Geometric shape-d, Top view of step airfoil

The designed airfoils were produced with a high precision 3D printer. Each airfoil consists of approximately 4 parts and the production time corresponds to 60 hours. PLA was used as the production material. Figure 12 represents the production process of the test models.

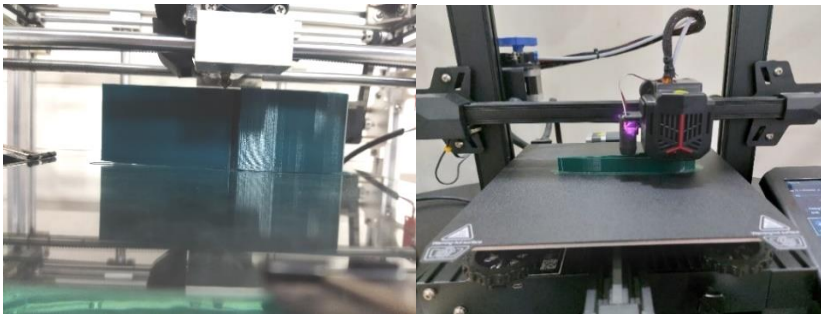


Figure 12. Production of airfoils on 3D printers

The joints of the produced airfoils were subjected to special sanding processes. Various assembly processes were carried out to achieve the desired dimensions. This assembly process and sanding processes were carried out carefully to ensure that the airfoils have the appropriate strength and close to the desired values during wind tunnel tests. Figure 13 shows the airfoil model at the end of this process.



Figure 13. *Airfoil with gluing and sanding operations realized*

After joining, the airfoils were subjected to special sanding processes to achieve the desired smoothness. During these processes, production errors and unwanted parts were eliminated, resulting in smooth surface products in terms of aerodynamic performance as seen in Figure 14 and 15.

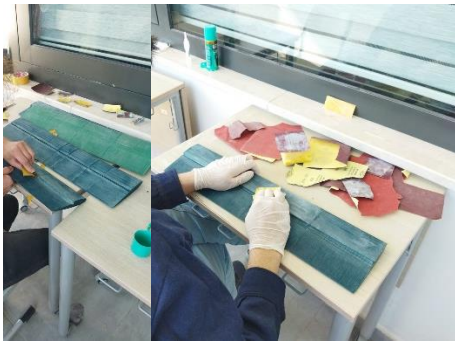


Figure 14. *Sanding process*

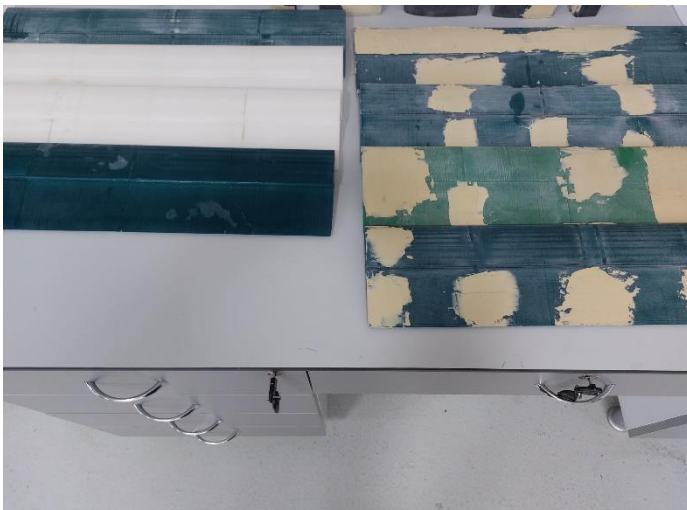


Figure 15. *Polyester putty process*

The defective parts on the airfoils were removed by sanding processes to achieve the desired smoothness, while the gaps were filled with polyester putty. After these filling processes, the airfoils were sanded again as seen in Figure 16.



Figure 16. *Sanding process*

In the last stage (in Figure 17), painting and polishing processes were carried out on the wings and the wing was finalized for wind tunnel tests.

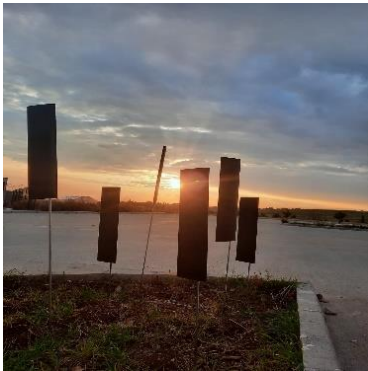


Figure 17. *Drying process of painted wings*

EXPERIMENTAL SETUP

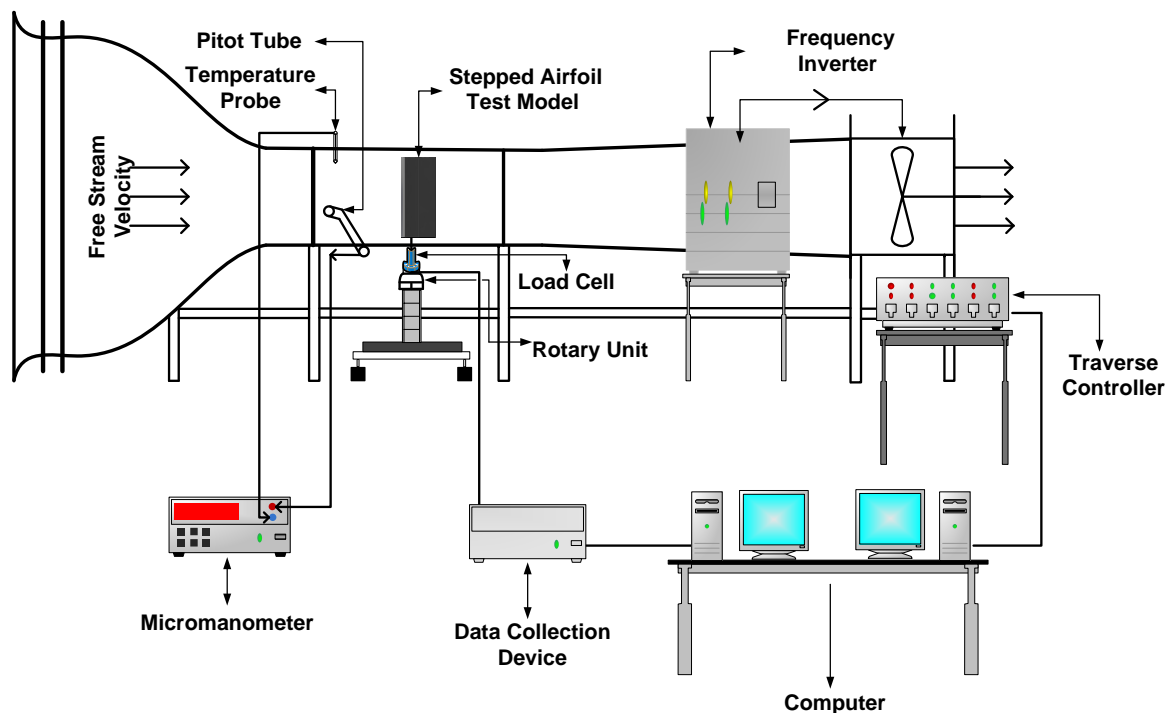


Figure 18. Schematic view of the experimental setup

The open suction type wind tunnel was used in this study and schematically shown in Figure 18. The measurements were recorded in the data acquisition card and converted into lift force and drag force values. In Figure 19, force measurement system schematic view is presented. A six-axis load cell is used to collect aerodynamic forces. This load cell is located on the top of the computer controlled rotary unit. This computer controlled rotary unit helped to arrange the desired attack angle of the test models. There is a gap between the airfoil and wind tunnel walls.

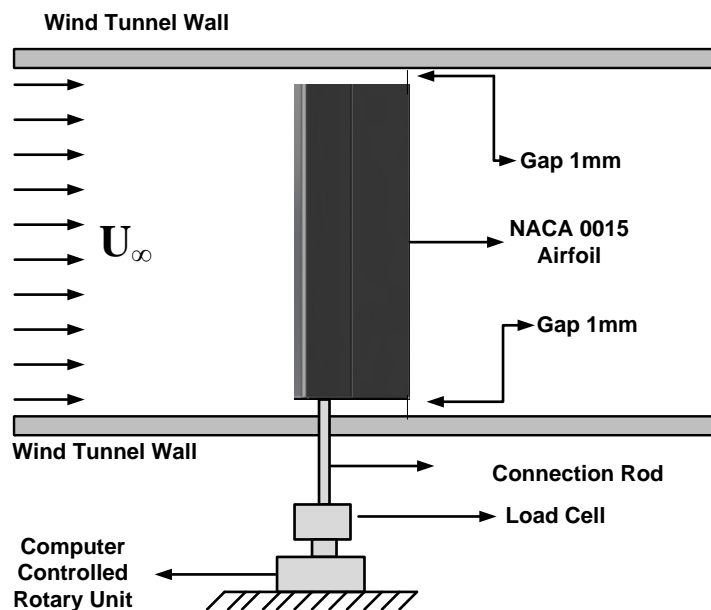


Figure 19. Appearance of test model and their placement in the test area

FINDINGS AND DISCUSSION

Tests of 14 airfoil models with different designs were carried out in the wind tunnel in the Aerodynamics Laboratory of the Mechanical Engineering Department of Niğde Ömer Halisdemir University. As a result of the force measurements, the data were taken for NACA0015-b2, NACA0015-b3, NACA0015-c3, NACA0015-d and NACA0015-d3 airfoils and were compared with the NACA0015 base airfoil model.

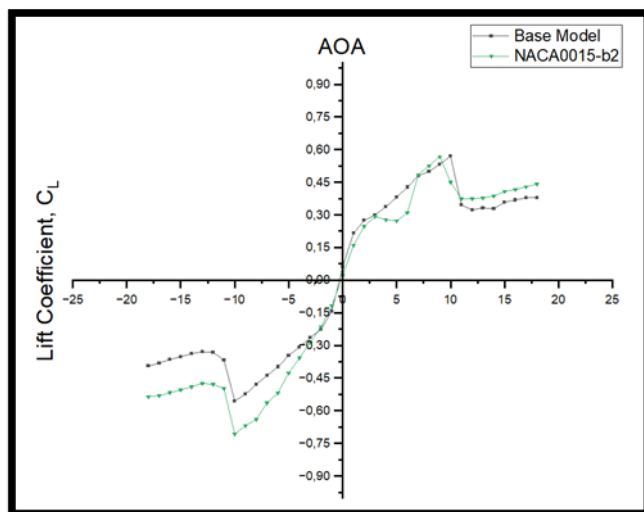


Figure 20. Lift coefficient and angle of attack plot of NACA0015 and NACA0015-b2

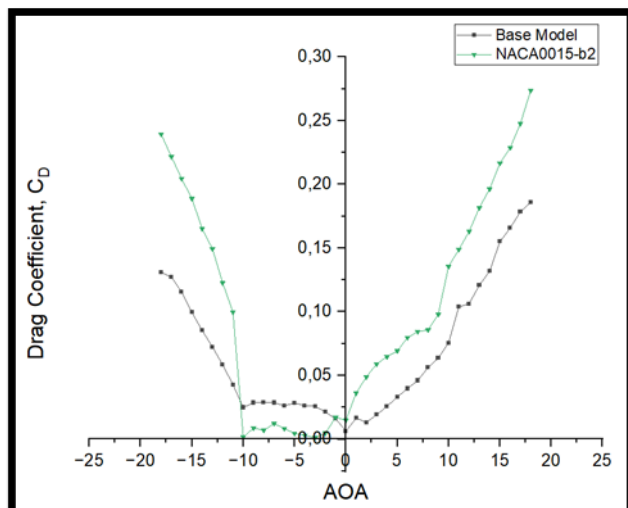


Figure 21. Drag coefficient and angle of attack plot of NACA0015 and NACA0015-b

When NACA0015-b2 and the base airfoil are compared in the lift graph (Figure 20) at -18° and $+18^\circ$ angles of attack, NACA0015-b2 is more efficient than that of negative angles of attacks. At positive attack angles, NACA0015-b2 has higher lift values, but stalled 1° earlier. When NACA0015-b2 and the base airfoil are compared in the drag graph (Figure 21), NACA0015-b2 model has lower drag. At positive angles of attack, the base airfoil has lower drag values than NACA0015-b2 airfoil model.

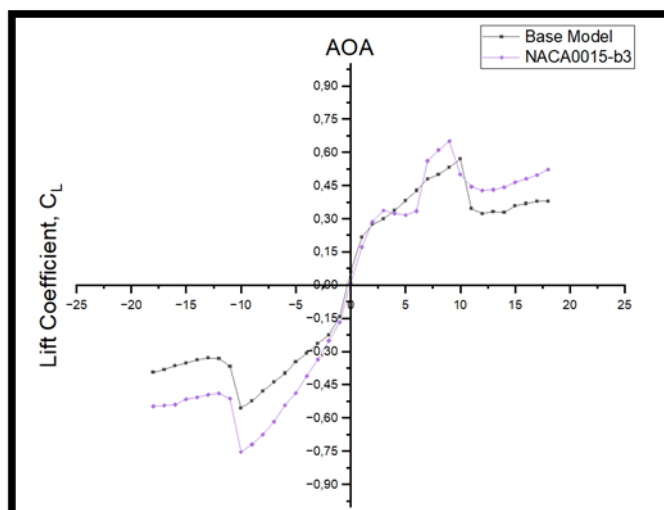


Figure 22. Lift coefficient and angle of attack plot of NACA0015 and NACA0015-b3

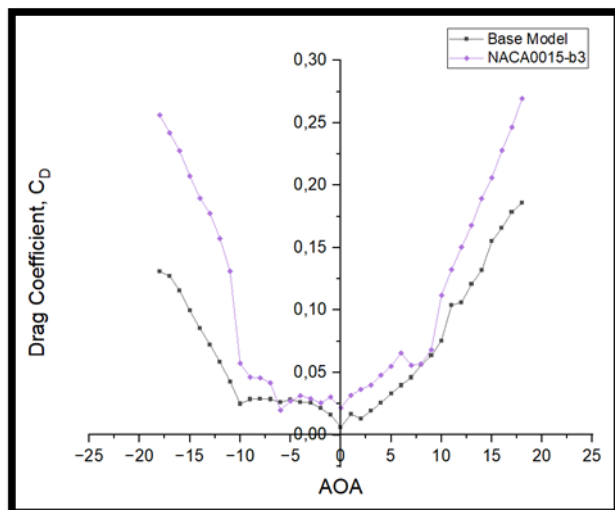


Figure 23. Drag coefficient and angle of attack plot of NACA0015 and NACA0015-b3

When NACA0015-b3 and the base airfoil are compared in the lift graph (Figure 22), NACA0015-b3 is more efficient at both all negative angles of attack and at positive angles of attack. When NACA0015-b3 and the base airfoil are compared in the drag coefficient graph (Figure 23), NACA0015-b3 airfoil has more drag at all angles of attack.

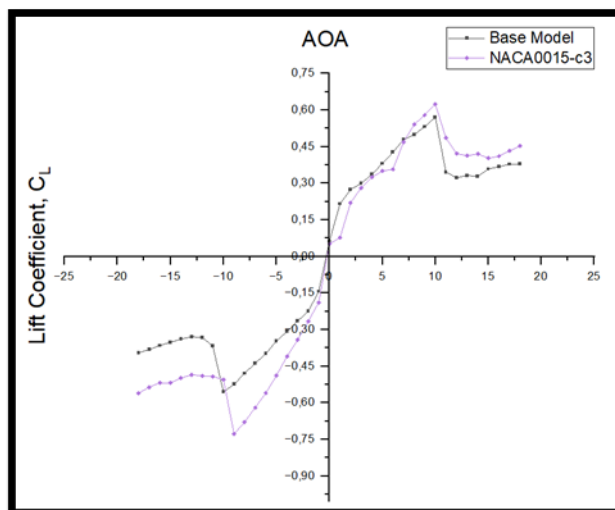


Figure 24. Lift coefficient and angle of attack plot of NACA0015 and NACA0015-c3

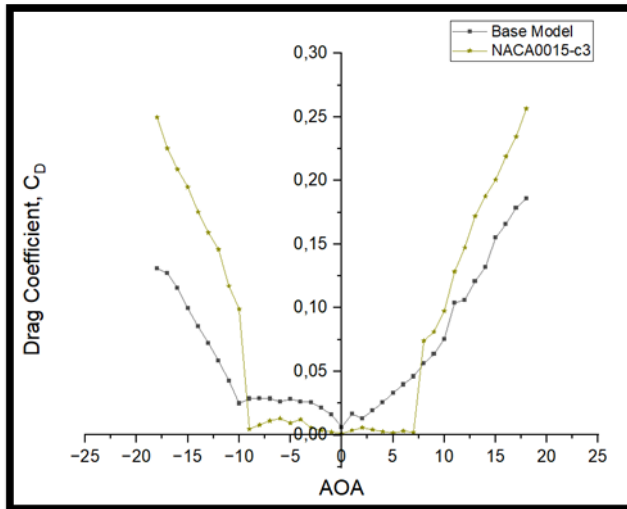


Figure 25. Drag coefficient and angle of attack plot of NACA0015 and NACA0015-c3

When NACA0015-c3 and the reference airfoil are compared in the lift graph, NACA0015-c3 stalled around 7° at positive attack angles. But one considers negative attack angles, NACA0015-c3 stalled around 9° as seen in Figure 25.

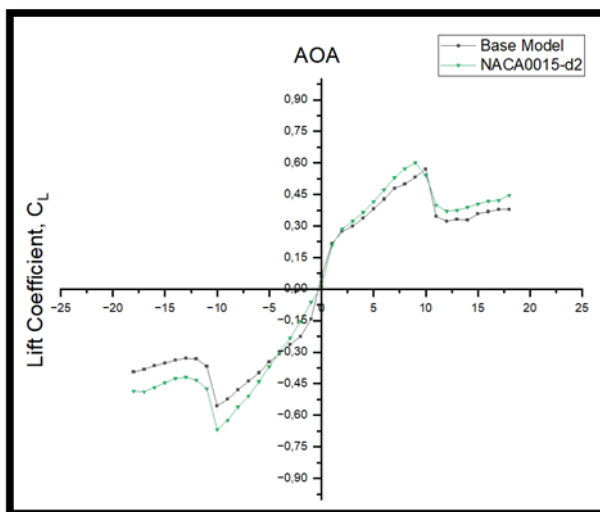


Figure 26. Lift coefficient and angle of attack plot of NACA0015 and NACA0015-d2

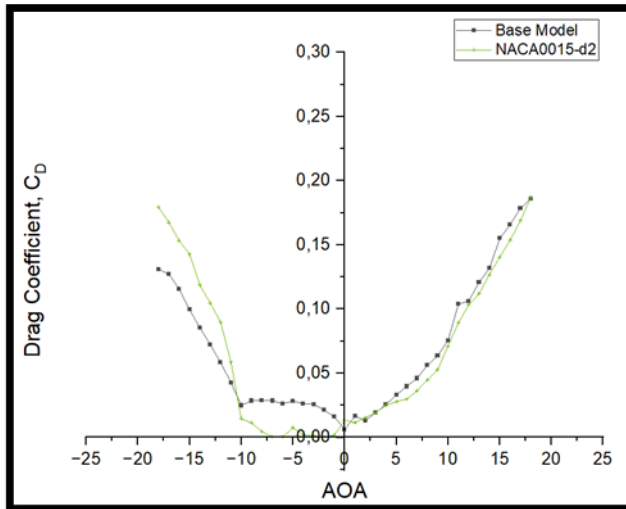


Figure 27. Drag coefficient and angle of attack plot of NACA0015 and NACA0015-d2

When NACA0015-d2 and the base airfoil are compared in the lift graph, the NACA0015-d2 airfoil design shows a more efficient performance at negative angles of attack. While at positive angles of attack the NACA0015-d2 airfoil design again it shows more efficient lift values as seen in Figure 26. When NACA0015-d2 and the reference airfoil are compared in the drag coefficient graph (Figure 27), the NACA0015-d2 airfoil design has almost similar trend. But for negative side, it exhibits totally different trend.

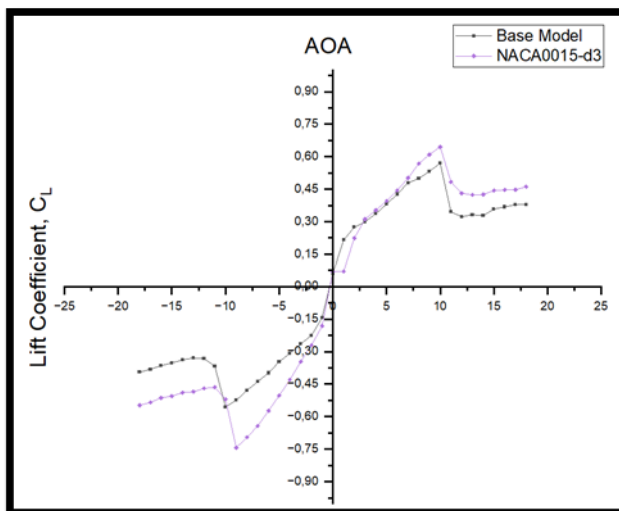


Figure 28. Lift coefficient and angle of attack plot of NACA0015 and NACA0015-d3

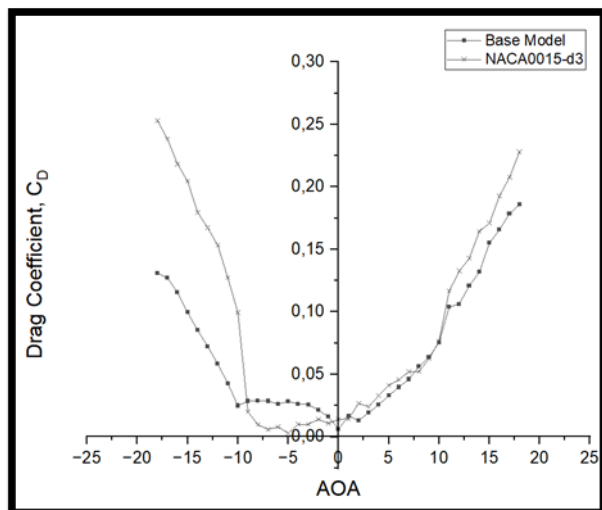


Figure 29. Drag coefficient and angle of attack plot of NACA0015 and NACA0015-d3

When the NACA0015-d3 and the reference airfoil are compared in the lift graph (Figure 28) at -18° and $+18^\circ$ angles of attack, the NACA0015-d3 airfoil design shows a more efficient performance at negative angles of attack, but enters stall 1° earlier. At positive attack angles, the NACA0015-d3 airfoil model again has higher lift values. When NACA0015-d3 and the reference airfoil are compared in the drag graph (Figure 29) at -18° and $+18^\circ$ angles of attack, the NACA0015-d3 airfoil design has lower drag values at angles between 0° and -9° and at all positive angles of attack.

As a result of the wind tunnel experiments, it was concluded that NACA0015-b2 airfoil aerodynamic force values were suitable for flow visualization tests. For the flow visualization experiments, new airfoil models were produced with reference to the same aspect ratio (AR). Titanium dioxide mixture was applied on the wing surface and flow visualization experiments were performed at $-12, -10, -8, -4, 0, 4, 8, 10, 12$ attack angles.



Figure 30. Top and bottom views of the b2 airfoil models at -4 and -8 degrees angles of attack



Figure 31. Top and bottom views of the b2 airfoil models at -10 and -12 degrees angles of attack



Figure 32. Top and bottom views of the b2 airfoil models at 0 and 4 degrees angles of attack

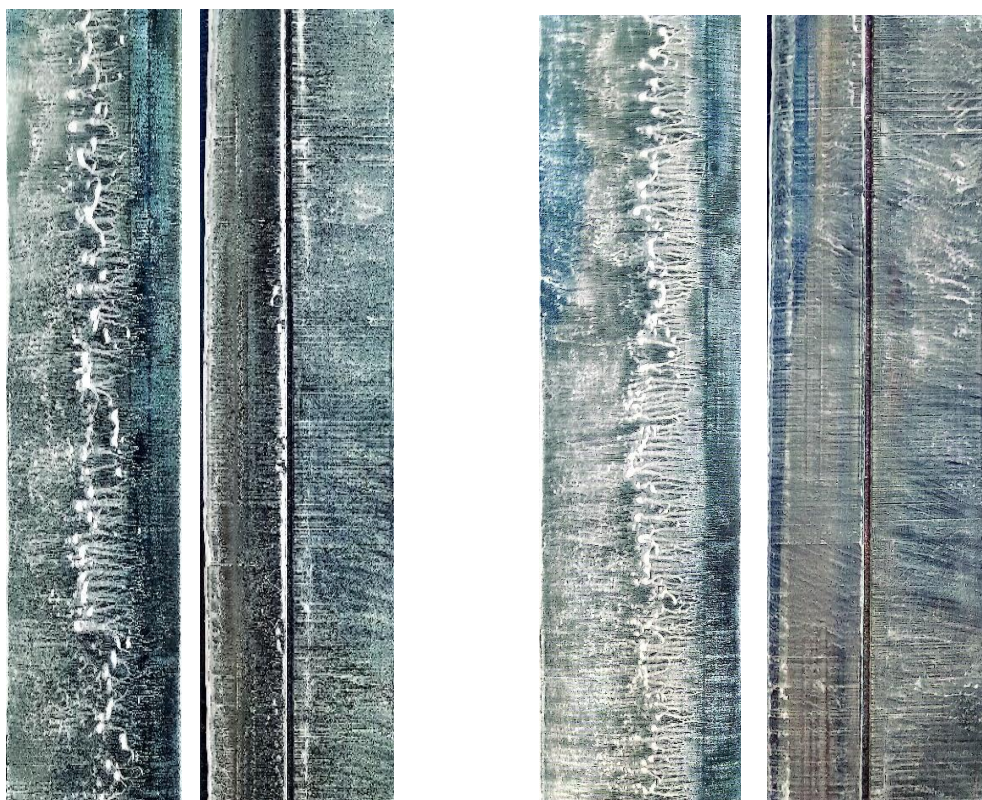


Figure 33. Top and bottom views of the b2 airfoil models at 8 and 10 degrees angles of attack



Figure 34. Top and bottom surface flow structures of the b2 airfoil models at 12 degrees angles of attack

Investigating the flow characteristics on the airfoils with flow visualization methods is critical for improving aerodynamic performance. Figures from 30 to 34 show the flow structures on the NACA0015-b2 airfoil model under different angles of attack (0, 4, 8, 10, 12, -4, -8, -10, -12 degrees) on the suction and pressure surfaces of the airfoil. It is clearly seen that a corner eddy is formed just behind the step structure on the wings and a recirculation zone is formed just behind this formation. The experimental results show that the recirculation zone and the reattachment line change at different angles of attack. The results are consistent with the flow structures in the literature and provide important information for aerodynamic design processes.

RESULTS

In this study, 14 different airfoil models with stepped geometrical modification were tested in the open suction wind tunnel. The experiments were carried at 60000 Reynolds number at attack angles between -18° and $+18^\circ$ with an increment of 1° . With the collected data, flow visualizations experiments were conducted for NACA0015-b2 airfoil model. As a result, it was seen that maximum aerodynamic performance was obtained from the NACA0015-b2 wing geometry. It is also enlightened that the stepped part of the modified airfoil showed the occurrence of the corner eddy, reattachment line and recirculation zone.

ACKNOWLEDGMENT

This project is supported by the Scientific and Technological Research Council of Türkiye (TUBITAK)-Grant No. 1919B012219132 with TUBITAK 2209-A.

REFERENCES

- Acarer, S. (2017). Kanatlarına basamak açmanın darrieus düşey eksenli rüzgar türbini güç üretimine etkisi. Dokuz Eylül Üniversitesi Mühendislik Fakültesi Fen ve Mühendislik Dergisi, 19(56), 399-409.
- Aydın, İ. (2013). Balıkesir’de Rüzgâr Enerjisi. *Doğu Coğrafya Dergisi*, 18(29), 29-50.
- Bayraç, H. N., and Çildir, M. (2017). AB Yenilenebilir Enerji Politikalarının Ekonomik Büyüme Üzerindeki Etkisi. *Uluslararası Yönetim İktisat ve İşletme Dergisi*, 13(13), 201-212.
- Bekar, N. (2020). Yenilenebilir enerji kaynakları açısından Türkiye’nin enerji jeopolitiği. *Türkiye Siyaset Bilimi Dergisi*, 3(1), 37-54.
- Çıtak, E., and Pala, P. B. K. (2016). Yenilenebilir enerjinin enerji güvenliğine etkisi. *Süleyman Demirel Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 25, 79-102.
- Elibüyük, U., and Üçgül, İ. (2014). Rüzgâr türbinleri, çeşitleri ve rüzgâr enerjisi depolama yöntemleri. *Yekarum*, 2(3).
- Güner, E. D., and Turan, E. S. (2017). Yenilenebilir enerji kaynaklarının küresel iklim değişikliği üzerine etkisi. *Doğal Afetler ve Çevre Dergisi*, 3(1), 48-55.
- Iddou, H., Nait Bouda, N., Benaissa, A., and Zereg, K. (2024). Numerical Analysis of the Kline and Fogleman Airfoil's Effect on the Operation of Straight Darrieus Wind Turbine. *Journal of Applied Fluid Mechanics*, 17(8), 1568-1592.
- Karunakaran, C. S. (2013). Study of flow field over fabricated airfoil models of NACA 23015 with its kline-fogleman variant. *Advances in Aerospace Science and Applications*, 3(2), 95-100.
- Kaya, K., Şenel, M. C., and Koç, E. (2018). Dünyada ve Türkiye’de yenilenebilir enerji kaynaklarının değerlendirilmesi. *Technological Applied Sciences*, 13(3), 219-234.
- Korkmaz, Ö., and Develi, A. (2012). Türkiye’de birincil enerji kullanımı, üretimi ve Gayri Safi Yurt İçi Hasıla (Gsyih) arasındaki ilişki. *Dokuz Eylül Üniversitesi İktisadi İdari Bilimler Fakültesi Dergisi*, 27(2), 1-25.
- Kline R. *The ultimate paper airplane*. New York, NY: Simon and Schuster, 1985.
- Mishriky, F., and Walsh, P. (2016). Effect of the backward-facing step location on the aerodynamics of a morphing wing. *Aerospace*, 3(3), 25.
- Nurbay, N., and Çınar, A. (2005). Rüzgar türbinlerinin çeşitleri ve birbirleriyle karşılaştırılması. III. Yenilenebilir Enerji Kaynakları Sempozyumu, 19-21.
- Radhika, R., Joshy, P. J., and Tide, P. S. (2018). Study of flow developments around an airfoil with a range of backward steps. *International Journal of Applied Engineering Research*, 13(3), 99-103.
- Sapmaz, H. (2023). Karbon Vergisinin Türkiye’de Uygulanabilirliği. *Uluslararası Ekonomik Araştırmalar Dergisi*, 8(3), 1-10.
- Witherspoon S and Fathi F. (1996). Experimental and computational studies of flow developments around an airfoil with backward-facing steps. *American Institute of Aeronautics and Astronautics* 96, 2481.

**AN APPLICATION OF MOST EFFICIENT PATH ESTIMATION FOR ELECTRIC
VEHICLES: THE CASE OF ISTANBUL**

Ramazan YERLİKAYA

Research Assistant, Kütahya Dumlupınar University, Faculty of Engineering, Department of Computer
Engineering

ORCID ID: 0000-0001-9046-6960

Ahmet ÇELİK

Assistant Professor, Kütahya Dumlupınar University, Tavşanlı Vocational School, Department of Computer
Technologies

ORCID ID: 0000-0002-6288-3182

ABSTRACT

In today's world, where efforts to combat global warming and climate change are gaining momentum, radical changes are being made in the transportation sector as in many other sectors. This is clearly seen in the policies pursued worldwide. The share of the transportation sector in climate change has made it inevitable to make significant changes in this sector. Electric Vehicles offer a promising solution for sustainable transportation due to their environmentally friendly features, including low carbon emissions. The proliferation of electric vehicles as an alternative to internal combustion engine vehicles is one of the major changes in the transportation sector. However, although electric vehicles are environmentally friendly, they have some fundamental problems. These problems include insufficient charging stations, long charging times, range anxiety and the lack of DC charging units, which we call fast charging, in existing charging stations. In this study, a new routing application has been made by addressing the routing problem, which is one of the problems of electric vehicles.

For this purpose, a city from 7 different regions of Turkey and random charging stations located on the road were selected. In the study, by taking the vehicle information and charging status information received from the user, the optimal route was calculated and an application that visually draws a route was developed. According to the results obtained, the developed algorithm has a deviation of 5.21% compared to the Google Maps algorithm.

Keywords: Electric vehicle, charging station finding, learning algorithm, range estimation, route detection.

1. INTRODUCTION

The excessive use of fossil fuels worldwide leads to serious environmental problems such as climate change and air pollution on a global scale. In particular, carbon dioxide (CO₂) emissions

stand out as the greenhouse gas that contributes the most to the atmosphere. Carbon emissions from the combustion of fossil fuels increase with industrial activities, deforestation and agricultural practices, accelerating global warming. (Tubiello et al., 2022).

Electric vehicles are seen as an important solution to these environmental challenges. Electric vehicles provide lower carbon emissions compared to fossil fuel vehicles and contribute to zero emission targets when supported by renewable energy sources (Hawkins et al., 2013). Many countries are developing policies to encourage the use of electric vehicles in order to reduce carbon emissions and create a sustainable transportation infrastructure. (Global EV Outlook, 2021). In particular, major economies such as the European Union, China and the United States are accelerating this transformation with regulations promoting electric vehicles. (Mazzucato & Semieniuk, 2018). The European Union's target for new vehicle sales to be completely zero-emission by 2035 is considered an important step in this context (European Commission, 2021). However, there are also some challenges to the widespread adoption of electric vehicles. The shorter range of electric vehicles compared to gasoline and diesel vehicles, limited charging capacity, and the fact that energy consumption varies depending on factors such as load and road gradient are among the factors that increase the risk of these vehicles being stranded. Therefore, determining the most suitable routes for electric vehicles plays a critical role in minimizing this risk. (Olcay, 2024).

One of the most important challenges preventing the widespread adoption of electric vehicles is range anxiety. In this paper we will focus on the problem of range anxiety. Range anxiety is defined as a stress experience faced by EV users, and this concept refers to the difficulties in managing the current or expected range situation (Lazarus, 1995). To manage range anxiety, battery EV users often avoid critical range situations by allocating large range safety buffers. Comfortable range refers to the distance users can comfortably travel and is directly related to range anxiety. Range comfort zones are equivalent to about 80% of available range, and this comfortable range can increase with BEV experience. Research shows that there is a relationship between comfort range and range anxiety, and that a comfortable range experience can reduce range anxiety (Rauh et al., 2015).

In this study, weight and altitude parameters are added to the vehicle routing problem in order to overcome the deficiencies in previous studies. Thus, it is aimed to find the most efficient path. The performance of the algorithm in real-world scenarios is analyzed by sampling between Istanbul and other cities. It is observed that the developed algorithm is successfully implemented and can optimize energy consumption, especially for long distances and routes with challenging altitude differences.

2. METHOD

In this study, a comprehensive algorithm is developed to determine energy efficient and safe routes for electric vehicles. This algorithm goes beyond traditional routing methods and aims

to determine the optimal route by considering many parameters that affect the energy consumption of the vehicle. The method basically consists of five main stages: data collection and database integration, display of user inputs, route generation and distance calculation, route updating with the use of stations and visualization of the results. These stages work in interaction with each other to provide a dynamic and adaptive routing process. The flowchart of the developed algorithm is given in Figure 1.

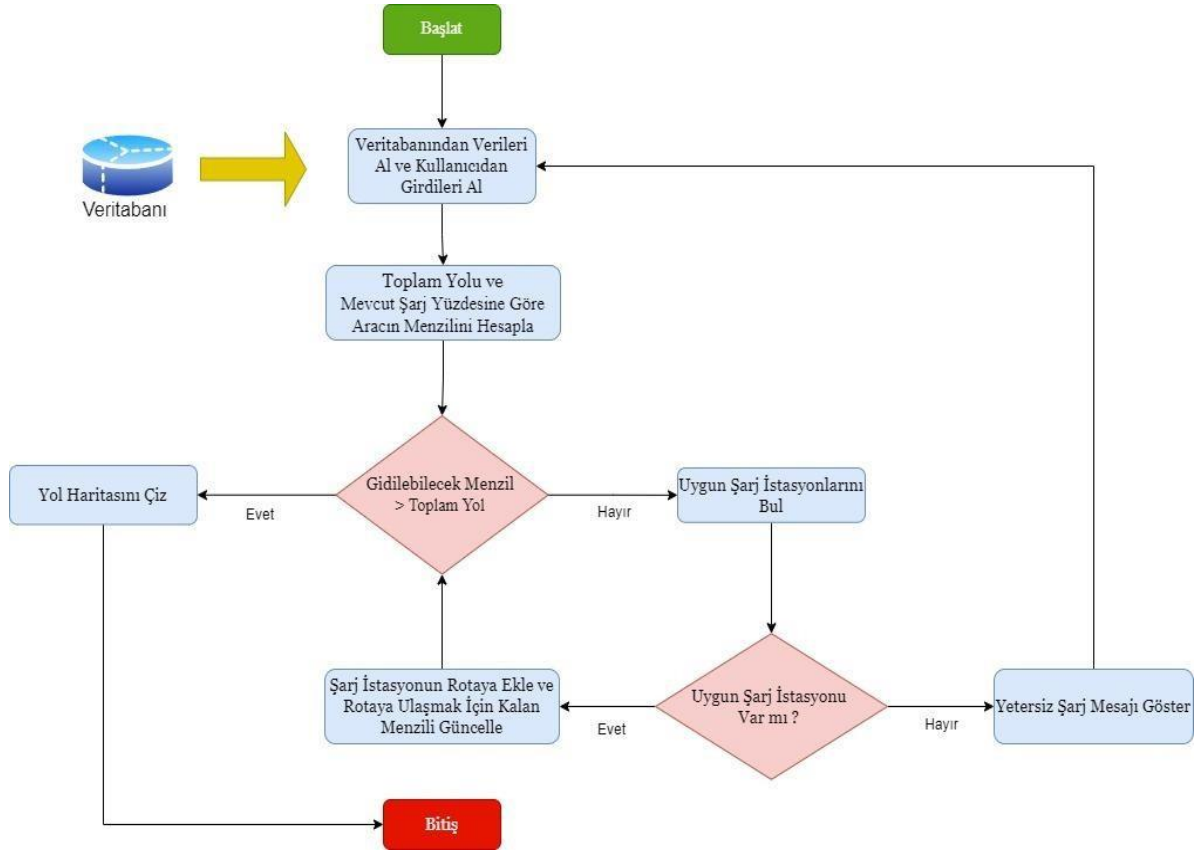


Figure 1. Algorithm flowchart

2.1. Data Collection and Database Integration

At this stage, the developed application structure consists of vehicle model and features, city and altitude interface, charging station and database interface.

2.1.1 Vehicle Models and Specifications

The energy consumption of electric vehicles can vary greatly depending on the vehicle model. For this reason, characteristics of different vehicle models are stored in the database. These characteristics include parameters such as maximum range, battery capacity, energy consumption rate (kWh/km) and vehicle weight. This information is collected from the source data on the vehicles' own websites and is used directly in the calculation of the vehicle's range.

2.1.2 City and Altitude Data

The algorithm determines the optimal route by taking into account the distances and altitude differences between cities. Therefore, the latitude, longitude and altitude information for each city is stored in the database. This information is collected from sources such as Google Maps API and OpenStreetMap and integrated into the database. Moreover, since altitude data is an important factor affecting the energy consumption of the vehicle, the accuracy of this data is of great importance. Altitude data has been optimized especially for routes with high gradients.

2.1.3 Charging Stations

The location of the charging stations is one of the most critical components of the algorithm. The latitude and longitude information of the charging stations is stored in the database and this information is used to determine the most suitable charging points along the route. The locations of the charging stations are taken from sample charging station databases such as PlugShare, ChargePoint.

2.1.4 Database

The data is stored in a MySQL based database. This database stores information on vehicle models, cities and charging stations through different tables.

2.2. Creating the User Information Screen

This section describes the creation of a graphical user interface (GUI) that allows the user to enter the starting and destination cities, vehicle model, current state of charge and number of passengers. Designed using the Tkinter library, this interface collects the information needed to calculate the travel route and provides a user-friendly experience. The interface is structured with various input fields and drop-down lists, supported by basic controls to ensure the accuracy and consistency of the information received from the user. This interface is shown in Figure 2. There are drop-down lists for origin and destination cities and vehicle model, and an input box for charging status. The number of passengers is also selected from a drop-down list. All this information is the basic data to be used in the calculation of the optimal route. Based on the information entered by the user, the route calculation process is initiated by clicking on the "Find Route" button. This simple and effective design aims to provide the user with a comfortable and intuitive experience.



The screenshot shows a web application window titled "En Verimli Yol". It contains a form with the following fields: "Başlangıç Şehri" (Start City) with a dropdown menu showing "Ankara"; "Varış Şehri" (Destination City) with a dropdown menu showing "Antalya"; "Araç Modeli Seçiniz" (Select Vehicle Model) with a dropdown menu showing "TOGG T10X"; "Araçın Şarj Durumu (%)" (Vehicle Charge Status (%)) with a text input field containing "55"; and "Yolcu Sayısı" (Number of Passengers) with a dropdown menu showing "2". At the bottom of the form is a green button labeled "Yolu Bul" (Find Route).

Figure 2. User input screen

2.3. Route Generation and Distance Calculation

The main goal of the routing algorithm is to determine the optimal route while at the same time reducing energy consumption. Graph structure and distance calculation methods were used to generate the route.

2.3.1 Graph Structure and Dijkstra Algorithm

A graph algorithm is a computational procedure that operates on graph structures consisting of nodes (or vertices) and edges (or links). In graph theory, nodes represent entities, while edges denote the relationships or connections between these entities. The study of graph algorithms covers a wide range of applications, from network analysis to optimization problems, and is fundamental in fields such as computer science, mathematics and engineering (Gross et al., 2018). An example graph structure is drawn in Figure 3.

The Dijkstra Algorithm is an algorithm for finding the optimal path. Since this algorithm searches for the minimum cost path among all paths in sequence starting from the starting point, the search space expands concentrically (Noto & Sato, 2000). Dijkstra's algorithm is a well-known method for finding shortest paths from a source node to all other nodes in a weighted graph where all edge weights are non-negative. Developed by Edsger W. Dijkstra in 1956, the algorithm uses a systematic approach to explore the graph and uses a priority queue to select the next node with the smallest temporal distance (Rahmadi, 2023).

The implementation of this algorithm for electric vehicles requires the determination of weights (distances) between each node (city or charging station), taking into account energy consumption and vehicle charging status.

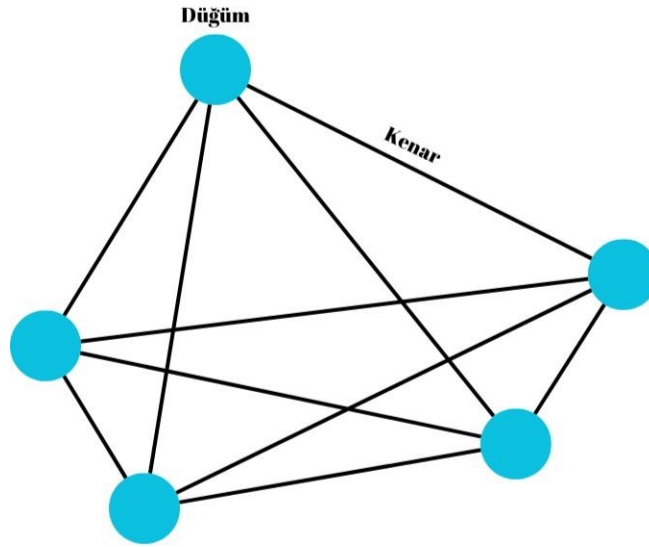


Figure 3. An example graph structure

2.3.2 Current Charging Status

One of the most critical factors in route planning is the current state of charge of the vehicle. This is vital in calculating the amount of energy that will be depleted along the way and the remaining range, even if the vehicle starts with an initial 100% charge. For example, if the range of a vehicle on a full charge is 400 km and the current state of charge is 50%, the vehicle can theoretically travel 200 km. The charging data received from the user is processed with the vehicle model data to calculate the prioritized vehicle range. The vehicle range calculation is shown in equation 1:

$$Q_m = \frac{v_s}{100} * v_m \quad (1)$$

Q_m = Reachable range, V_s Vehicle charging status, V_m is the maximum range of the vehicle.

2.3.3 Passenger Number Impact

Each extra passenger in the vehicle increases the total vehicle weight and therefore the energy consumption. In the calculation here, each passenger is assumed to weigh 80 kg, reducing the range of the vehicle by 2.43% for 1 passenger (Szumska & Jurecki, 2021). For example, a vehicle with 5 passengers will have a range that is about 12.15% shorter than the empty range. The calculation here is shown in equation 2:

$$Q_{mt} = Q_{max} - (n_y * Q_{max} * (\frac{2.43}{100})) \quad (2)$$

Q_{mt} maximum total distance, Q_{max} maximum distance, n_y is the number of passengers.

2.3.4 Altitude Difference Effect

The slope of the road can significantly affect the energy consumption of the vehicle. On sloping roads, the vehicle needs to expend more energy on exits. Therefore, in the calculation here, only if the altitude difference is positive, it is included in the algorithm. For descents, the range loss due to altitude difference is assumed to be zero. According to the altitude information of the cities from the database, for every 100 meters of altitude difference, 1.955 km of range is lost (Yang et al., 2014). The calculation is shown in equation 3 and equation 4:

$$m_i = \frac{e_d}{100} * 1.955 \quad (3)$$

$$Q_{max} = Q_{max} - m_i \quad (4)$$

$$m_i = \text{menzil kaybı}$$

$$e_d = \text{rakım farkı}$$

2.4. Use of Charging Stations and Route Updating Procedures

If the current state of charge of the vehicle is not sufficient to reach the destination, it is necessary to find a suitable charging station on the route and update the route of the vehicle accordingly. At this stage, the algorithm determines the nearest charging station and the route is updated to fully replenish the vehicle's current state of charge.

2.4.1 Determining the Nearest Charging Station

When determining the closest charging station from the current location to the destination, the algorithm applies several technical steps to determine whether the vehicle's available range is sufficient. These steps include coordinate calculations and range constraints to verify whether charging stations are within range.

First, the distance to the current position was calculated using the geographical coordinates of each charging station. This calculation was done using the function "geopy.distance.great_circle", a Python library. This function uses a great circle distance calculation to calculate the shortest distance between two coordinates. This calculated distance is compared to the updated range, taking into account factors such as the current state of charge of the vehicle, the number of passengers and the height difference. To calculate the range of the vehicle, it takes into account the loss of range depending on the percentage of charge, number of passengers and altitude difference. The function "calculate_achievable_distance" integrates these factors to calculate the maximum achievable distance. The charge percentage determines a proportion of the vehicle range, while the number of passengers reduces the range loss per 80 kg by a percentage. Altitude difference is used to calculate the range loss for a given elevation change, usually a certain distance loss is calculated for every 100 meters of elevation difference.

The range value from these calculations is used to determine whether each charging station is within the available range. If a charging station is within the available range of the vehicle, the algorithm considers it as a suitable stop and the vehicle is diverted to it. Additional criteria such as the capacities and waiting times of the charging stations also play a role in selecting the most suitable charging station. At this stage, the most suitable station is determined by taking into account the distance calculations used to verify whether the stations are within range, distance calculations with the great circle function and range constraints.

2.4.2 Route Update and Charge Planning

Once charging is complete, the algorithm checks the route for any changes and updates it again if necessary. Since the charging stations are chosen to optimize the energy consumption of the vehicle, stops at charging stations aim to minimize the overall distance and total energy consumption of the route.

2.5. Visualization of Results and User Interface

The results of the developed algorithm are presented to the user visually. The route and related parameters determined by the algorithm are visualized using Python libraries such as matplotlib and plotly (matplotlib, Accessed 24.08.2024). These libraries visually present the user with information such as the current state of the vehicle, the selected route, charging status, number of passengers, altitude difference and road conditions. The graphics used in the visualization are dynamically updated, providing the user with information in real time.

Figure 4 shows an example route planning between Istanbul and Malatya. When a person who wants to travel from Istanbul to Malatya with his/her electric vehicle enters the charging status, vehicle model and the number of passengers in the vehicle, he/she is presented with a visual that includes the vehicle route, range loss due to altitude difference, altitude difference, initial charge, distance that can be traveled with the current charge of the vehicle, maximum range of the vehicle, distance between the two cities, and draws the most efficient route to the destination he/she wants to go, with cities and charging stations on the map of Turkey at the bottom.

Figure 1



Figure 4. A sample route planning between Istanbul and Malatya

3. Experimental Results and Discussion

In Table 1, a comparison between the developed algorithm and the Google Maps algorithm is made. Renault Zoe R110 electric vehicle was selected for comparison. The initial charge is assumed to be 50% and the number of passengers in the vehicle is assumed to be 2 people. According to this comparison, there is an average deviation of 5.21% between the developed algorithm and the Google Maps algorithm. In the scenario, Istanbul city was selected as the starting point and 8 cities were selected as destination points. The shortest distance was found between Istanbul and Ankara, with a difference of only 0.45%. The farthest distance is between Istanbul and Iğdır, resulting in a difference of 6.3%. The lowest deviation was observed on the Istanbul - Ankara route and the highest deviation was observed on the Istanbul - Malatya route with a deviation of 10.5%. The average deviation was calculated as 5.21%.

Table 1. Deviation differences between the developed algorithm and Google Maps

Scenario	Google Maps	Developed Algorithm	Difference
Istanbul - Ankara	448 km	446 km	%0.45
Istanbul - Trabzon	1098 km	1017 km	%7.37
Istanbul - Iğdır	1538 km	1441 km	%6.3
Istanbul - Malatya	1099 km	984 km	%10.5
Istanbul - Antalya	698 km	660 km	%5.44
Istanbul - Izmir	482 km	488 km	%1.24

Mean Deviation **%5.21**
Share

4. Discussion

Some studies on Electric Vehicle Route Planning (EARP) have been conducted in the literature. The comparison of the studies and the developed model is shown in Table 2.

Table 2. Comparison of some electric vehicle routing algorithms used in the literature and the algorithm developed in this study

Researcher and Algorithm Used	Test environment or test tool	Method or Success
(Mao et al., 2020) - Ant Colony Algorithm	Visual C++	Average cost savings of 2.29% compared to variable neighborhood search
(Basso et al., 2019) - 2-stage EARP	Matlab-based Global Simulation Platform (GSP) A fully electric medium-duty truck from Volvo	Average error according to classical EARP 2.48
(Yu et al., 2022) - Simulated Annealing Algorithm	C++	1.90% for small datasets, 4.82% for medium datasets and 27.68% for large datasets compared to Gurobi algorithm
Developed model	Python Renault Zoe R110 electric vehicle	5.21% Margin of Error according to Google Maps algorithm

In a study by Mao et al. the Ant Colony Optimization Algorithm was used. This algorithm is a method developed to solve the electric vehicle routing problem. The algorithm is a meta-heuristic algorithm inspired by the foraging behavior of ant colonies in nature. The tests were performed on a computer with Intel Core i5 3GHz processor and 8GB RAM. The algorithm was coded using Visual C++ and tested on a dataset provided by Schneider et al. This dataset contains 56 test cases with different distribution types (clustered, random and randomly clustered) with 100 customers and 21 charging stations. This algorithm achieved an average cost savings of 2.29% compared to the variable neighborhood search algorithm (Mao et al., 2020).

In a study by Basso et al, a 2-stage EARP algorithm was used. This algorithm was developed to solve routing problems for electric vehicles. The 2-stage EARP optimizes the routes of vehicles by improving the energy consumption estimation and takes into account battery and time window constraints. The algorithm uses an energy prediction model based on Newton's

law of motion and plans routes taking into account factors such as topography, speed profile, acceleration and braking. The tests were carried out on the Gothenburg, Sweden road network. The vehicle model used is a fully electric medium-duty truck from Volvo. Simulations were performed using the Global Simulation Platform (GSP), a MATLAB/Simulink based platform. The simulations used a two-speed electric powertrain model of the vehicle and an average driver model. Furthermore, road network data were obtained from the Swedish Transport Administration (NVDB) and OpenStreetMap. The 2-stage EARP has an average error rate of 3.48% in energy consumption estimation. This algorithm was able to estimate energy consumption more accurately by using detailed topographic and speed profiles. In comparisons with real data, the energy predictions of the 2-stage EARP showed an average deviation of only 2.48% compared to the actual consumption, indicating the high accuracy of the algorithm. (Basso et al., 2019).

The Simulated Annealing algorithm was used in Yu et al. This algorithm is a preferred meta-heuristic optimization algorithm for solving the vehicle routing problem. This algorithm works in a similar approach to the cooling process and it cycles through possible solutions to reach the global optimum solution. The algorithm has shown competitive and even superior results compared to Gurobi Optimizer in various situations, including large data sets. Gurobi Optimizer is a prescriptive analytics platform and decision-making technology. Gurobi Optimizer is a solver because it uses mathematical optimization to compute the answer to a problem. As a testbed, the algorithms were implemented in the C++ programming language. The experiments were performed on a computer with an Intel Core 3.40 GHz CPU. The mathematical programming model was tested on the same computer using the Gurobi solver. The test data sets are divided into small, medium and large data sets. The performance of the Simulated Annealing algorithm is quite good compared to Gurobi. It improved Gurobi's results by 1.90% on small data sets, 4.82% on medium data sets and 27.68% on large data sets. These results show that the algorithm is more suitable for large-scale problems and can produce high quality solutions in less time. The overall success rate of the algorithm is quite high in terms of solution quality and computation time (Yu et al., 2022).

The findings from these studies reveal the effectiveness of various meta-heuristic algorithms for solving electric vehicle routing problems. While Mao et al.'s Ant Colony Optimization Algorithm has shown cost savings compared to the variable neighborhood search algorithm, Yu et al.'s Simulated Annealing algorithm has shown significant improvements over the Gurobi solver, especially for large data sets. The 2-stage EARP algorithm developed by Basso et al. is notable for its accuracy in energy consumption estimation. All three algorithms stand out with their specific advantages and show that they offer solutions to improve performance in electric vehicle routing problems.

In the model developed in this study, unlike other studies, a simulation environment was developed with Python programming language and the scenarios were tested on this platform. The algorithm finds the shortest route between two cities based on the charging status of the

vehicle. If the charge is not sufficient, it stops at a charging station on the way and repeats this process until the destination. The most important contribution of the algorithm is that while making these calculations, it includes the height difference between the two points and the weight of the vehicle depending on the number of people in the vehicle.

5. CONCLUSION

In this study, a new route optimization algorithm to improve energy efficiency for electric vehicles is developed and tested with examples between Istanbul and other cities. The algorithm performed with a deviation of only 5.21% compared to existing systems such as Google Maps. The ability to optimize energy consumption, especially over long distances and routes with challenging altitude differences, demonstrates the effectiveness of the algorithm. The algorithm's flexibility and user-friendly interface help reduce range anxiety for EV users. However, there are some limitations such as the lack of charging stations in rural areas and the fact that the route drawn does not exactly pass through highways. In future studies, it is suggested to overcome these limitations and to strengthen the algorithm with artificial intelligence. The algorithm is considered as an important step in determining energy efficient routes for electric vehicles.

REFERENCES

- Basso, R., Kulcsár, B., Egardt, B., Lindroth, P., & Sanchez-Diaz, I. (2019). Energy consumption estimation integrated into the Electric Vehicle Routing Problem. *Transportation Research Part D: Transport and Environment*, 69, 141-167. <https://doi.org/10.1016/j.trd.2019.01.006>
- Global EV Outlook 2021*. (2021).
- Hawkins, T. R., Singh, B., Majeau-Bettez, G., & Strømman, A. H. (2013). Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles. *Journal of Industrial Ecology*, 17(1), 53-64. <https://doi.org/10.1111/j.1530-9290.2012.00532.x>
- Mao, H., Shi, J., Zhou, Y., & Zhang, G. (2020). The Electric Vehicle Routing Problem With Time Windows and Multiple Recharging Options. *IEEE Access*, 8, 114864-114875. <https://doi.org/10.1109/ACCESS.2020.3003000>
- Mazzucato, M., & Semieniuk, G. (2018). Financing renewable energy: Who is financing what and why it matters. *Technological Forecasting and Social Change*, 127, 8-22. <https://doi.org/10.1016/j.techfore.2017.05.021>
- Noto, M., & Sato, H. (2000). A method for the shortest path search by extended Dijkstra algorithm. *SMC 2000 Conference Proceedings. 2000 IEEE International Conference on Systems, Man and Cybernetics. "Cybernetics Evolving to Systems, Humans, Organizations, and Their Complex Interactions" (Cat. No. 00CH37166)*, 3, 2316-2320. <https://doi.org/10.1109/ICSMC.2000.886462>
- Olcay, Y., & Danışmanı, T. (n.d.). *OPTIMIZATION OF ELECTRIC VEHICLE ROUTING IN*

LOGISTICS SECTOR.

- Rahmadi, D. (2023). On Finding Shortest Path Over Vocational High School in Yogyakarta Based on Graph Theory Algorithm. *Mathematical Journal of Modelling and Forecasting*, 1(2), 10-14. <https://doi.org/10.24036/mjmf.v1i2.14>
- Rauh, N., Franke, T., & Krems, J. F. (2015). Understanding the Impact of Electric Vehicle Driving Experience on Range Anxiety. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 57(1), 177-187. <https://doi.org/10.1177/0018720814546372>
- Szumaska, E. M., & Jurecki, R. S. (2021). Parameters Influencing on Electric Vehicle Range. *Energies*, 14(16), 4821. <https://doi.org/10.3390/en14164821>
- Tubiello, F. N., Karl, K., Flammini, A., Gütschow, J., Obli-Laryea, G., Conchedda, G., Pan, X., Qi, S. Y., Halldórudóttir Heiðarsdóttir, H., Wanner, N., Quadrelli, R., Rocha Souza, L., Benoit, P., Hayek, M., Sandalow, D., Mencos Contreras, E., Rosenzweig, C., Rosero Moncayo, J., Conforti, P., & Torero, M. (2022). Pre- and post-production processes increasingly dominate greenhouse gas emissions from agri-food systems. *Earth System Science Data*, 14(4), 1795-1809. <https://doi.org/10.5194/essd-14-1795-2022>
- Yang, S. C., Li, M., Lin, Y., & Tang, T. Q. (2014). Electric vehicle's electricity consumption on a road with different slope. *Physica A: Statistical Mechanics and Its Applications*, 402, 41-48. <https://doi.org/10.1016/j.physa.2014.01.062>
- Yu, V. F., Susanto, H., Jodiawan, P., Ho, T.-W., Lin, S.-W., & Huang, Y.-T. (2022). A Simulated Annealing Algorithm for the Vehicle Routing Problem With Parcel Lockers. *IEEE Access*, 10, 20764-20782. <https://doi.org/10.1109/ACCESS.2022.3152062>
- European Commission. (2021). *Fit for 55: Delivering the EU's 2030 Climate Target on the way to climate neutrality*. https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541 International Energy Agency. (2022). *Electric vehicle charging infrastructure development*. <https://www.iea.org/reports/electric-vehicle-charging-infrastructure-development>
- Lazarus R. S. (1995). Psychological stress in the workplace. In Crandall R., Perrewé P. L. (Eds.), *Occupational stress: A handbook* (pp. 3-14). Philadelphia, PA: Taylor & Francis. <https://matplotlib.org/stable/>, Accessed 24.08.2024
- Gross, J. L., Yellen, J., & Anderson, M. (2018). Graph theory and its applications. <https://doi.org/10.1201/9780429425134>

**DETERMINATION OF A RELIABLE MEASUREMENT DURATION FOR RADIAL
FORCE**

Oğuzcan DEMİR

SKT Spare Parts, Bursa, Turkey.

ORCID: 0009-0007-2099-7812

ABSTRACT

Seals are widely used components in passenger and commercial vehicles, as well as many other machines which require lubrication. Their use and proper functioning are vital for mechanical systems, such as; engine, transmission, axles and many more, to maintain a longer and healthier service life of the machines used. All of the mentioned machines and mechanisms require a proper and perpetual lubrication to serve well upto their targeted performance and efficiency. All metrics and dimensioning aside, there is one critical parameter which is directly linked to leak-tightness and sealing performance of a sealing element, which is radial force. Radial force can be tersely defined as ‘a force exerted in a radial direction towards or away from the center’. This specific parameter per se, indicates if the sealing element is too loose or too tight on a shaft. In the case of sealing element being too loose, facing a leakage as a result will be inevitable. Despite being not exactly the same but similarly, if a sealing element is too tight on a shaft, it will also result in leakage after some time due to excessive wear caused by high friction and overheating. Therefore, regardless of the device or the method used, it is imperative that an adequate and reliable measurement duration for radial force measurement of sealing elements needs to be determined in order to prevent any issues.

Keywords: Rotary Shaft Seal, Sealing Elements, Seal, Radial Force, Leak-Tightness

THE EFFECT OF COMPRESSION FUNCTION ON DIGITAL IMAGES

MENEZLA Fayssal

University Center Nour El Bachir of El Bayadh, LEPO Laboratory, Sidi Bel Abbés. ALGERIA.

DEBBAL Mohammed

University of Ain-Temouchent, LTT Laboratory, Tlemcen, ALGERIA.

BOUREGAA Mouweffeq

Université Mustapha Stambouli Mascara, LTT Laboratory, Tlemcen, ALGERIA.

SADOUKI BOUAMAMA Reda

University of Saida, Algeria, LEPO Laboratory, Sidi Bel Abbés, ALGERIA.

MAHDJOUR Zoubir

University of Sidi Bel Abbés, LEPO Laboratory, Sidi Bel Abbés. ALGERIA.

ABSTRACT

The image has become an increasingly present means of communication in our daily lives. Being a medium with high semantic content, the image has become an essential working tool in the medical field, satellite and astronomical imagery, film production, etc.

This boom has not diminished since the 1970s, and it is driven by developments in acquisition methods, storage capacities and computing performance.

Even with the development of storage media capacities and network speeds, we still need to compress the image thanks to the evolution of the use of images and videos and the increase in the acquisition capacities of digital sensors. So we must use image compression techniques, we can perform lossless or lossy methods.

In this paper we will study the different compression algorithms that exist in the literature such as JPEG, JPEG 2000, SPIHT and EZW. Subsequently, we will proceed to a comparison of the performances of these algorithms for a transmission of the different images.

Depending on the desired application, the compression algorithm must be able to verify a certain number of quality criteria (validation parameters).

Keywords: Digital Image, JPEG 2000, SPIHT and EZW.

COMPARISON OF CORROSION RESISTANCE OF 316L STEEL PRODUCED BY SLM AND CONVENTIONAL METHODS

Natalia MAKUCH

Institute of Materials Science and Engineering, Poznan University of Technology, Pl. M. Skłodowskiej-Curie 5,
60-965 Poznan, Poland

ABSTRACT

Selective laser melting (SLM) is a technology that complies with the requirements of modern industry of the 4th Industrial Revolution era. This additive manufacturing method was used to produce rods from commercial AISI 316L powder. This steel is one of the most widely used steels of the stainless group. The high corrosion resistance of this steel is achieved due to its high chromium content, which is responsible for the formation of a protective passive layer on the surface of the steel. The chemical composition of the sample produced by SLM method was comparable to the commercially available rods produced by conventional methods. Especially, very similar chromium contents were obtained for both samples, 17.3 wt. % for the conventionally produced steel and 17.8 wt. % for the steel produced by SLM. The porosity of the AISI 316L steel produced by the additive manufacturing method was 12.89 %, which affected its slightly lower corrosion resistance in 3.5 % NaCl solution compared to the steel produced by the conventional. The electrochemical parameters of steel manufactured by SLM were: $E_{corr} = -0.988$ V and $I_{corr} = 1.38 \times 10^{-4}$ A/cm². Whereas in the case of AISI 316L steel conventionally produced the corrosion parameters were more advantageous ($E_{corr} = -0.704$ V and $I_{corr} = 8.12 \times 10^{-5}$ A/cm²). Both samples, produced by SLM technology and conventionally, were characterized by the occurrence of passivation during the potentiodynamic polarization test.

Keywords: selective laser melting, additive manufacturing, stainless steel, corrosion resistance

INTRODUCTION

Additive manufacturing (AM) is an intensely developing production method that compiles various techniques to join materials to create parts from 3D model data - usually layer by layer. Additive manufacturing is a combination of various technologies, such as CAD (computer-aided design), CAM (computer-aided manufacturing), laser and electron energy beam technology, CNC (computer numerical control) machining and laser scanning (Korpela et al. 2010). Additive manufacturing was originally developed to produce parts from polymers, waxes and paper laminates and was mainly used for rapid prototyping purposes (Gibson et al. 2015). Additive manufacturing of metals has been developing for more than 30 years and is a manufacturing method that has now reached a level that allows industrial

application (Vadlamannati et al. 2019). Parts produced by the most common and widely used metal additive manufacturing processes are only partially finished, but in some cases can be used directly as end products (Cabrini et al. 2016). Metal AM enables the creation of geometries that conventional subtractive manufacturing is not capable of (Leary 2017). Among AM techniques, selective laser melting (SLM) is the most versatile, allowing the creation of functional parts with mechanical properties comparable to conventionally manufactured materials (Kruth et al. 2010). In addition, products with low surface roughness can be obtained using this technique (Vanmeensel et al. 2018).

Currently, in metal additive manufacturing technologies, one of the most studied and used materials is AISI 316L austenitic steel, as evidenced by the extensive scientific literature (Ansari et al. 2021, D'Andrea 2023, Malladi et al. 2023, Maicas-Esteve et al. 2022, Qiu et al. 2018, Röttger et al. 2020, Vignal et al. 2021). The extensive use of this steel in additive manufacturing is due to its high thermal conductivity, which promotes the dissipation of heat generated during the manufacturing process, preventing excessive thermal gradients and minimizing thermal stresses (D'Andrea 2023).

MATERIALS AND METHOD

In this study, conventionally produced AISI 316L austenitic stainless steel was used in order to compare its corrosion properties to the additively manufactured AISI 316L steel. The chemical composition of the commercially available steel was presented in Table 1. The additively manufactured steel was produced from powder with the nominal chemical composition shown in Table 2. The powder was characterized by a spherical morphology and a particle size of 15-45 μm .

Table 1. Nominal chemical composition of commercially available AISI 316L steel produced by conventional metalurgy.

Fe	Cr	Ni	Mo	Si	Mn	Cu	C	S	P
Bal.	17.0-19.0	13.0-15.0	2.25-3.0	0.75	2.0	0.5	0.03	0.01	0.025

Table 2. Nominal chemical composition of AISI 316L steel powder for additive manufacturing.

Fe	Cr	Ni	Mo	Si	Mn	S	P
Bal.	16.0-18.0	10.0-14.0	2.0-3.0	Max. 1.0	Max. 2.0	Max. 0.03	Max. 0.045

Selective Laser Melting was performed using AM 250 RENISHAW's laser sintering machine. Basic parameters of process were as follows: laser beam power of 200 W, wavelength of 10.6 μm , scanning speed of 1.0 m/s, laser beam with a spot diameter of 70 μm . Before further investigations, the samples were prepared in a form of disks. The surface of the samples was

grinded using abrasive papers and polished using Al_2O_3 paste. Chemical composition of steels was determined using EDS microanalysis. For this study a Tescan Mira 3 Scanning Electron Microscope was used. The porosity of AISI 316L steel produced by SLM method was calculated based on binary image of the microstructure. A potentiodynamic anodic polarization test in 3.5% NaCl solution was used for evaluation of corrosion resistance. The investigations were carried out using an ATLAS 0531 EU&IA device equipped with Atlas Lab v 2.24 software. A three-electrode cell system containing a counter electrode (platinum electrode), a reference electrode (saturated calomel electrode), and a working electrode (tested sample) were used for the experiments. The exposed surface was equal to 50 mm^2 and was kept immersed in the 3.5% NaCl solution at a constant temperature of $22 \text{ }^\circ\text{C}$. The specimens were polarized in the anode direction from the potential -2.0 V up to 2.0 V , with a change rate potential equal to 0.5 mV/s . The recorded $E\text{-log}(I)$ polarization curves were analyzed based on the Tafel extrapolation technique (Dziarski et al. 2024). From the recorded polarization curves ($E\text{-log } I$) the corrosion potential E_{corr} , corrosion current density I_{corr} and passivation current density I_{pass} were determined.

RESULTS AND DISCUSSION

The most important alloying element in AISI 316L steel is chromium, as its appropriate content provides corrosion resistance due to the formation of a thin oxide layer on the surface. EDS microanalysis was carried out to ensure the appropriate concentration of chromium in both steels. In the case of conventionally produced AISI 316L steel chromium concentration was equal 17.3 wt. % (Figure 1a), whereas additively manufactured AISI 316L steel contained 17.8 wt. % of chromium (Figure 1b). Considering the very similar chromium contents of the two steels, it can be concluded that its content cannot be the reason for the differences in corrosion resistance.

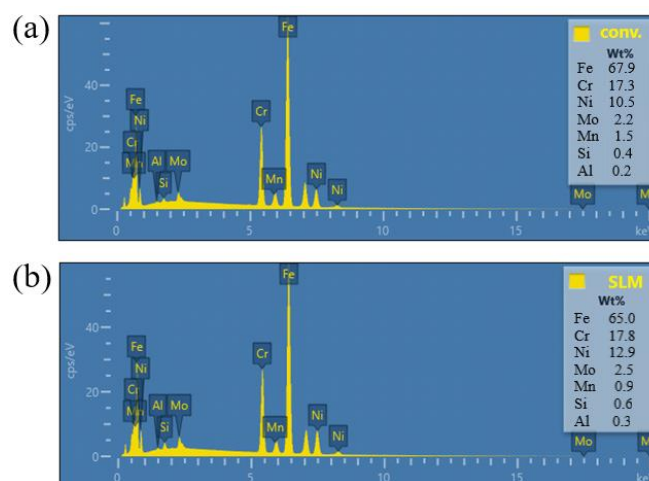


Figure 1. The results of EDS microanalysis of (a) conventional AISI 316L steel and (b) AISI 316L steel produced by Laser Metal Sintering (SLM) method.

The second factor that could affect corrosion resistance was the porosity of the AISI 316L steel produced by the SLM method. The degree of porosity was calculated based on the binary image of the microstructure presented in Figure 2. Six areas were analyzed and the average percentage of porosity (black areas in images) in the additively manufactured steel was calculated. A high degree of porosity of 21.09% was observed in some areas (Figure 2a) of the sample. Simultaneously, in others, such as those shown in Figure 2b, a low percentage (6.12%) of porosity was measured. The average percentage of porosity was 12.89 %.

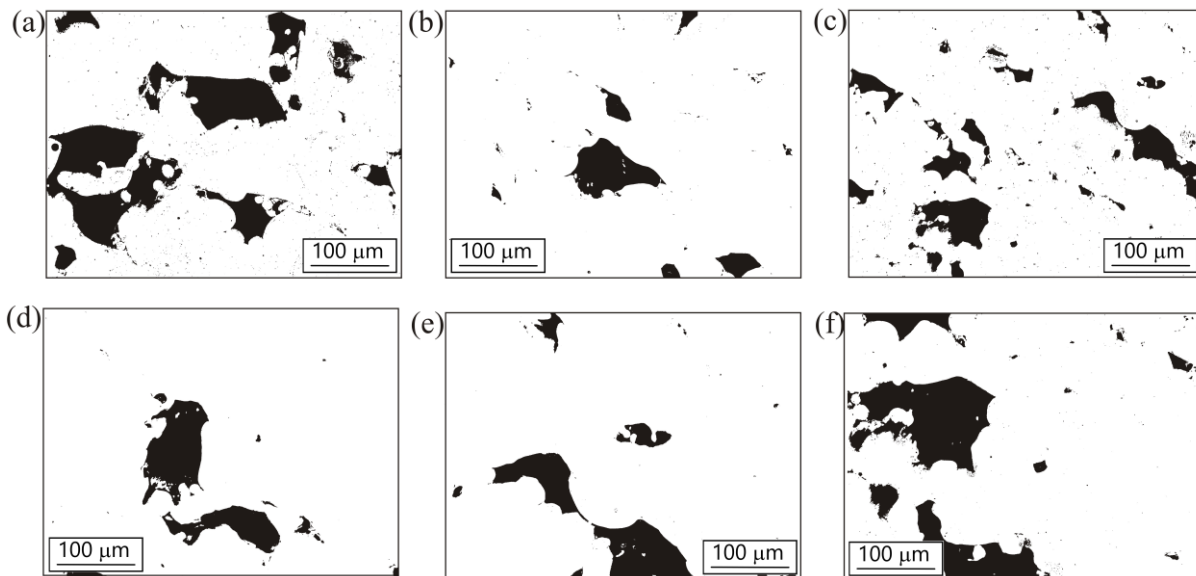


Figure 2. Binary images of microstructure of AISI 316L steel manufactured by SLM method.

The potentiodynamic polarization curves recorded for the conventionally produced AISI 316L steel and additively manufactured AISI 316L steel were presented in Figure 3. The electrochemical parameters corrosion potential E_{corr} , corrosion current density I_{corr} and passivation current density I_{pass} were determined and were compiled in Table 3. The conventionally manufactured AISI 316L steel was characterized by a significantly higher (more noble) corrosion potential ($E_{corr}=-0.704$ V) than the additively manufactured AISI 316L steel ($E_{corr}=-0.988$ V). Moreover, the lower value of corrosion current density I_{corr} was characteristic of conventionally produced steel. These two quantities (E_{corr} and I_{corr}) indicated that the conventionally manufactured AISI 316L steel shows a higher corrosion resistance in 3.5% NaCl solution than the additively manufactured steel. Both steels were characterized by the characteristic phenomenon of the presence of a passive region on the potentiodynamic curve. While the value of passivation current density I_{pass} of the two steels differed, again in favor of conventionally produced steel (Table 3).

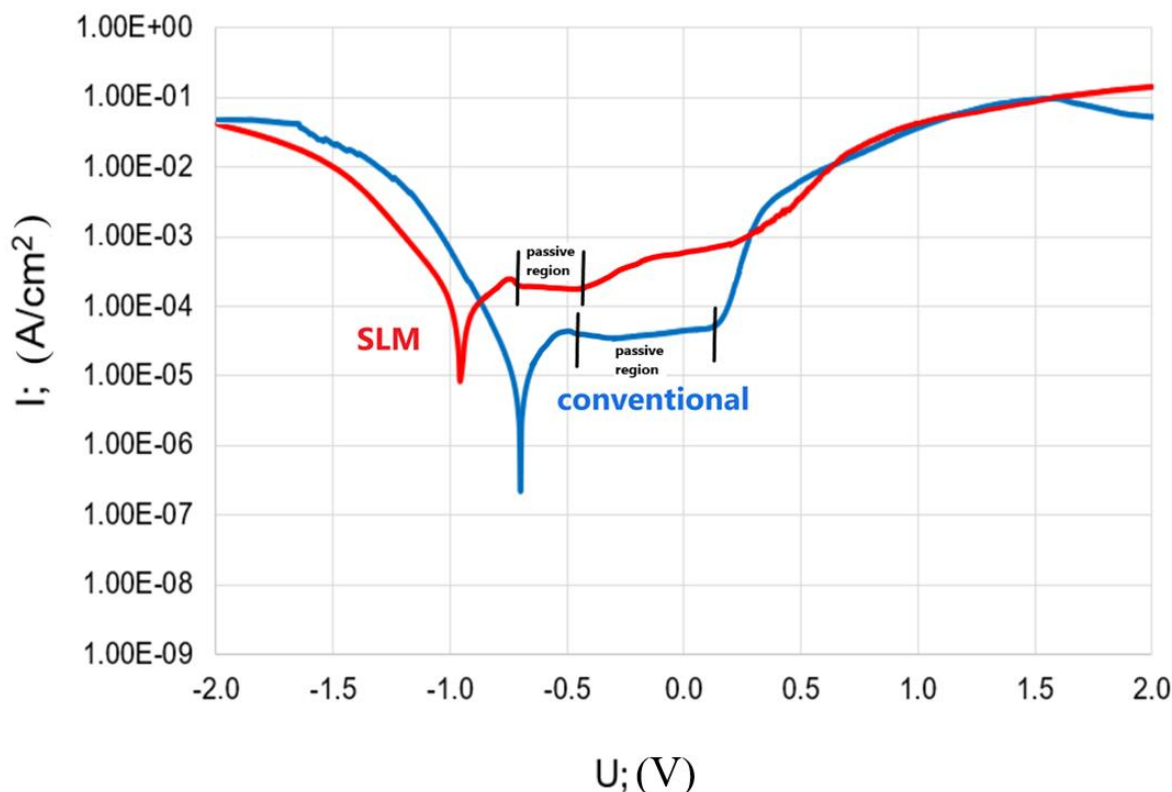


Figure 3. Polarization curves recorded for AISI 316L steel produced by conventional and SLM methods.

Table 3. Electrochemical parameters estimated from polarization curves recorded for AISI 316L steel produced by conventional and SLM methods.

	E_{corr} (V)	I_{corr} (A/cm ²)	I_{pass} (A/cm ²)
Conventionally produced AISI 316L steel	-0.704	8.12×10^{-5}	4.07×10^{-5}
Selective Laser Melted AISI 316L steel	-0.988	1.38×10^{-4}	2.16×10^{-4}

It was concluded that the reason for the reduced corrosion resistance of steel produced by SLM method was its porosity. The detailed reason for this situation is shown schematically in Figure 4. In the case of conventionally produced AISI 316L steel, a dense and compact protective layer was formed by the reaction of chromium with oxygen. The chromium oxide layer produced provided protection for the steel against corrosion (Figure 4a). The presence of porosity in the additively produced steel was the cause of the discontinuity of the protective chromium oxide layer (Figure 4b). As a result, the corrosion solution had easy access to the exposed areas, and thus favored areas for the formation of corrosion pits were formed (Figure 4c). The protective passive layer became the cathode, and the porosity played the role of the anode. As a result, chloride ions present in the solution caused corrosion of the steel and dissolution of iron, chromium and other alloying elements in the corrosion solution (Figure 4c).

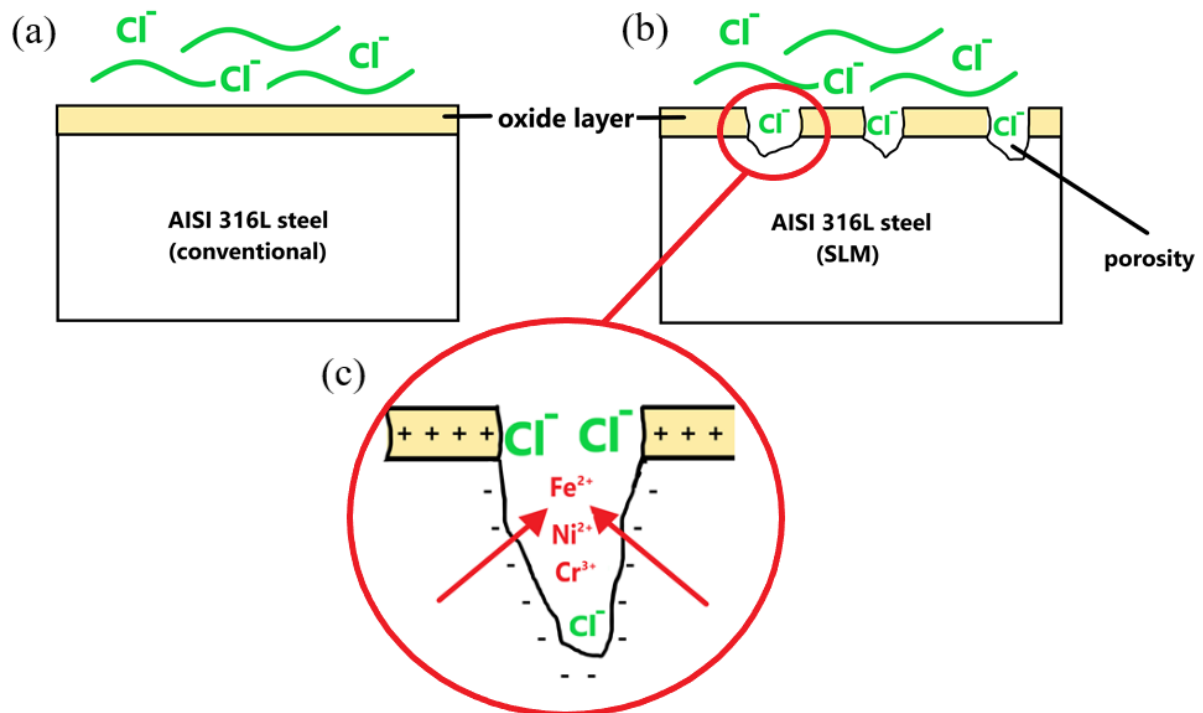


Figure 4. A scheme of the protective role of the passive layer on the surface of conventionally produced AISI 316L steel (a), a scheme of the effect of porosity on the discontinuity of the passive layer on the surface of additively produced AISI 316L steel (b), and a detailed representation of porosity as a nucleation point for corrosion pitting (c).

CONCLUSION

Production of AISI 316L steel is possible using the conventional metallurgical method and the additive manufacturing method. Based on the results obtained, the following conclusions were formulated:

- (1) independent of the method of steel production (conventional metallurgical or SLM), both contained a sufficiently high chromium content (about 17%).
- (2) average porosity percentage of 12.89 % was characteristic of additive manufactured steel.
- (3) The electrochemical parameters of steel manufactured by SLM were: $E_{corr} = -0.988$ V and $I_{corr} = 1.38 \times 10^{-4}$ A/cm². Whereas in the case of AISI 316L steel conventionally produced the corrosion parameters were more advantageous ($E_{corr} = -0.704$ V and $I_{corr} = 8.12 \times 10^{-5}$ A/cm²).
- (4) Both samples, produced by SLM technology and conventionally, were characterized by the occurrence of passivation during the potentiodynamic polarization test.
- (5) The porosity of the steel produced by AM was the reason for the discontinuity of the passive layer and negatively affected the corrosion resistance in a 3.5% sodium chloride solution.

REFERENCES

- Ansari, P., Rehman, A.U., Pitir, F., Veziroglu, S., Mishra, Y.K., Aktas, O.C. & Salamci, M.U. (2021). Selective Laser Melting of 316L Austenitic Stainless Steel: Detailed Process Understanding Using Multiphysics Simulation and Experimentation. *Metals*, 11, pp. 1076-1-1076-19.
- Cabrini, M., Lorenzi, S., Pastore, T., Pellegrini, S., Ambrosio, E., Calignano, F., Manfredi, D., Pavese, M. & Fino, P. (2016). Effect of heat treatment on corrosion resistance of DMLS AlSi10Mg alloy. *Electrochimica Acta*, 206, 346–355.
- D’Andrea, D. (2023). Additive Manufacturing of AISI 316L Stainless Steel: A Review. *Metals*, 13, p. 1370-1-1370-24.
- Dziarski, P. & Makuch, N. (2024). Characterization of wear resistance and corrosion resistance of plasma paste borided layers produced on pure titanium. *Materials*, 17, pp. 3922-1-3922-19.
- Gibson, I., Rosen, D. & Stucker, B. (2015). *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*. Second Edition. New York: Springer, p. 498
- Korpela, M., Riikonen, N., Piili, H., Salminen, A. & Nyrrhila, O. (2020). Additive Manufacturing—Past, Present, and the Future. In: Collan, M., Michelsen, KE. (eds) *Technical, Economic and Societal Effects of Manufacturing 4.0*. Palgrave Macmillan, p. 18
- Kruth, J.P., Badrossamay, M., Yasa, E., Deckers, J., Thijs, L. & Van Humbeeck, J. (2010) Part and material properties in selective laser melting of metals. In *Proceedings of the 16th International Symposium on Electromachining (ISEM XVI)*, Shanghai, China, 19–23 April 2010, 3–14.
- Leary, M. (2017). Surface roughness optimization for selective laser melting (SLM): accommodating relevant and irrelevant surface. *Laser additive manufacturing: Materials, design, technologies, and applications*, pp. 99–116.
- Maicas-Esteve, H., Taji, I., Wilms, M., Gonzalez-Garcia, Y. & Johnsen, R. (2022). Corrosion and Microstructural Investigation on Additively Manufactured 316L Stainless Steel: Experimental and Statistical Approach. *Materials*, 15(4), pp. 1605-1-1605-23.
- Malladi, B., Tam, E., Cao, Y., Guo, S. & Nyborg, L. (2023). Corrosion behaviour of additively manufactured 316L and CoCrNi. *Surface and Interface Analysis*, 55(6-7), pp. 404-410.
- Qiu, C., Al Kindi, M., Aladawi, A.S. & Al Hatmi I. (2018). A comprehensive study on microstructure and tensile behaviour of a selectively laser melted stainless steel. *Nature Scientific Reports*, 8, pp. 7785-1-7785-16.
- Röttger, A., Boes, J., Theisen, W., Thiele, M., Esen, C., Edelmann, A. & Hellmann, R. (2020). Microstructure and mechanical properties of 316L austenitic stainless steel

- processed by different SLM devices. *The International Journal of Advanced Manufacturing Technology*, 108, pp. 769–783.
- Vadlamannati, S., Vipin, S. & Soumitra, B. (2019). *Metal Powder Based Additive Manufacturing Technologies—Business Forecast. n 3D Printing and Additive Manufacturing Technologies*. First edition. Singapore: Springer, p. 311
- Vanmeensel, K., Lietaert, K., Vrancken, B., Dadbakhsh, S., Li, X., Kruth, J.P., Krakhmalev, P., Yadroitsev, I. & Van Humbeeck, J. (2018). Additively manufactured metals for medical applications. In *Additive Manufacturing: Materials, Processes, Quantifications and Applications*; Elsevier: Amsterdam, The Netherlands, pp. 261–309.
- Vignal, V., Voltz, C., Thiébaud, S., Demésy, M., Heintz, O. & Guerraz, S. (2021). Pitting Corrosion of Type 316L Stainless Steel Elaborated by the Selective Laser Melting Method: Influence of Microstructure. *Journal of Materials Engineering and Performance*, 30 (7), pp. 5050-5058.

THE MEASUREMENT OF *CHROMOLAENA ODORATA* GROWTH IN INDOLE BUTYRIC ACID (IBA) TREATED SOIL

Anyasi R.O.

Department of Environmental Sciences, University of South Africa

ABSTRACT

In this study the effect of rooting media and indole butyric acid hormone on root development of stem cuttings of *Chromolaena odorata* were assessed. Stem cuttings of *C. Odorata* treated with equal quantities of IBA hormone (0.7%) were grown in 1kgs of vermiculate, perlite, planting soil, sand, and equal mixture of all media. The set up were treated equally with water and organic manure. Control set up was made with a mixture of different rooting media without IBA. Data on shoot development were noted for 6weeks and root length was measured on the day of harvest. The parameters measured were analysed statistically using ANOVA, and it was found out that root and shoot lengths were significant at $p>0.05$ in the entire rooting media and the highest percentage development (49 and 51%) respectively for root and stem respectively, was observed in the rooting media that has equal measure of each constituent (i.e., the mixed constituents). Germination rate among the media were 100, 70, 60, 50 and 40% for mixed, sand, planting soil and vermiculate, perlite and control respectively. Different sections of mature stem tested with IBA hormone were not significant in their root and stem development, although basal cutting stems tend to mature faster than apical. This therefore means that propagating *C. Odorata* by stem cutting can be optimally achieved through mixture of 0.7% of IBA in a collection of different rooting media.

Keywords: Chromolaena odorata, Indole butyric acid, Rooting media, Root formation.

1.0 Introduction

The success of rooting of stem cuttings have been attributed amongst other factors to the rooting medium as well as the presence of rooting hormone and its concentration (Al-Saqri and Alderson, 1996; Hartmann *et al.*, 1997; Anyasi *et al.*, 2024). Influences of rooting media and hormone on rooting in different kinds of plant have been documented and its effects in structure propagations were elucidated (Akwatulira *et al.*, 2011). Material combinations used in the rooting of cuttings provide physical support as well as oxygen and water to the cuttings (Larsen and Guse, 1997). However, IBA; an auxin containing product was reported to stimulate adventitious roots in apical cuttings of some plants (Araya *et al.*, 2007). This was buttressed by the study by Rao *et al.*, (2005) which reported that IBA was the leading plants hormone used to promote the generation of roots in Tomatoes.

Chromolaena odorata (L) King and Robinson is referred to as Asteraceae and is commonly known as siam weed. The plant is an invasive shrub of the neotropical origin but have been introduced to Africa and Asia in addition to other parts of the world (Singh *et al.*, 2009; Anyasi, 2023). *C. odorata* is a fast-growing oppressive competitor occupying different kinds of arable land by forming dense strands that tends to prevent the growth of other flora. Therefore, it affects plantation and other organisms in the ecosystem, by its suppressive effects to young plants as it is a growth inhibitor and has allelopathic capabilities. As a result of the much negative influence of the plant and its low economic importance, not very much is known about the plants and very little had been done in the research world (Akinmoladun *et al.*, 2011). However, recent introduction into the use of the plant in the phytoremediation of inorganic and organic contaminants has somewhat changed the influence of the plant (Singh *et al.*, 2009, Tanhan, 2011).

Although much is not known about *C. Odorata*, as a result of its noxious effect to the habitat especially in those areas they invaded, to some other areas there are economic plants that have been found used for its phytochemical properties (Che Man, 2010; Anyasi *et al.*, 2019). The medicinal properties of plants lies in their phytochemicals components like alkaloids, flavonoids, tannins in addition to other phenolics that co-opt as to producing definite physiological functions to the body of man and animals (Taiwo *et al.*, 2000; Che Man, 2010). *C. odorata* plants have been found growing as a medicinal plant for the treatment of skin wounds (Metwally and Ekejuba, 1981; Phan *et al.*, 1996). This was as a result of its antispasmodic, antiprotozoal, antibacterial, antihypertensive as well as antitrypanosomal activities as was reported by Taiwo, (2000) (Phan *et al.*, 1996; Akinmoladun *et al.*, 2007). *C. Odorata* has also been implicated by its diuretic, hepatotropic and adstringent properties (Weninger and Robenean 1988; Iwu, 1993).

Traditionally, boiled fresh leaves of *C. Odorata* have been used in so many countries for the treatment of various skin ailments. For example in Vietnam, decoction of the plant were used to treat leech bite, burns, wounds of the soft tissue, as well as other skin infections (Phan *et al.*, 2001; Che Man, 2010). The leaf poultice of the plant has also been traditionally used in the treatment of fresh cut or wounds as an aid to stop bleeding. In other instances, *C. Odorata* were implicated in the treatment of sting from a pine of sea catfish, its root used as analgesic and antipyretic remedy and the extracts from the leave mixed with table salt could be used as gargle for the treatment of sore throat and flu (Che Man, 2010; Anyasi *et al.*, 2024). Hence with the quest for a systematic search for specific useful factors from medicinal plants like *C. Odorata*, even though most plants cuttings can root without hormone, there is need for an improved method of propagation and growth for such nutraceutical plants. This will therefore form a rational approach towards drug and nutritional research. The aim of this study was to evaluate the effect of IBA hormone and rooting media for optimal rooting of propagated *C. Odorata* cuttings.

2.0 Materials and methods

Mature stems of *C. odorata* plants was collected from the greenhouse at the University of South Africa. The mature stems were made into cuttings of 10cm containing at least a node and a leaf bud. The experiment took place in PVC pots with dimensions 30x25x30 at a garden at the University of South Africa. The pots contain 1kgs of different rooting medium that has been mixed with equal volume of organic manure collected at the animal farm of the University of Pretoria in Onderstepoort. Inside each pot was made holes designed to contain equal weight of IBA hormone (0.7%), for the plants. The set up was made in a complete randomized design containing a 3x4 factorial treatment model (Jeruto *et al.*, 2008). The rooting media used here were vermiculate, planting soil, sand, perlite, planting soil and a mixture of equal volume of the four medium (w/w). About thirty six stem cuttings were used in each set of rooting media and IBA hormone concentration by volume percentage. Then set of water treated cuttings were inserted into the IBA hormone in the rooting media and were replicated by three. Random allocation of cuttings to the rooting media using random digit from a table was employed as to eliminate bias (Johnson and Bhattacharyya, 2006).

2.1 Rooting media

The rooting media was homogenized by hand, mixed with equal volume of organic manure and air dried on an impervious polythene sheet for 24hours, there were pasteurized and fumigated, measured into the PVC pots with the hole containing about 0.7% of IBA hormone.

2.2 Propagation of the cuttings

The 10.0 cm cuttings with lateral buds were about 360 collected at tale end of the afternoon when the weather was moist, and were kept in a bow containing water (Agbo and Obi, 2007). The bases were made squared by the use of sharp sickle in order to spread the rooting. For each of the cuttings, about half of it was dipped into the IBA hormone that has been made into hole in each of the pots as to soak the powder. Excess of it was shaken off the base of the cuttings and the hormone was manually made to concentrate at the base. The cutting was then inserted into the soil to about 6 cm, watered and maintained to about 70% humidity (Tanhan *et al.*, 2007). Fungicides were sprayed onto the cuttings to control infections (Yeboah and Amoah, 2009). The set up was allowed to grow for six weeks while monitoring in between days to remove any invading weeds. Data on shoot development was taken at interval of weeks and root length was measured on the day of harvest after weeks.

2.3 Data collection

Data collection which commenced on the first week after propagation continued till the sixth week and the parameters measured were survived cuttings, length of shootings/buds, and the root length, number and weight of the cuttings on the day of harvest.

2.4 Data analysis

The data collected was analysed using Microsoft excel to obtain the mean number and percentage of cuttings that were able to form developed root and sprouted shoots from the series of stem cuttings. The data was then imported into SPSS version 13.0 and was analysed using analysis of variance (ANOVA) and standard deviation for the length of shoot and roots. The significance effects were determined at 5% level of significance.

3.0 Results

C. odorata cuttings treated with concentration of 0.7% (w/w) IBA hormone propagated in different growth media recorded the highest mean number of cuttings that developed roots and sprouted shoots in the set up with equal mixtures of the four growth media with organic manure. While the cuttings propagated in the perlite and control recorded the shortest mean rooted and sprouted shoots as recorded in Table 3.1. Amazingly, perlite and vermiculate maintained almost equal numbers of root developed like in the mixture. However, significant difference existed among the different media with reference to their mean rate of development and formation of root and shoot. The efficacy of IBA hormone to the development of root and shoots was noticed by the difference between the treated samples and the controls without the hormone. There was significance difference between the two samples.

Number and length of roots developed among different rooting medium and the concentration of hormone were not significant (Table 3.5a-c), but shoot lengths and number per sprouted stem was significant. Increase in shoot length occurred in this order: mixture>vermiculate>perlite>planting soil>sand>control while increase in root length were in the order: mixture>vermiculate>perlite>planting soil>sand>control. But it made a turn around in the number that rooted and shooted within the rooting media, i.e. sand and planting soil had the same mean number of roots (4) and a little difference in Shoots (6 and 12). . The mixture of the media had a high occurrence in root and shoot followed by planting soil, sand, perlite, vermiculate and control media maintained equal numbers. In fresh weight of cutting positions (apical and basal), there were higher weight measurement in the basal cutting than the apical ones, though not significant. Equally, set up containing the mixture of the rooting media still maintained the highest weight followed by sand, perlite, planting soil, vermiculate and the control. Thesame sequence was also followed in their dry weights. In sand however, there were greater number of apical root numbers while in other rooting media basal cuttings had greater number of roots. Shoot and root length of mixture of rooting media and vermiculate were synonymous with each other and were almost significant with the rest of the medium. Apical root length were 34 and 33mm for mixture and vermiculate respectively, 39 and 37mm in basal. In apical shoot length, there were 41 and 41mm and 43mm all in basal respectively. Mixture set up had 100% germination rate compared to 70, 60 50 and 40% for sand; planting soil, vermiculate; perlite and control respectively. However, the rest of the media

demonstrated improved significant effects in all the parameters measures compared to the control.

Table 3.1 Number of rooted and shooted cuttings within rooting media. Values are mean of replicates (Numbers with same superscript within same row are not statistically significant at $p=0.05$)

Rooting media	Number of cuttings		IBA hormone concentration
	Rooted	Shooted	
Planting soil	4±0.75 ^a	12±2.55 ^b	0.7
Perlite	2±0.71 ^a	4±1.22 ^a	0.7
Sand	4±0.71 ^a	6±0.71 ^a	0.7
Vermiculate	2±0.68 ^a	3±0.71 ^a	0.7
Mixture	13±1.41 ^b	29±1.41 ^c	0.7
Control	2±0.69 ^a	3±0.00 ^a	0.7

Table 3.2 Rate of germination of shoots among rooting media with 0.7% concentration of IBA hormone. Values are mean of replicates (Numbers with same superscript within same row are not statistically significant at $p=0.05$)

Rooting media	IBA hormone concentration (%)	Rate of germination (%)
Planting soil	0.7%	60 ^b
Perlite	0.7%	50 ^a
Sand	0.7%	70 ^b
Vermiculate	0.7%	60 ^b
Mixture	0.7%	100 ^c
Control	0.7%	40 ^a

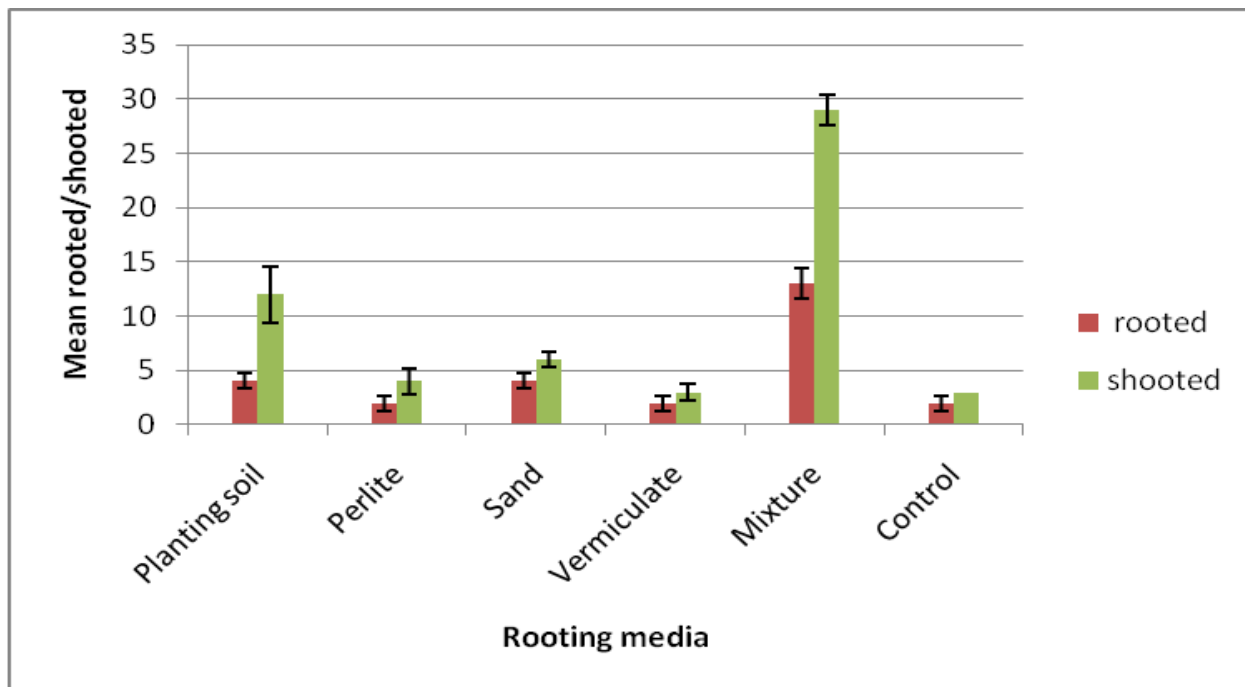


Figure 3.1 Bar chart representation of the means values of rooted and shooted cuttings within rooting media (The error bars represent the standard error from the mean).

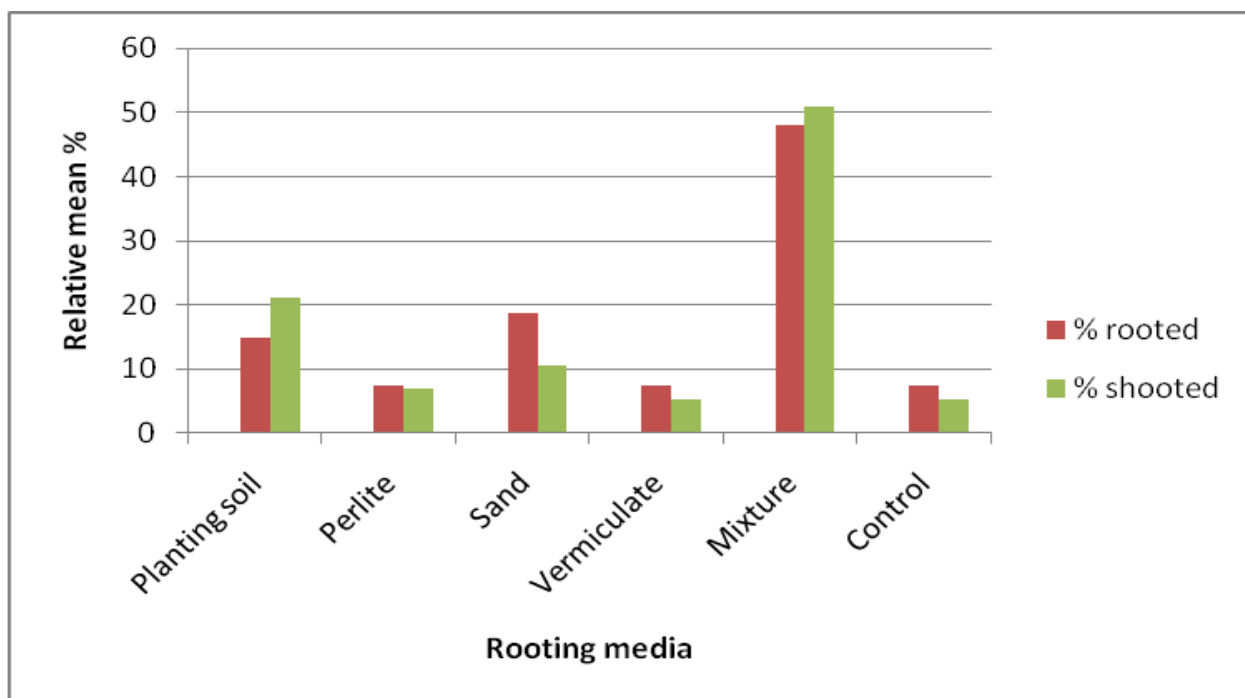


Table 3.2 Relative mean percentage of the rooted and shooted cuttings among the rooting media.

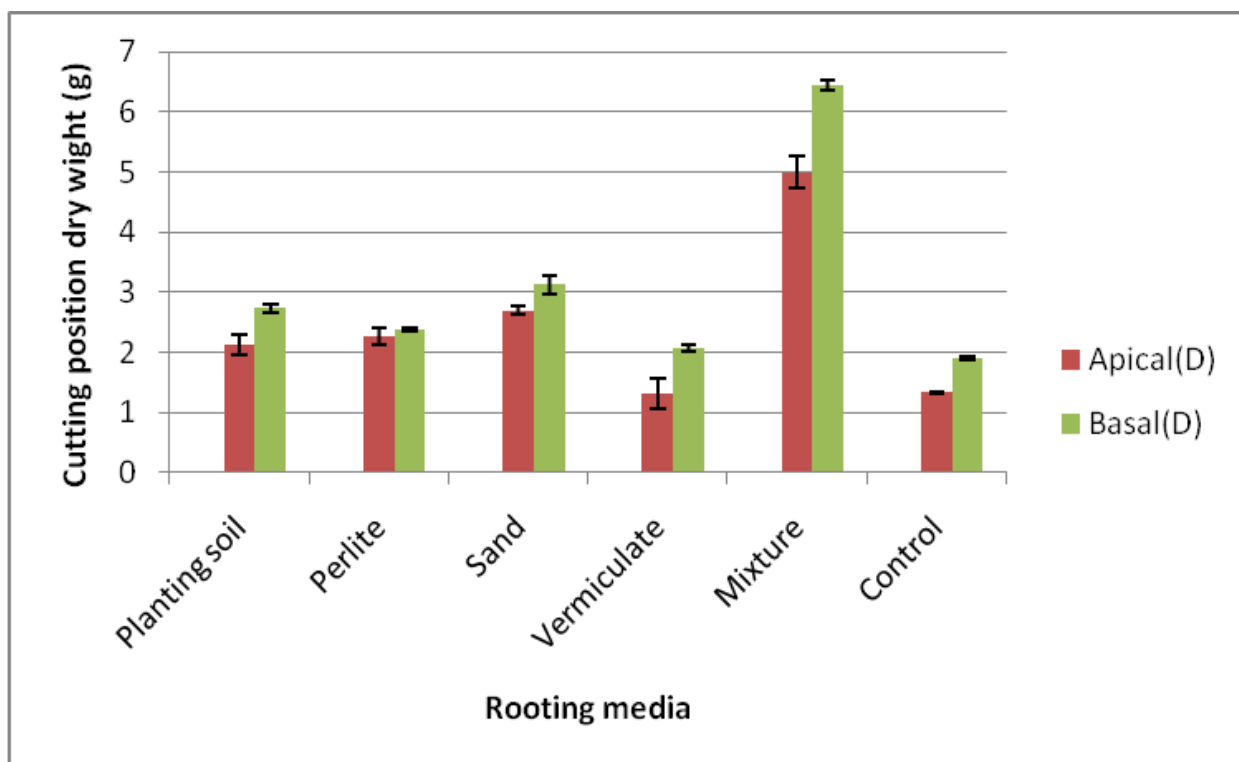


Figure 3.3 Dry weight of Cutting positions within different rooting media (The error bars represent the standard error from the mean)

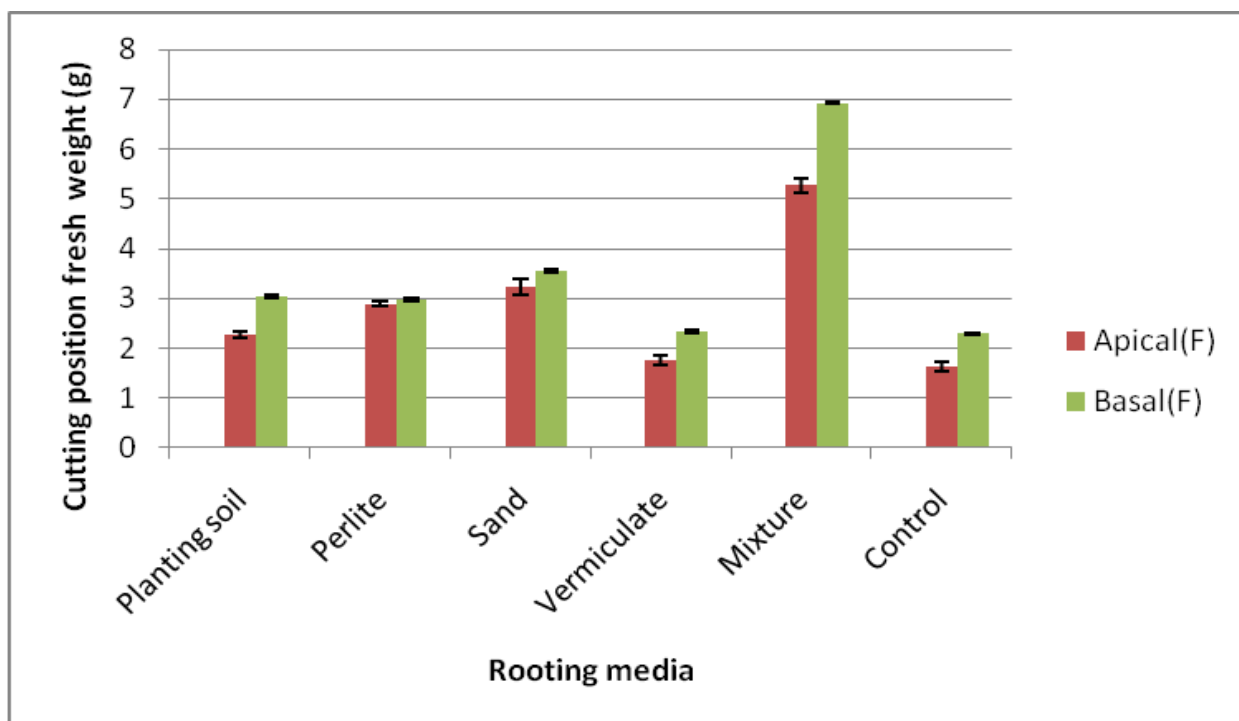


Figure 3.4 Fresh weight of of Cutting positions within different rooting media (The error bars represent the standard error from the mean)

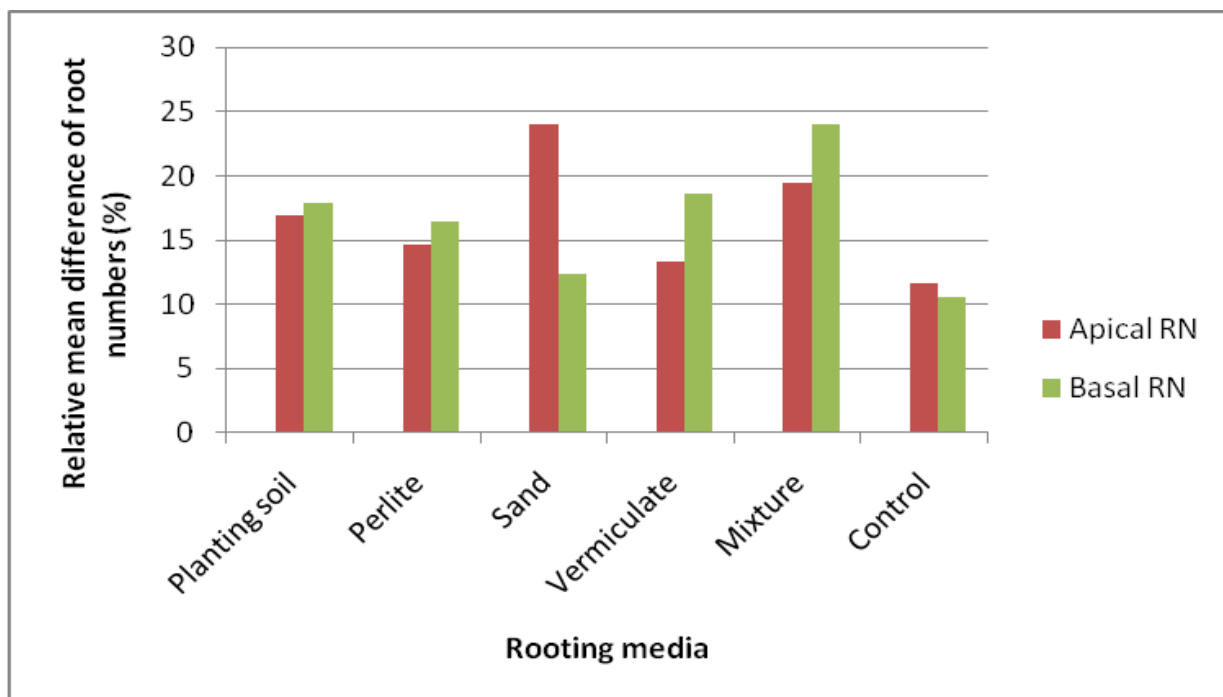


Figure 3.5a Percentage relative mean difference of root numbers in cutting position among rooting media

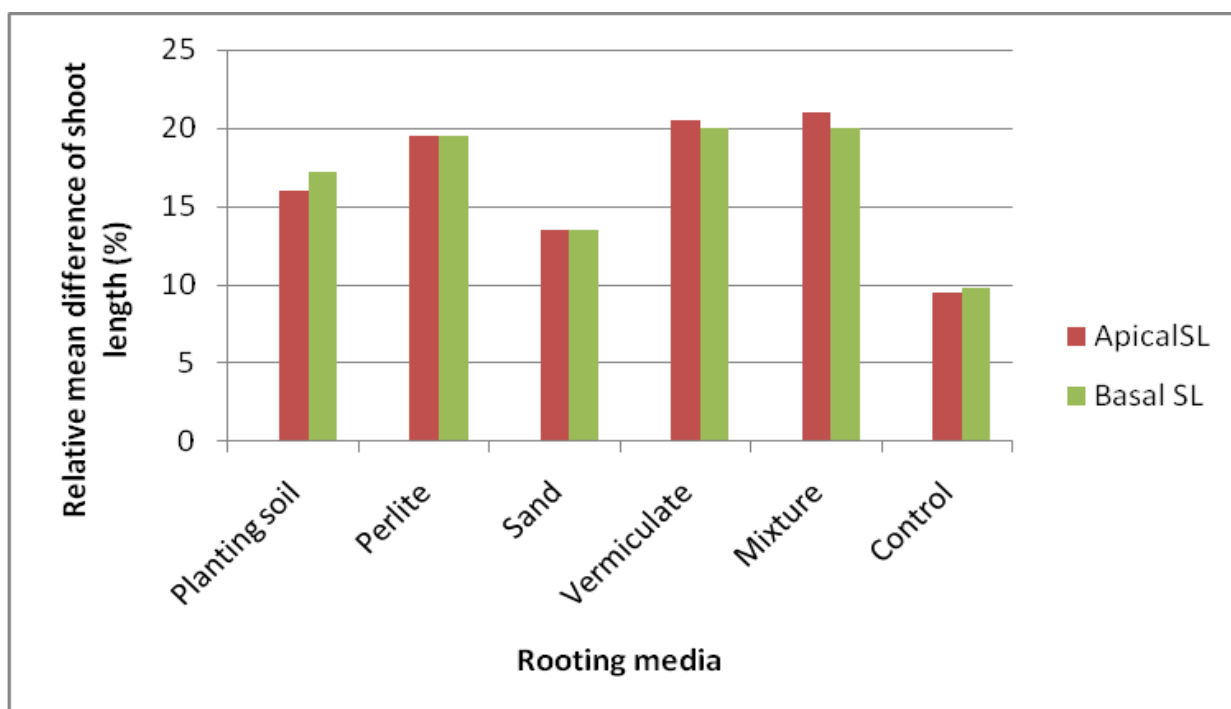


Figure 3.5b Percentage relative mean difference of shoot length in cutting positions among rooting media

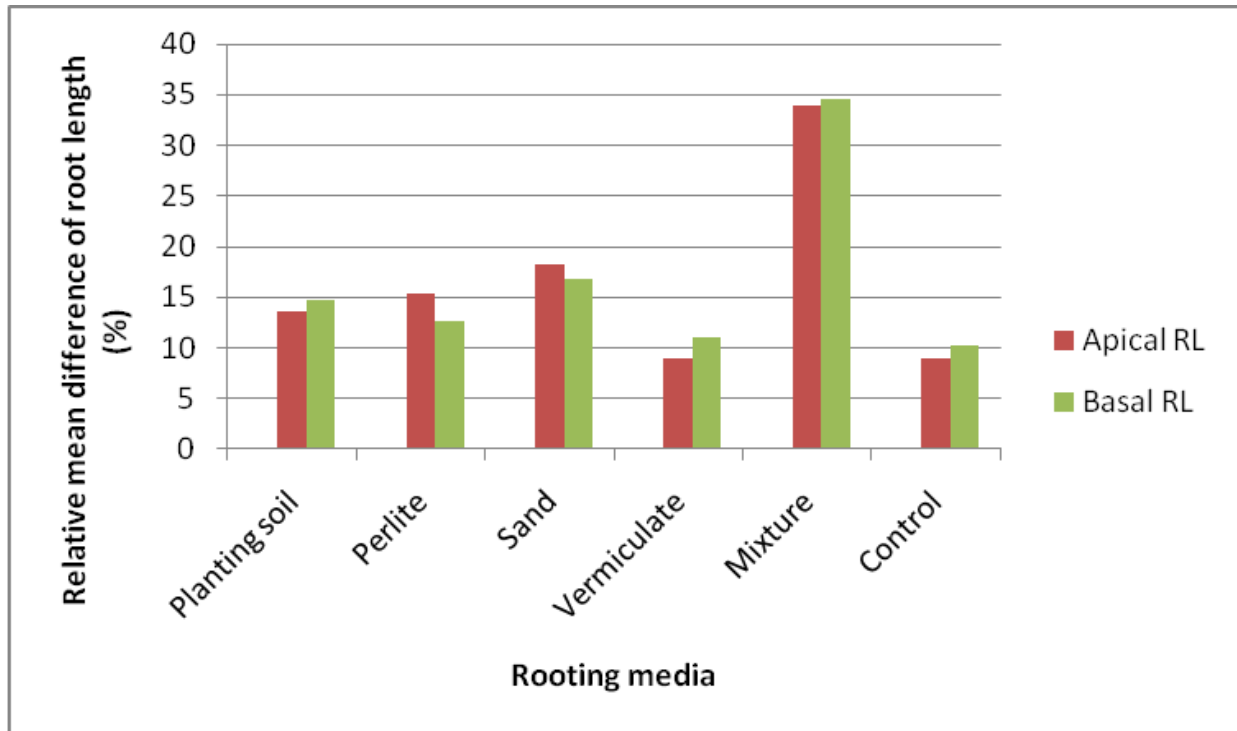


Figure 3.5c Percentage relative mean difference of root length in cutting positions among rooting media

Discussions

The rooting medium supplement that has mixtures of planting soil, perlite, sand and vermiculite at equal proportion enabled highest development of root and shoot in a cutting of *Chromolaena odorata*. This improved effect could be attributed to the fact that the combined nutrient supplement of the entire rooting media acted optimally with the IBA hormone concentration added which created the enabling soil condition for example optimum aeration and moisture level (Kalyoncu and Ozer, 2000; Anyasi and Anyasi Raymond, 2020). Meanwhile dose application of IBA hormone was shown be an aid to improved moisture content in the soil for an optimal rooting and shooting development of cuttings (Milleton et al., 1980; Leakey et al., 1982;; Aminah *et al.*, 2006). Meanwhile most of these past studies has however maintained their IBA hormone concentration to about 0.7-0.8% of the rooting media used. The control sample of rooting medium supported low development of root and shoot than the auxin treated samples in the entire experiment. This could be because soil resistant to root penetration is dependent on amongst other factors on water content, structure and strength of soil as well as bulk densities though these were not measured in the rooting media (Amri *et al.*, 2009). Soils do not posses the required aeroion porosity for optimal gas exchange required for rooting of the cuttings resulting in poor rooting in the control. Poor rooting numbers in control could also be attributed to the feel of anoxia which is an effect of low oxygen in the soil (Hartmann et al., 2002; Anyasi *et al.*, 2019). Low incidence of rooting was found in the control samples. Non-theless, there are instances where optimum

concentration of IBA in the soil has resulted in the failure of the development of roots by stem cuttings as was reported by Griffin and Shroeder (2004). That was an indication of the sensitivity of root formations to hormone formulations (Akwatulira *et al.*, 2011). It has also been reported that rooting hormone to a certain instance could be inhibitory to the development of roots in the cutting especially during the initiation stage (Anyasi *et al.*, 2024). This then means that different rooting media accommodates different concentration of auxin for optimal growth of plants.

Conclusion and recommendations

Mixture of various rooting media in the right proportion with 0.7% of IBA hormone has been proven to be effective in the root and shoot development of cuttings of *Chromolaena odorata* irrespective of the position of the cuttings. Although the individual medium did not have high incidences in most of the parameters measured, but there were able to support root and shoot development as well. Therefore, there is need for a study of IBA concentration effects on the media as to be able to determine if concentration was not the factor responsible for the low root and shoot development. This will enable the promotion of mass production of *C. odorata* especially in areas that the plants does not occur naturally.

References

- Agbo, C.U., Obi, I.U. 2007. Variability in propagation potentials of stem cuttings of different physiological ages of *Gongronema latifolia* Benth. *World Journal of Agricultural Science*, 3(5): 576-581.
- Akinmoladun, A.C., Ibukun, E.O., Dan-Ologe, I.A. 2007. Phytochemical constituents and antioxidants properties of extracts from the leaves of *Chromolaena odorata*, *Scientific Research and Essay*, 2(6): 191-194.
- Akwatulira, F., Gwali, S., Okullo, J.B.L., Ssegawa, P., Tumwebaza, F.B., Mbwabo, J.R. Muchugi, A. 2011. Influence of rooting media and indole-3-butyric acid (IBA) concentration on rooting and shooting formation on *Warburgia Ugandensis* stem cuttings, *African Journal of Plant Soil*, 5(8): 421-429.
- Al-Saqri, F., Alderson, P.G. 1996. Effects of IBA, cutting type and rooting media on rooting of *Rosa centifolia*. *Journal of Horticultural Science*, 71,729-737.
- Aminah, H., Nor Hasnita, R.M.N., Hamzah, M. 2006. Effects of Indolebutyric acid concentrations and media on rooting of leafy cuttings of *Shorea parvifolia* and *Shorea macroptera*. *Journal of Tropical Forest Science*, 18(1): 1-7.
- Amri, E., Lyarun, H.V.M, Nyomora, A.S., Kanyek, Z.L. 2009. Evaluation of provenances and rooting media for rooting ability of African Blackwood (*Dalbergia melanoxylon* Guill. and Perr.) stem cuttings. *Research Journal of Agriculture and Biological Science*, 5(4): 524-532.

- Anyasi R.O. (2023). Studying the growth of *Chromolaena odorata* in two soil samples under greenhouse condition. Proceedings of the *ISPEC* 11th International Conference on Agriculture, Animal Sciences and Rural Development, Mus, Turkiye, March 03-05, 2023. Pg 591-608
- Anyasi, R.O., Atagana, H.I. and Sutherland, R 2019. Comparative study of the colonization of *Chromolaena* and tobacco plants by *Bacteria safensis* CS4 using different methods of inoculation. *Pakistan Journal of Biological Science*, 22(7): 309-317.
- Anyasi, RO., Eze, N.C., Agbo, D.C. and Ifechukwu, P.E. (2024). IAA and its enhancing growth parameters in tobacco. Proceedings of the 11th International May 19 Innovative Scientific Approaches Congress, Samsun, Turkiye, October 19-20. Pg 185-192.
- Araya, H.T., Soundy, P., du Toit, E.S., Mudau, F.N. 2007. Influence of cutting position, medium, hormone and season on rooting of Bush tea (*Athrixia phylicoides* DC). Stem cuttings. *Medicinal and Aromatic Plants Science and Biotechnology*, 1: 243-252.
- Che Man, N.B. 2010. Phytochemical analysis of the leaves of *Chromolaena odorata* (Asteraceae). BSc Hons. Thesis, Faculty of Applied Sciences-University of Technology, Mara, pp 9-12.
- Griffin, J.J., Schroeder, K.R. 2004. Propagation of *Ulmus parvifolia* "Emerald Prairies" by stem cuttings. *Journal of Environmental Horticulture*, 22 (2): 55-57.
- Hartmann, H.T., Kester, D.E., Davies, F.T. Jr., Geneve, L.R. 1997. Plant propagation: Principles and Practices (6th Edn), Prentice Hall International Edition, Englewood Cliffs, New Jersey, USA, pp 880.
- Iwu, M.M. 1993. Handbook of African Medicinal Plants, CRC Press Inc., Boca Raton. pp. 181-182.
- Jeruto, P., Lukhoba, C., Ouma, G., Mutai, C. 2008. Propagation of some endangered Indigenous trees from the South Nandi District of Kenya using cheap, non-mist Technology. *ARPN Journal of Agriculture and Biological Sciences*, 3(3): 1-6.
- Johnson, R.A., Bhattacharyya, G.K. 2006. Statistics: Principles and Methods. 5th Edition. John Wiley and Sons, USA, p. 688
- Kalyoncu, H., Ozer, E. 2000. Gilaburu'nun (*Viburnum opulus* L.), green side köklendirilmesi steels and to obtain seedlings. II. National Nursery Symposium (25-29 September 2000). Almond-Edema, Izmir, 1: 1-10
- Larsen, F.E., Guse, W.E. 1997. Propagating deciduous and evergreen shrubs, trees and vines with stem cuttings. A Pacific Northwest Cooperative Extension Publication, Washington, USA, p. 10.
- Leakey, R.R.B., Chapman, V.R., Longman, K.A. 1982. Physiological studies for tree improvement and conservation. Some factors affecting root initiation of *Triplochiton scleroxylon* K.. *Ecological Management*, 4: 53-66.
- Metwally, A.M., Ekejuba, E.C. 1981. Methoxylated flavonols and flavones from *Eupatorium odoratum*I. *Planta Medica*, 42: 403.

- Millett, W., Jarvis, B.C., Booth, A. 1980. The role of auxins in leaves and boron dependant on rooting stem cuttings of *Phaseolus aureus* Roxb. *New Phytology*, 84: 251-259.
- Montesano R, Orci L. 1988. Transforming growth factor β stimulates collagen-matrix contraction by fibroblasts: Implications for wound healing. *Proceedings of the National Academy of Sciences*, 85:4894-4897.
- Phan, T. T., Wang, L., See, P., Grayer, R.J., Chan, S.Y., & Lee, S.T. 2001. "Phenolic compounds of *Chromolaena odorata* protect cultured skin cells from oxidative damage: implication for cutaneous wound healing." *Biological and Pharmaceutical Bulletin*. 24(12): 1373-1379.
- Phan, T.T., Hughes, M.A., Cherry, G.W., Le, T.T., Pharm, H.M. 1996. An aqueous extract of the leave of *Chromolaena odorata* (Formerly *Eupatorium odoratum*) (Eupolin) inhibits hydrated collagen lattice contraction by normal dermal fibroblasts. *The Journal of Alternative and Complementary Medicine*, 2(3): 335-343.
- Rao, V. K., Kasula, K., Umate, P., Sree, T., A. V. Rao, A.V., Abbagani, S. 2005. Introduction of multiple shoots from leaf segments, *in vitro* flowering and fruiting of dwarf tomato. *Journal of Plant Physiology*, 162(8): 959-962.
- Raymond Anyasi, J.O. and Anyasi, R.O. 2020. Use of Bacterial Endophyte as a Control for White Aphid's Infestation in Tobacco Plant *Sumerianz Journal of Agriculture and Veterinary*. 2(10): 88-95.
- Singh, S., Thorat, V., Kaushik, C.P., Raj, K., Eapen, S., D'Souza, S.F. 2009. Potential of *Chromolaena odorata* for phytoremediation of ^{137}Cs from solution and low level nuclear waste. *Journal of Hazardous Material*, 162: 743-745.
- Taiwo, O.B., Olajide, O.A., Soyannwo, O.O., Makinde, J.M. 2000. Antiinflammatory, antipyretic and antispasmodic properties of *Chromolaena odorata*. *Pharmaceutical Biology*, 38: 367-370.
- Tanhan, P., Kruatrachue, M., Pokethitiyook, P., Chaiyarat, R. 2007. Uptake and accumulation of cadmium, lead and zinc by siam weed [*Chromolaena odorata* (L) King & Robinson]. *Chemosphere*, 68:323-329.
- Tanhan, P., Pokethitiyook, P., Kruatrachue, M., Chaiyarat, R., Upatham, S. 2011. Effects of soil amendments and EDTA on lead uptake by *Chromolaena odorata*: Greenhouse and field trial experiments. *International Journal of Phytoremediation*, 13: 897-911.
- Wniger, B., Robinean, L. 1988. Elements for Caribbean Pharmacopoeia. *Proceedings of TRAMIL workshop*, Cuba. Pp 16-23.
- Yeboah, J.S.T.L., Amoah, F.M. 2009. The rooting performance of Shea tree (*Vitellaria paradoxa* C.F. Gaertn) cuttings leached in water and application of rooting hormone in different media. *Journal of Plant Science*, 4(1): 10-14.

**USING OF MODIFIED ALGINATE-BASED NANOCOMPOSITES BEADS FOR THE
REMOVAL OF SOME HEAVY METALS FROM INDUSTRIAL WASTEWATER**

Eman Sanad

Environmental Science Department, Faculty of Science, Port Said University, Port Said, Egypt

Khalid Z. Elwakeel

Environmental Science Department, Faculty of Science, Port Said University, Port Said, Egypt
University of Jeddah, College of Science, Department of Chemistry, Jeddah, Saudi Arabia.

Mokhtar S. Beheary

Environmental Science Department, Faculty of Science, Port Said University, Port Said, Egypt

Ahmed Abdelaal

Environmental Science Department, Faculty of Science, Port Said University, Port Said, Egypt

Abbreviations

Alg/ZnS/ZnO	Alginate/Zinc sulfide/Zinc Oxide
Alg/ZnS/ZnO/Ti₂O₃	Alginate/Zinc sulfide/Zinc Oxide/Titanium Oxide
Alg/ZnS/ZnO/GA	Alginate/Zinc sulfide/Zinc Oxide/Gum Arabic
SEM	Scanning electron microscope
EDX	Energy dispersive X-ray
FTIR	Fourier transform infrared

ABSTRACT

Heavy metal pollution has emerged as a significant environmental concern due to the discharge of heavy metals from modern industrial effluents. Adsorption is considered an eco-friendly, cost-effective solution for removing heavy metals from industrial wastewater. Sodium alginate, a natural polysaccharide rich in hydroxyl and carboxyl groups, has been extensively studied for this purpose. However, its industrial applications are limited by its weak physical strength and poor thermal stability. Recent advances in sodium alginate-based adsorbents, through surface grafting and cross-linking, have improved their uptake capacity and removal efficiency of heavy metal ions. This paper presents the development of sodium alginate-based composite materials, focusing on their polymeric properties, modifications, and adsorption behaviors for metal removal from industrial effluents. The study investigated the adsorption mechanisms of various alginate-based composites for removing heavy metals such as Cd(II), Pb(II), and Ni(II). Specifically, three alginate-based nanocomposites — Alg/ZnS/ZnO, Alg/ZnS/ZnO/Ti₂O₃, and Alg/ZnS/ZnO/GA — were prepared via the sol-gel method, characterized by SEM, EDX, Zeta potential, and FTIR techniques, and evaluated through kinetic and isothermal models. The results indicated that all three adsorbents reached

removal equilibrium at pH 6, 25 °C, and 270 min of contact time. Alg/ZnS/ZnO/Ti₂O₃ and Alg/ZnS/ZnO/GA demonstrated the highest removal efficiency for Pb(II), with rates of 99% and 96%, respectively, followed by Ni(II) and Cd(II). In contrast, Alg/ZnS/ZnO showed the highest removal efficiency for Cd(II) at 88%, followed by Pb(II) and Ni(II). All prepared adsorbents adhered to Pseudo second order, Intra-particle diffusion equation, and Elovich model, and isothermal studies showed conformity with the Freundlich and Temkin models. Regeneration studies revealed that the beads could be reused after treatment with a 0.5 M HNO₃ solution.

Keywords; Adsorption, heavy metals, alginates, nanomaterials, kinetics, isothermal studies.

**ANALYSIS OF STATISTICS OF CRIME RATES IN NORTHWEST NIGERIA
USING PRINCIPAL COMPONENT TECHNIQUE**

ADEYEMI, Deborah A.

Department of Engineering and Software Development, Tim-R Programming Consult, Nigeria

OGUNLEYE, Timothy A.

PhD., Department of Statistics, Faculty of Basic and Applied Sciences, Osun State University, Osogbo, Nigeria

ABSTRACT

The study was based on crime statistics in Nigeria. Six states of the northwest geopolitical zone were considered. Crimes are broadly categorized into nine: felonies, misdemeanors, violations, treason and espionage, inchoate offenses, personal crimes, victimless crimes, white-collar crimes, and organized crimes. Monthly reported cases of each of these crimes were retrieved from the police records over a period of thirty-six months. Some basic descriptive statistics and principal component analysis were employed to explore the hidden characteristics in the data obtained. The results revealed that personal crime was mostly committed while treason and espionage happened to be the least occurring crime for the duration covered. It's also reported that at least two of these crimes were inter-related and as a result, the occurrence of one influenced the occurrence of others.

Keywords: Crimes, Crime Rates, Northwest Geopolitical Zone, Principal Component Analysis

1. Introduction

Crime is ubiquitous; it exists every part of the world. Crime could be defined as an illicit act performed by humans either intentionally or unintentionally. It can also be defined as offence committed by human which certainly attracts punishment in accordance with the degree of such an offence. Zhou and Mathuthu (2019) defined crime as any act or omission that goes against the law of the land with attraction of punishment. It should be reiterated that no culture in the world allows excuse for committing a crime among human race. Therefore, some researchers define crime as an act that goes against a laid down rules and regulations of any community or society (Estevez-Soto, 2021; Junger, et al., 2020).

Atrocities and crimes are interchangeably used in many contexts. As reported by Antony, et al. (2022); Zhou & Mathuthu (2019); ENACT (2018); and Isiaka & Okaphor (2018), many factors such as poverty, unemployment, drug abuse, peer group, and religion are responsible for increasing rate at which crimes are committed in our today's society. These factors are

very inter-correlated with one another (Isiaka & Okaphor, 2018). This indicates that the occurrence of one influences the occurrence of other.

However, other factors that are responsible for increasing crime rate are family condition, societal influence, economic and educational deprivations, unfair or biased judicial systems (Bothos & Thomopoulos, 2016; Zhou & Mathuthu, 2019). These and many more can result to increase in crime statistics. As you may know in the northern Nigeria, a family might be composed of ten to fifteen members with one or two wife/wives. With this, it might be difficult for the head of the family to provide all necessary needs, which may eventually result into creating a nuisance in the society. At the end, the children of such a man can create nuisance to the society.

When a child is being deprived educationally, it should be at the back of our mind that such a child will lead a crime in the future. Any government that abandons educational right of children plans to fail the future of all stakeholders; it is like a seed expected to germinate someday. Like that of Nigeria's system of governance, where universities are closed down for several months and weeks due to strike actions emanated from the rightful request of the academic staff needs and welfare, no significant expectation from the youths of such age bracket, who are kept at home doing nothing, than indulging themselves in criminal acts and some other social vices.

This study focuses mainly on using dimensionality reduction approach to explore some hidden characteristics in crimes committed by people living in the northwestern states of Nigeria with a view to examining the effect of various degrees of inter-connections between at least two of the crimes within the study areas and also identifying the most occurring and the least occurring crime in northwestern states of Nigeria.

1.1 Rationale

Crime has been a subject of discussion in relation with the level of insecurity of today's Nigeria, most especially states in the northwest region of Nigeria, which are considered as case studies because of the increase in crime rates in those areas (Isiaka & Okaphor, 2018). According to Agency Report (2022), the area is not friendly to visit these days as a result of concurrent bomb attacks, human kidnappings, live shooting, manslaughter, and other acts of terrorism.

However, a number of academic papers and articles have been published on crime and criminal acts within and outside Nigeria. Some focus on factors responsible for or influencing crime rates, causes of crime, review on different forms of crime, and so on (Oliveira, 2021; Caldwell, et al., 2020; Zhou and Mathuthu, 2019; ENACT, 2018; Bothos and Thomopoulos, 2016; Leggett, et al., 2005; Williamson, 1957) but no sufficient academic reports have been published on exploring some important hidden characteristics on various types of crimes

committed by Nigerians using exploratory data analysis as well as principal component technique.

However, it's established that no publicly available dataset on crime statistics in Nigeria reported in recent time. This paper intends to provide research report on the rate of crime statistics in northwest Nigeria, bearing in mind that the study will provide statistics on the most and least occurring crimes in the last thirty-six months.

1.2 Aim and objectives

The primary aim of this study is to explore some hidden characteristics in the rate of crime statistics within the northwest geopolitical zone of Nigeria using principal component analysis (PCA) as well as exploratory data analysis (EDA). The objectives are:

- (i) To identify various categories of crimes that exist within the study area.
- (ii) To determine some hidden basic characteristics of various crimes committed by people residing within northwest geopolitical zone of Nigeria.
- (iii) To examine the rate of increase in crime statistics within the study areas in the last thirty-six months.
- (iv) To identify the most occurring and the least occurring crime in northwest Nigeria.

1.3 Scope, data and approach

The scope of this study includes six states of the northwest geopolitical zone in Nigeria which comprises Jigawa, Kaduna, Kano, Kastina, Kebbi, and Zamfara states. The reason for focusing these areas is because of the continuous increase in criminal acts and terrorism (Sowmya, 2014; Jaclyn & Jose, 2022). Though many forms of crimes exist, all of them are summarized into nine in this study: felonies, misdemeanors, violations, treason and espionage, inchoate offenses, personal crimes, victimless crimes, white-collar crimes, and organized crimes (Catherine, 2022). Examples of all these crimes include but not limited to: larceny theft, burglary, violent crime, aggravated assault, motor vehicle theft, robbery, rape, attempted rape, murder and non-negligent manslaughter, financial crime, kidnapping, banditary, arson, extortion, theft, child abuse, counterfeiting currency, cybercrime, drug abuse, forgery, prostitution, terrorism and armed insurgency, sedition, drug trafficking, smuggling, human trafficking, works of art trafficking, and fraud.

The data used is secondary collected from the Planning and Research Unit of the Department of Information and Communication Technology (ICT) of the Nigeria Police Force Headquarters, Abuja, Nigeria. It is taken on monthly basis to cover thirty-six months spanning January, 2019 through December, 2021. Exploratory data analysis (EDA) of some demographic information of the suspects was reported mainly with frequencies and percentages. This indicates that descriptive results are presented in tabular forms while

checking the violation of some basic assumptions for employing the use of principal component analysis.

2. Some related works

The concept of crime has existed since the dawn of civilization and has changed across time and space in accordance with the social mores or values of a specific geographic community during a specific period. Therefore, as crime changes, so do its meaning, form, and perception of time, societal norms, and political systems. Over time, certain transgressions lose their relevance, while others develop new and more serious elements (Robert, et al., 2019). A normative definition states that crime is abnormal behaviour that deviates from the norms that now regulate how individuals should behave (Matthew, 2018). This approach to studying crime aims to comprehend how shifting social, political, psychological, and economic circumstances may influence how definitions of crime are created. As a result, depending on the era in which they were written, definitions from various sociologists and criminologists differ (Matthew, 2018).

It's debatable what constitutes criminality in the first place. The definition of a crime is not universally agreed upon. However, from a legal perspective, a crime is just an act that violates the law (Schur, 1965). This is the most straightforward approach to look about crime. The law expressly declares it to be unlawful. This will provide the behaviour two components: a criminally motivated harm and a criminally motivated blame. Even if we think a given act is wrong, bothersome, or harmful, if it isn't against the law, it won't be considered a crime. Criminologists have questioned notions of criminal responsibility as well as the benefits and drawbacks of a proactive, personal-responsibility-based strategy (David, 2019).

Any conduct that is against the letter or spirit of the law is considered a crime. Or, to put it another way, crime and legality are social conceptions that are dynamic and alter through time. Crimes come in a wide variety of forms, including crimes against people, crimes without a victim, violent crimes, and white-collar crimes. A significant area of sociology is the study of crime and deviance, with a focus on who commits what kinds of crimes and why (Crossman & Ashley, 2021).

William claims that criminal activity is a legal violation that may be followed by criminal proceedings and penalties. According to Gledhill, a crime is any human behaviour that the state decides to forbid via the use of specific legal processes and the threat of penalty. There are viewpoints that consider crime as a typical social phenomenon, an unavoidable by-product of human interaction and social development (Schur, and Bedau, 1974). According to Durkheim, a people's collective conscience determines what constitutes crime. In other words, crimes may be based on what is generally accepted as morally right or bad. Durkheim went on to say that all discussions of crime revolve on figuring out what punishments should be in order for them to serve as remedies. Some points of view accepted the intent and goal of

defining crime in legal terms, but they felt that these definitions were excessively limiting and said that crime is often more than just a breach of the law per se (Isiaka & Okaphor, 2018).

A purposeful, unjustifiable conduct that contravenes the law is referred to as a crime and is penalized by the state as a felony or misdemeanour. It was emphasized that the legal orientation is the only definition that is precise and administratively important, and sociologists may try to improve processes for a complete and more precise ascertainment of offenders. The term "breach of the legal norms which attracts a penal punishment and the violator or the criminal is the one who conducted such act of breach" was thus simplified to serve as the definition of crime. To define crime, several legal experts have worked. Crime is an infraction against the duties and rights of the public that belong to the whole community or to the community at large. Criminal is defined by Blackstone, one of the most important writers on English law in the seventeenth century, as "criminal on violating public law banning or demanding it" (Isiaka & Okaphor, 2018).

Crimes frequently involve conduct that has a harmful impact on society as a whole in addition to violating the rights of the person. As a reminder of the public nature of crimes, the distinctions between civil and criminal procedural laws should be made. Unless there are special restrictions to the contrary, any citizen may make a criminal complaint 31, whether or not they have suffered any particular damage that distinguishes them from other members of the public and regardless of whether they have an interest in seeing the criminal law implemented. The majority of prosecutions are really handled by the state or one of its agencies, and neither they nor the person who committed the crime have any personal interest in how the case turns out or who is found guilty (Scott, 2022). Even if it's illegal, an oil spill will affect society considerably more than a fight in a parking lot. The work of distinguishing between the two kinds of wrongs would be reduced, in accordance with this criterion, to that of drawing a line between the various degrees of injury (Isiaka & Okaphor, 2018).

Crime is a social injustice (Shang and You, 2019). It is an unlawful conduct that transgresses state law and is roundly condemned by society. Crime is defined as any action or inaction that is against the law and is subject to a jail sentence or monetary penalties. Crimes include murder, robbery, burglary, rape, driving while intoxicated, maltreatment of children, and failing to pay taxes. The word "crime" comes from the Latin "crimen," which both an offense and a wrongdoer. Criminal behaviour is viewed as being anti-social. Crime may be defined differently in each community. A crime may be authorized by law or not. According to criminal law, breaking any rule of administration or state law, or engaging in any action that is damaging to oneself or others, is an illegal and punishable crime. All actions of self-defence are legal and not criminal offenses (Sowmyya, 2014).

No one is born a criminal, claims Sowmyya (2014); rather, it is the circumstances and environment in which a person lives that causes him to act criminally. An individual might

become a criminal for a variety of reasons. There were combined families in the past, and the children were always under family authority. In modern cities, every family member is occupied following their own goals. Having traits like a high level of freedom, recklessness, revolt, violent impulses, suspicion, a lack of self-control, sadism, emotions, social maladjustment, poor behaviour, immaturity, etc., identifies someone as abnormal. He partakes in all of the aforementioned, as well as prostitution, theft, vandalism, smoking, taking drugs, and smashing stuff.

Crime is the wilful commission of an act that is commonly considered to be hazardous or socially detrimental and is specifically forbidden by law and punishable by criminal penalties. The majority of countries have codified their criminal laws; however, English law, which is the basis for many other criminal-law systems, has not. The definitions of certain offenses in a code must be interpreted in light of several concepts, some of which may not be expressed expressly in the code. For instance, a number of judicial systems take the accused's mental state at the time the alleged crime was committed into account. In order to assign cases to different courts, the majority of legal systems also classify crimes. Due to social changes, new criminal laws are constantly introduced, and existing ones are made ineffective (Antony, et al., 2022).

According to Google, America is one of the most dangerous countries in which to live. Globally, there are 3 billion people that are categorized as poor and have extremely low per capital incomes (Britannica, 2019, Nov.). Drug users typically experience addiction and struggle to escape it, which leads them to form bad behaviours. People are compelled to participate in behaviours they ought to avoid by poor living situations. Drug addiction is the leading cause of death in the United States, taking up to 0.7 million lives (Catherine, 2022).

In this planet, more than 30% of individuals are unemployed. The key cause of why so many individuals commit crimes is frequently this increasing aspect in numerous nations. When they get involved in illegal activity relatively early in their lives, most young people ruin their careers. People who don't get justice typically turn hostile and commit crimes. People often kill each other in a lot of underdeveloped nations. You must search for a Los Angeles criminal lawyer if you are a US citizen looking to meet a qualified criminal defence attorney for a friend or relative. Another contentious aspect of our world is religion. Many people don't realize that having the right to practice one's own religion is a fundamental human right. Religious extremists have been charged with murdering innocent individuals in a number of criminal instances. However, crime rates are often lower in developed and secular nations (General Categories of Crime, 2014; Catherine, 2022).

3. Methods

3.1 Study area

Nigeria as a sovereign nation is divided into six geopolitical zones: south west, south south, south east, north east, north central, and north west. This study chooses north west region as a case study because of the high rate of crimes in Nigeria. Though the region is composed of seven states, only six states: Jigawa, Kaduna, Kastina, Kano, Kebbi, and Zamfara are captured by this study. The only one left out is Sokoto. The main reason for this action is because of non-availability of statistical records of reported cases of crimes as at the time of carrying out this study.

3.2 Statistical approach for basic assumptions

It is important to some of the technicalities and methods for testing some basic assumptions since the dataset is taken on monthly basis. This is subdivided into five parts: normality assumption, stationarity, multicollinearity, serial correlation and outliers. For normality, we make use of shapiro-wilk test. For stationarity, we make use of Augmented Dicker-Fuller (ADF) test. We used correlation matrix to check for multicollinearity while Ljunkt-Box test was used to check for autocorrelation.

3.3 Principal component analysis

The principal component analysis (PCA) is a statistical approach used to simplify the complexity of high-dimensional data while retaining the originality and significance of the trends and patterns of the datasets. The method is primarily designed for dimensionality reduction of variables.

However, the method of principal components is a special case of the generally method of Factor Analysis. The aim of the method of principal components is the construction out of a set of variables, X_j 's ($j=1,2,\dots,k$) of new variables (P_i) called principal components, which are linear combinations of the X 's. The procedures are outlined as follows:

3.3.1 Step I: Confirmation of linearity

Since the method assumes that X_j 's ($j=1,2,\dots,k$) are linearly related, the first step is to confirm this linearity assumption by plotting X_i against X_j . For instance, X_1 may be plotted against each of the $X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9$.

3.3.2 Step II: Determination of the number of principal components

It is important to determine the number of PC to be included in the analysis. This can be achieved by several methods but the method of percentage of variance proportion is employed here and all computations are done within R environment. This is simply tailored as follows:

In this case, prepare the dataset and label each with appropriate variable names, standardize the dataset by having a new variable called Z_i such that $Z_i = \frac{(X_i - \bar{X})}{\sigma_x}$, for $i=1,2,\dots,n$.

After that, obtain the percentage contributions of each of the principal components by the relation in (1).

$$\text{Percentage Contribution of } P_i = \frac{\text{Var}(P_i)}{\text{trace}(R)} \text{ multiply by } 100 (\%), \text{ where } \text{Var}(P_i) = \lambda_i \quad (1)$$

3.3.3 Step III: Formation of principal components (PC)

Now, we shall use the eigenvectors as coefficients and the standardized variables as the principal component variables. This can be obtained as follows:

$$P_1 = a_{11}Z_1 + a_{12}Z_2 + \dots + a_{1i}Z_i \quad (2)$$

$$P_2 = a_{21}Z_1 + a_{22}Z_2 + \dots + a_{2i}Z_i \quad (3)$$

$$P_3 = a_{31}Z_1 + a_{32}Z_2 + \dots + a_{3i}Z_i \quad (4)$$

$$P_4 = a_{41}Z_1 + a_{42}Z_2 + \dots + a_{4i}Z_i \quad (5)$$

$$P_5 = a_{51}Z_1 + a_{52}Z_2 + \dots + a_{5i}Z_i \quad (6)$$

$$P_6 = a_{61}Z_1 + a_{62}Z_2 + \dots + a_{6i}Z_i \quad (7)$$

$$P_7 = a_{71}Z_1 + a_{72}Z_2 + \dots + a_{7i}Z_i \quad (8)$$

$$P_8 = a_{81}Z_1 + a_{82}Z_2 + \dots + a_{8i}Z_i \quad (9)$$

$$P_9 = a_{91}Z_1 + a_{92}Z_2 + \dots + a_{9i}Z_i \quad (10)$$

Nine Principal Components are formed because there are nine explanatory variables which give rise to nine eigenvalues and the corresponding eigenvectors.

4. Results

4.1 EDA results

Though crimes are numerous, for the purpose of this study, they are classified into nine different categories. Thus, the highest number of reported cases of crime is personal crime, which is 117682 while the least is 3069 (treason and espionage). However, 14376, 17781, 22403, 15256, 3152, 91950, and 45052 reported cases of felonies, misdemeanors, violations, inchoate offence, computer crime, white-collar crime, and organized crime are

obtained for this study. The following Table 2 shows the frequency and percentage of each of these crimes while Figure 2 corroborates these results.

Table 2: Summary of reported cases of crimes in northwestern states, Nigeria

S/N	Crimes	Frequency	Percentage (%)
1.	Felonies	14376	4.35
2.	Misdemeanors	17781	5.38
3.	Violations	22403	6.77
4.	Treason and espionage	3069	0.93
5.	Inchoate offenses	15256	4.61
6.	Personal crime	117682	35.6
7.	Computer crime	3152	0.95
8.	White-collar crime	91950	27.8
9.	Organized crime	45052	13.6

Source: PRS Department of NPF, Abuja

From these results, the percentage of the crime with the highest frequency (personal crime) is 35.6% while that of the crime with the least frequency (treason and espionage) is 0.93% .

4.1.1 Socio-demographic information of suspects of felonies

The frequency and percentage of each of the socio-demographic information are presented in connection with the six states that are considered for the study. Out of 14376 reported cases of felonies in this geopolitical zone, 2352 representing 16.36% are come Jigawa State, 2328 representing 16.19% are from Kaduna State, 2482 (17.27%) are from Kano State, 2378 representing 16.54% reside in Kastina State, 2408 (16.75%) reside in Kebbi State while 2428 (16.89%) are from Zamfara State.

However, the same Table 3 shows approximately 57% of 14376 felonies suspects are within the age bracket 18 - 37 years, approximately 70% are male gender, while about 85.5% are unmarried either single, widowed or divorced. These results really show the reality of today's society as it is peculiar to Nigerian system.

Table 3: Some basic socio-demographic information of suspects of felonies

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	584	558	608	586	492	551	3379 (23.50%)
28 - 37	847	948	984	987	1184	1267	6217 (43.24%)
38 - 47	472	453	461	477	457	306	2626 (18.26%)

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X
 October 05-07, 2024

48 - 57	259	183	310	157	111	117	1137 (7.91%)
58	- 190	186	119	171	164	187	1017 (7.04%)
Above							
Sex distribution							
Male	1549	1646	1841	1598	1702	1678	10014 (69.66%)
Female	803	682	641	780	706	750	4362 (34.34%)
Marital status							
Divorced	382	247	342	492	385	320	2168 (15.08)
Married	461	404	334	254	306	329	2088 (14.52%)
Single	1201	1362	1417	1143	1289	1391	7803 (54.28%)
Widowed	308	315	389	489	428	388	2317 (16.12%)
Total	2352 (16.36%)	2328 (16.19%)	2482 (17.27%)	2378 (16.54%)	2408 (16.75%)	2428 (16.89%)	14376

Source: PRS Department of NPF, Abuja

4.1.2 Socio-demographic information of suspects of misdemeanors

The distribution of misdemeanors suspects' age is normally distributed as 19.6% (3488) fall between the age bracket 18 - 27 years, 19.9% (3546) fall between the age bracket 28 - 37 years, 20.1% (3568) fall between 38 - 47, while the rest 20.3% (3606) and 20.1% (3576) are within the age brackets 48 - 57 and 58 and above respectively. The results for state-wise number of misdemeanors crime are also presented in Table 4. These also appear to be normally distributed as no smell of skewness is perceived from any of the states' results.

Table 4: Some basic socio-demographic information of suspects of misdemeanors

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	569	560	626	574	591	568	3488
28 - 37	599	570	600	602	593	582	3546
38 - 47	574	591	596	581	629	597	3568
48 - 57	597	621	598	597	595	595	3603
58 - Above	561	634	581	631	579	590	3576
Sex distribution							
Male	2472	2426	2532	2462	2467	2503	14862

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X
 October 05-07, 2024

Female	428	550	469	523	520	429	2919
Marital status							
Divorced	716	741	754	738	776	765	4481
Married	693	751	726	747	772	696	4385
Single	756	685	778	724	691	747	4381
Widowed	735	799	743	776	748	733	4534
Total	2900	2976	3001	2985	2987	2932	17781

Source: PRS Department of NPF, Abuja

4.1.3 Socio-demographic information of suspects of violation crime

The demographics of the suspects of violation crime are presented in Table 5. From the table, it is obvious that approximately 57% (12737) of the suspects fall between the ages 18 to 37, which are considered as youthful ages. Also, the report says that about 66% (14860) of the suspects of violation are male while majority are non-married, that is, they are either single, divorced or widowed. Figures 5A, 5B and 5C also elaborate more on these descriptive results.

Table 5: Some basic socio-demographic information of suspects of violations

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	1054	1050	1097	1047	1084	1008	6340
28 - 37	1078	1062	1115	1036	1096	1010	6397
38 - 47	546	541	538	508	584	538	3255
48 - 57	533	483	540	533	500	533	3122
58 - Above	559	522	527	567	519	595	3289
Sex distribution							
Male	2541	2406	2546	2409	2504	2454	14860
Female	1229	1252	1271	1282	1279	1230	7543
Marital status							
Divorced	0	0	3817	0	3783	0	7600
Married	0	0	0	3691	0	0	3691
Single	3770	3658	0	0	0	0	7428
Widowed	0	0	0	0	0	3684	3684
Total	3770	3658	3817	3691	3783	3783	22403

Source: PRS Department of NPF, Abuja

4.1.4 Socio-demographic information of suspects of treason and espionage

The results in Table 6 as well as Figures 6A-C show that 29.6% (907) are suspects of age bracket 18 - 27, 27.6% (847) are between the ages 28 and 37, while 15% (461) are within the age bracket 38 and 47. Altogether, all these ages are active ages which invariably are the youth of the nation. The same apparatus also show that male are those committing treason and espionage crime. This is empirically established that 68.4% of all the suspects of treason are male. However, those without partners (single, widowed, and divorced) form the larger percentage (84.6%). This could be so because they may not have anyone to whom they are responsible.

Table 6: Some basic socio-demographic information of suspects of treason & espionage

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	144	162	143	149	171	138	907
28 - 37	146	124	153	114	161	149	847
38 - 47	68	95	70	68	69	77	461
48 - 57	67	69	74	68	69	77	424
58 - Above	77	77	69	75	60	72	430
Sex distribution							
Male	344	364	352	304	380	355	2099
Female	158	163	157	169	167	156	970
Marital status							
Divorced	0	0	509	0	547	0	1056
Married	0	0	0	473	0	0	473
Single	502	527	0	0	0	0	1029
Widowed	0	0	0	0	0	511	511
Total	502	527	509	473	547	511	3069

Source: PRS Department of NPF, Abuja

4.1.5 Socio-demographic information of suspects of inchoate crime

It is evident from the results in Table 7 and Figures 7A, 7B and 7C that more than half (approximately 57%) are within the youthful ages of 18 to 37 while only 14.6% of the suspect of inchoate crime fall between 58 years and above. It is also established that approximately 66% are male gender. The same results indicate that only 16.5% of the suspects of inchoate

crime are married while the rest are not occupied but remain unmarried either by being a widow, single or divorced.

Table 7: Some basic socio-demographic information of suspects of inchoate crime

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	710	718	760	704	738	712	4342
28 - 37	758	704	748	699	763	783	4355
38 - 47	370	378	356	361	401	349	2215
48 - 57	366	328	360	366	345	355	2120
58 - Above	378	353	352	388	362	391	2224
Sex distribution							
Male	1715	1656	1724	1663	1708	1668	10134
Female	867	825	852	855	901	822	5122
Marital status							
Divorced	0	0	2576	0	2609	0	5185
Married	0	0	0	2518	0	0	2518
Single	2582	2481	0	0	0	0	5063
Widowed	0	0	0	0	0	2481	2481
Total	2582	2481	2576	2518	2609	2490	15256

Source: PRS Department of NPF, Abuja

4.1.6 Socio-demographic information of suspects of personal crime

It is evident from the results in Table 8 and Figures 8A, 8B and 8C that more than half (approximately 57%) are within the youthful ages of 18 to 37 while only 14.5% of the suspect of personal crime fall between 58 years and above. It is also established that approximately 67% are male gender. The same results indicate that only 16.5% of the suspects of personal crime are married while the rest are not occupied but remain unmarried either by being a widow, single or divorced.

Table 8: Some basic socio-demographic information of suspects of personal crime

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X
 October 05-07, 2024

18 - 27	5601	5566	5694	5510	5596	5512	33479
28 - 37	5672	5574	5503	5461	5683	5582	33475
38 - 47	2758	2808	2807	2780	2813	2893	16859
48 - 57	2810	2763	2869	2824	2796	2780	16842
58 -	2785	2799	2843	2851	2828	2921	17027
Above							
Sex distribution							
Male	13179	13087	13111	12787	13189	13125	78478
Female	6447	6423	6605	6639	6527	6563	39204
Marital status							
Divorced	0	0	19716	0	19716	0	39432
Married	0	0	0	19426	0	0	19426
Single	19626	19510	0	0	0	0	39136
Widowed	0	0	0	0	0	19688	19688
Total	19626	19510	19716	19426	19716	19688	117682

Source: PRS Department of NPF, Abuja

4.1.7 Socio-demographic information of suspects of computer crime

It is evident from the results in Table 9 and Figures 9A, 9B and 9C that more than half (approximately 57%) are within the youthful ages of 18 to 37 while only 13.9% of the suspect of computer crime fall between 58 years and above. It is also established that approximately 68% are male gender. The same results indicate that only 15.6% of the suspects of personal crime are married while the rest 84.4% are unmarried.

Table 9: Some basic socio-demographic information of suspects of computer crime

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	148	164	148	155	171	141	927
28 - 37	154	125	156	124	164	156	879
38 - 47	69	95	71	69	89	77	470
48 - 57	68	70	78	69	73	80	438
58 -	78	81	69	75	60	75	438
Above							
Sex distribution							
Male	353	368	360	314	387	366	2148
Female	164	167	162	178	170	163	1004

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X
 October 05-07, 2024

Marital status

Divorced	0	0	522	0	557	0	1097
Married	0	0	0	492	0	0	492
Single	517	535	0	0	0	0	1052
Widowed	0	0	0	0	0	529	529
Total	517	535	522	492	557	529	3125

Source: PRS Department of NPF, Abuja

4.1.8 Socio-demographic information of suspects of white-collar crime

It is evident from the results in Table 10 and Figures 10A, 10B and 10C that more than half (approximately 57%) are within the youthful ages of 18 to 37 while only 14.5% of the suspect of white-collar crime fall between 58 years and above. It is also established that approximately 67% are male gender. The same results indicate that only 16.5% of the suspects of white-collar crime are married while the rest 83.5% are unmarried.

Table 10: Some basic socio-demographic information of suspects of white-collar crime

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	4348	4309	4485	4310	4357	4263	26072
28 - 37	4460	4378	4312	4253	4459	4415	26277
38 - 47	2149	2196	2210	2150	2202	2280	13187
48 - 57	2187	2165	2200	2207	2191	2152	13102
58 - Above	2159	2181	2206	2274	2190	2302	13312
Sex distribution							
Male	10284	10169	10244	9970	10283	10302	61252
Female	5019	5060	5169	5224	5116	5110	30698
Marital status							
Divorced	0	0	15413	0	15399	0	30812
Married	0	0	0	15194	0	0	15194
Single	15303	15229	0	0	0	0	30532
Widowed	0	0	0	0	0	15412	15412
Total	15303	15229	15413	15193	15399	15412	91950

Source: PRS Department of NPF, Abuja

4.1.9 Socio-demographic information of suspects of organized crime

It is evident from the results in Table 11 and Figures 11A, 11B and 11C that more than half (approximately 70%) are within the youthful ages of 18 to 37 while only 1.24% of the suspect of organized crime fall between 58 years and above. It is also established that approximately 77.4% of the suspects of organized crime are male. The same results indicate that only 16.7% of the suspects of organized crime are married while the rest 83.7% are unmarried.

Table 11: Some basic socio-demographic information of suspects of organized crime

Variables of Interest	States within northwestern parts of Nigeria						Total
	Jigawa	Kaduna	Kano	Kastina	Kebbi	Zamfara	
Age classification							
18 - 27	3115	3054	3213	3096	3150	3094	18722
28 - 37	2185	2137	2181	2153	2210	2088	12954
38 - 47	1074	1079	1070	1058	1087	1091	6459
48 - 57	1067	1017	1087	1089	1028	1070	6358
58 - 59		77	118	117	55	133	559
Above							
Sex distribution							
Male	5001	4858	5103	4960	4982	4970	34874
Female	2499	2506	2566	2553	2548	2506	10178
Marital status							
Divorced	582	1113	5285	280	6983	956	15199
Married	312	147	376	6141	282	255	7513
Single	5917	5146	986	485	128	2202	14864
Widowed	689	958	1022	607	137	4063	7476
Total	7500	7364	7669	7513	7530	7476	45052

Source: PRS Department of NPF, Abuja

4.2 Checking some basic assumptions on the data

4.2.1 Normality

The reports of the application of shapiro-wilk statistical test are presented in Table 12.

Table 12: Results of normality test

Variables	Shapiro test statistic	Probability value	Interpretations
Felonies (x_1)	W = 0.97467	p-value = 0.5661	It is normally distributed
Misdemeanors (x_2)	W = 0.94918	p-value = 0.09853	It is normally distributed
Violations (x_3)	W = 0.9234	p-value = 0.01586	It is normally distributed
Treason and espionage (x_4)	W = 0.93763	p-value = 0.04288	It is normally distributed
Inchoate offenses (x_5)	W = 0.88592	p-value = 0.001438	It is not normally distributed
Personal crime (x_6)	W = 0.86194	p-value = 0.0003628	It is not normally distributed
Computer crime (x_7)	W = 0.97447	p-value = 0.5593	It is normally distributed
White-collar crime (x_8)	W = 0.82744	p-value = 6e-05	It is not normally distributed
Organized crime (x_9)	W = 0.85958	p-value = 0.0003188	It is not normally distributed

Recall that the null hypothesis states that the dataset is normally distributed while the alternative hypothesis negates it. The decision rule states that the null hypothesis should be rejected when the p-value is less than or equal to the chosen level(s) of significance. We consider both 1% and 5% respectively as criteria for making decisions here. However, each of the dataset is tested and it's established that inchoate offenses, personal, white-collar, and organized crimes are not normally distributed.

4.2.2 Stationarity

The report of the application of Augmented Dickey-Fuller test are presented in Table 13. The null hypothesis is such that the time series dataset is non-stationary. However, the ADF statistic with a p-value \leq chosen level of significance

Table 13: Results of stationarity test

Variables	ADF statistic	Probability value	Interpretations
Felonies (x_1)	ADF = -2.9757	Lag order = 3, p-value = 0.1935	Not stationary
Misdemeanors (x_2)	ADF = -2.0034	Lag order = 3, p-value = 0.5718	Not stationary
Violations (x_3)	ADF = -	Lag order = 3, p-value =	Not stationary

	2.1863	0.5006
Treason and espionage (x_4)	ADF = -2.0681	Lag order = 3, p-value = 0.5466 Not stationary
Inchoate offenses (x_5)	ADF = -2.5527	Lag order = 3, p-value = 0.3581 Not stationary
Personal crime (x_6)	ADF = -2.3248	Lag order = 3, p-value = 0.4468 Not stationary
Computer crime (x_7)	ADF = -2.3676	Lag order = 3, p-value = 0.4301 Not stationary
White-collar crime (x_8)	ADF = -3.0056	Lag order = 3, p-value = 0.1819 Not stationary
Organized crime (x_9)	ADF = -2.3992	Lag order = 3, p-value = 0.4178 Not stationary

The results from Table 13 show that none of the variables is stationary, meaning that the dataset is not stable over time. Though it is not a criterion for the application of PCA to hold, it is just to check whether or not the number of suspect of various crimes is stable over time.

4.2.3 Checking the existence of multicollinearity

In this sub-heading, a check for multicollinearity (true orthogonality of independent variables) is necessary. The following matrix, R, presents the results of Pearson's correlation.

$$R = \begin{bmatrix} 1 & .3187 & .0996 & .7870 & .5907 & .8128 & .5434 & .7716 & .6562 \\ & 1 & -.1165 & .6305 & .7615 & .4982 & .7517 & .4723 & .6187 \\ & & 1 & .0717 & .2201 & .3865 & .2876 & .2923 & -.1013 \\ & & & 1 & .7874 & .7901 & .8435 & .6801 & .5431 \\ & & & & 1 & .8711 & .8836 & .8509 & .7010 \\ & & & & & 1 & .7571 & .9590 & .7053 \\ & & & & & & 1 & .6415 & .4418 \\ & & & & & & & 1 & .8246 \\ & & & & & & & & 1 \end{bmatrix} \dots\dots\dots(11)$$

There are very high inter-connections among the different crimes under study. For instance, the result of 0.9590 obtained as the correlation coefficient between personal crime and white-collar crime indicates that an approximate 96% positive correlation, meaning that increase in personal crime results to corresponding increase in white-collar crime, and vice-versa. Hence, the crimes are non-orthogonal.

4.2.4 Checking serial correlation

One of the statistical tests for checking the existence of serial correlation in a dataset is Ljung-Box test, developed by two great statisticians: Greta M. Ljung and George E.P. Box. The

statement of null hypothesis is no serial correlation exists. However, the test is applied using R engine and results are presented in Table 14.

Table 14: Results of serial correlation test

Variables	Ljung-Box statistic	Probability value	Interpretations
Felonies (x_1)	X-squared 29.45	= p-value = 5.737e-08	Serial correlation exists
Misdemeanors (x_2)	X-squared 30.557	= p-value = 3.243e-08	Serial correlation exists
Violations (x_3)	X-squared 26.144	= p-value = 3.169e-07	Serial correlation exists
Treason and espionage (x_4)	X-squared 29.097	= p-value = 6.885e-08	Serial correlation exists
Inchoate offenses (x_5)	X-squared 35.346	= p-value = 2.76e-09	Serial correlation exists
Personal crime (x_6)	X-squared 35.636	= p-value = 2.379e-09	Serial correlation exists
Computer crime (x_7)	X-squared 28.693	= p-value = 8.481e-08	Serial correlation exists
White-collar crime (x_8)	X-squared 33.043	= p-value = 9.014e-09	Serial correlation exists
Organized crime (x_9)	X-squared 30.058	= p-value = 4.194e-08	Serial correlation exists

The existence of serial correlation in the dataset shows that number of suspects of each of the crimes does not seem to be random, that is, does not follow any particular pattern.

4.3 The analytical concept of PCA

4.3.1 Linearity

While confirming linearity assumption, some graphics are obtained to check the inter-connection between the number of suspects of one crime and another.

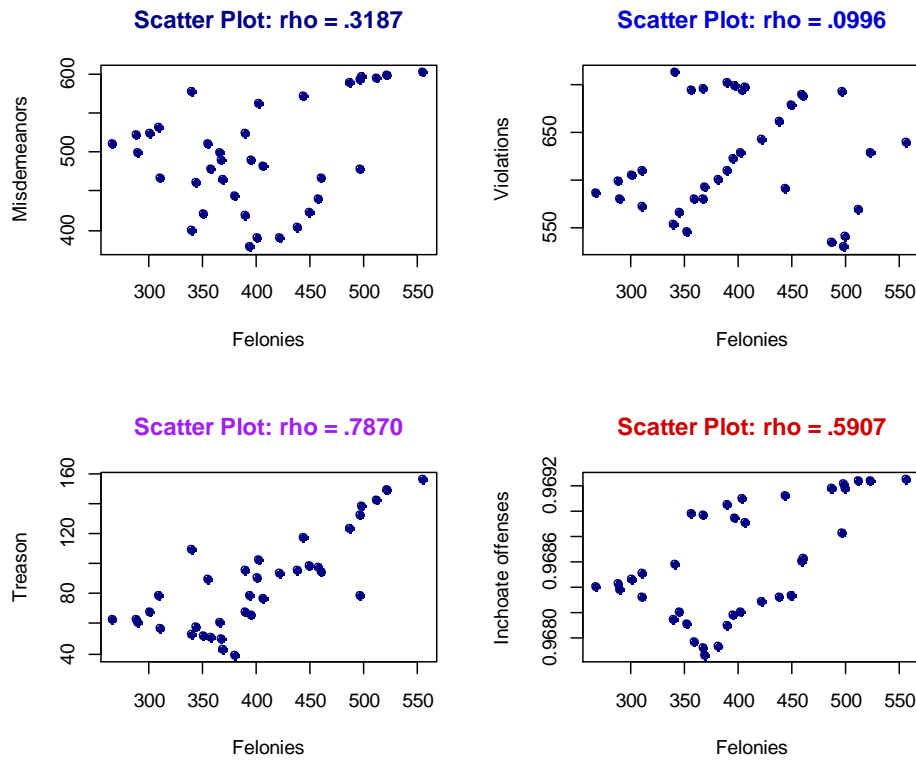


Figure 21: Scatter plot of number of suspects of felonies versus each of violations, treason, and inchoate crimes.

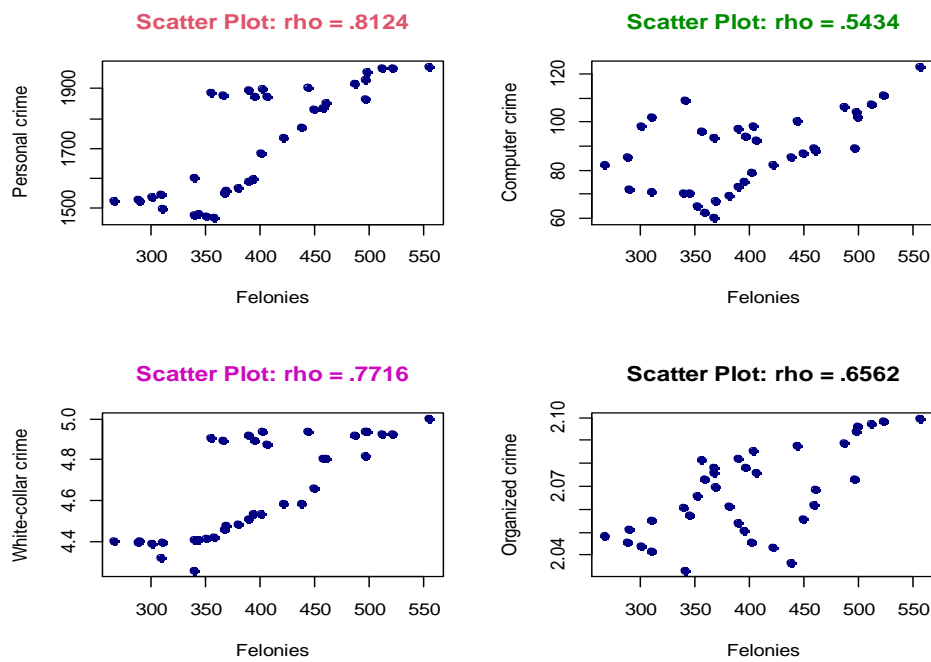


Figure 22: Scatter plot of number of suspects of felonies versus each of personal, computer, white-collar, and organized crimes.

Plots 21 and 22 are the evidences of the nature of inter-connection among the variables. The plots also show the degree of correlation apart from the visual expression observed in the graphics.

4.3.2 Obtaining the number of PC to be retained

Obtaining the number of principal components to be retained in this study is never a tedious task since the use of machine is employed. The results of the percentage proportion of variance are presented in Table 15.

Also, auto-generated plot of the principal components is displayed in Figure 23 from where the percentage contributions of each of the first two PC are shown.

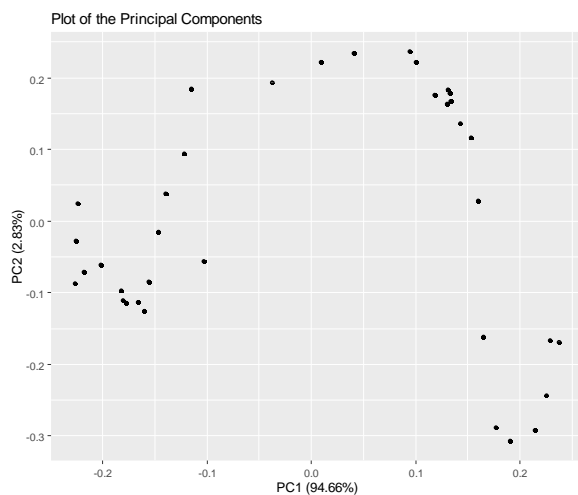


Figure 23: Scatter plot of the first two principal components

4.3.3 Obtaining the plot for PC

The results of the principal components are presented in Table 16 where the degrees of interconnections among the principal components are detailed.

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X
October 05-07, 2024

Table 15: Proportion of variance for the extraction of PC

Importance of components:									
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Standard deviation	389.5153	67.37917	53.55289	30.11307	14.69798	4.86662	0.04837	0.004425	8.73e-05
Proportion of variance	0.9466	0.02833	0.01789	0.00566	0.00135	0.00015	0.00000	0.00000	0.00e+00
Cumulative variance	0.9466	0.97495	0.99285	0.99850	0.99985	1.00000	1.00000	1.00000	1.00e+00

Source: Author's computation (2022)

Table 16: Principal components

Rotation: $N \times K = 9 \times 9$									
Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Felonies	0.15502	-0.08663	-0.68165	0.65871	0.25749	-0.05992	-0.000002	0.000095	0.0000016
Misdemeanors	0.08867	-0.76039	0.50482	0.31759	0.23096	0.06993	-0.000290	0.000167	-0.000001
Violations	0.05600	0.616158	0.51592	0.58662	0.05349	0.063605	0.000588	-0.000004	0.0000000
Treason and espionage	0.06507	-0.16145	-0.06962	0.26641	-0.87736	0.352283	0.002026	-0.000021	-0.000001
Inchoate offense	0.00000	-0.00000	0.000002	-0.00000	-0.00000	-0.000000	0.001196	0.002384	0.999996
Personal crime	0.97969	0.060245	0.034438	-0.18801	0.003865	0.0052819	-0.000803	-0.000052	0.000000
Computer crime	0.03075	-0.07033	0.091073	0.121518	-0.32818	-0.929161	0.001825	-0.000433	-0.000011
White-collar crime	0.00059	-0.00006	-0.000152	-0.001164	0.002372	0.0009139	0.992772	0.119966	-0.001474
Organized crime	0.00003	-0.000113	-0.000039	-0.000072	0.000512	0.0005137	0.119968	-0.992775	0.0022240

Source: Author's computation (2022)

5. Findings and conclusions

5.1 Findings

The dataset of a total number of three hundred and thirty thousand, seven hundred and twenty-one (330721) was collected on nine different crimes. One of the findings is that crimes involving murder, severe assault, rape, and robbery as well as burglary, larceny, vehicle theft, arson, and so on happen to be the most occurring crimes within study areas over the periods spanning January, 2019 through December, 2021. Meanwhile, treason and espionage has the least number of suspects.

Many youths aged between 18 and 47 get involved mostly in many of the crimes. And, most of them are males. It is established empirically that most of the suspects are either divorced, widowed or single. The higher percentage of these suspects fall into these categories. Also, it is established that none of the six states takes up to 20% of the crime in each scenario. This shows that the number of suspects committing an offence is even distributed in all the states considered.

The datasets on felonies, misdemeanors, violations, treason and espionage, as well as computer crime are close to normal distribution while those datasets on inchoate offence, personal crime, white-collar crime and organized crime do not follow normality. Box-Cox transformation is employed to handle the situation of non-normality of the datasets. However, the method is applied on only those that are not close to normality.

Stationarity was checked on the datasets and it's discovered that none of the datasets is stationary. Because the assumption is not as important as expected before running the PC analysis, that's why less attention is paid on that assumption. While employing the method of correlation matrix to check for the existence of multicollinearity, it's discovered that at least three variables are inter-connected. Results are presented in R.

The application of Ljung-Box test on checking for autocorrelation on the dataset result to existence of serial correlation on each of the datasets. The use of Box plot also reports the non-existence of outlier in the dataset used. Before applying PCA, the linearity check was performed with the use of scatter plots. More than half of the variables considered show that there exists linear relationship. Having applied auto-generated plot for the PC, only the first two PC are reported, indicating that the first two are most significant.

Though checking some basic assumptions is necessity, some of them are not that required for the application of principal components algorithm. The application of shaapiro-wilk statistical test is widely used for normality amongst other methods. In a bid to handle the non-normality, only the datasets for the four of them are transformed for subsequent use.

The instability observed in our dataset does not have anything to do with with the application of principal component analysis. From (11), the degree of relationship between misdemeanors and felonies is very high, indicating that there is a very connection among the variables.

Serial correction is also part of the weak assumptions for principal component to triumph. Whether the dataset follow a particular distribution or not has nothing to do with existence of serial correlation.

The results in Table 15 are the evidences to suggest that the first principal component carries about 95% of the variations while the second one takes about 3%. Thus, both the first and second take approximately 98% variations.

Also, our results in Table 16 show the degrees of association between the principal components and the original variables. This also establishes that the first PC is strongly correlated with personal crime. The first component increases with increasing personal crime. It is interpreted in such as way when the PC increases, the personal crime also increases and vice-versa. In fact, we can conclude that based on the correlation of 0.97969 that this principal component is primarily a measure of personal crime, it follows that personal crime rate is therefore empirically established as the most occurring crime within the geopolitical zone of northwest Nigeria.

The second principal component, however, confirms that misdemeanors has a negative correlation of 0.76039 indicating that as time goes on, misdemeanors crime tends to decrease at the rate of 76%. The positive value of 0.61615 obtained for violations indicates a very high positive relationship, meaning that as time goes on, there is likely for increase in violation crime to exist.

5.2 Conclusions

The study concludes that personal crime was the most occurring crime in North-west Nigeria while treason and espionage was the least occurring crime in the region. From the findings, it's also revealed that occurrence of one crime influences the occurrence of the other.

References

- Agency Report (2022) Abuja, Lagos record highest crime rate in Nigeria in 2016 – NBS. Retrieved 31 July, 2022 from <https://www.premiumtimesng.com/news/top-news/233908-abuja-lagos-record-highest-crime-rate-in-nigeria-in-2016-nbs.html>.
- Antony, N.; Bernard, W; Thomas, J.; Clarke, D.; Donald, C.; Thomas, H.; David, A.; Edge, I.; David, G. (2022) "Crime". Encyclopedia Britannica, 12 Nov. 2020, <https://www.britannica.com/topic/crime-law>. Accessed 29 July 2022.
- Britannica, T. Editors of Encyclopaedia (2019, November 19) Organized crime. Encyclopedia Britannica. <https://www.britannica.com/topic/organized-crime>.
- Bothos, J.M.A. and Thomopoulos, S.C.A. (2016) Factors influencing crime rates: an econometric analysis approach. Available at <https://www.researchgate.net/publication/303323965>

- Catherine F., (2022) Crime: Definition & Types. <https://study.com/academy/lesson/crime-definition-types.html>.
- Caldwell, M.; Andrews, J.T.A.; Tanay, T. and Griffin, L.D. (2020) AI-enabled future crime. *BMC Crime Science*, 9:14, Pp. 1-13.
- Crossman, A. and Ashley, R. (2021) 7 Different Types of Crimes. Retrieved from <https://www.thoughtco.com/types-of-crimes-3026270>.
- David S., (2019) <https://www.open.edu/openlearn/society-politics-law/criminology/what-crime>.
- ENACT (2018) Overview of serious and organized crime in Africa. The European Union funded project -analytical report on crime in Africa.
- Estevez-Soto, P.R. (2021) Crime and Covid-19: effect of changes in routine activities in Mexico city. *Open access crime sci.*, 10:15, Pp. 1-17.
- General Categories of Crime. (2014, December 17) Retrieved from <https://study.com/academy/lesson/general-categories-of-crime.html>.
- Isiaka, A. A. and Okaphor, E. F. (2018) Concept of crime in the administration of penal justice in Nigeria: an appraisal. *Nnamdi Azikiwe University Journal of International Law and Jurisprudence*, 9(1), 246-251.
- Jaclyn, T. and Jose, K. (2022) Criminality in Nigeria - The Organized Crime Index. (2022). Retrieved 31 July 2022, from <https://ocindex.net/country/nigeria>.
- Junger, M.; Wang, V. and Schlomer, M. (2020) Fraud against businesses both online and offline: crime scripts, business characteristics, efforts, and benefits. *Crime sci.*, 9:13, Pp. 1-15.
- Leggitt, T., Frate, A.A., Pietschmann, T., Kunnen, S., and Kagawa, A. (2005) Crime and development in Africa. An official report of the United Nations Office on Drugs and crime.
- Matthew, A. M. (2018) A Sociological Understanding of Deviance, Social Control, and Crime. Retrieved May 23, 2020, from <https://brewminate.com/a-sociologicalunderstanding-of-deviance-social-control-and-crime/>
- Oliveira, M. (2021) More crime in cities? On the scaling laws of crime and the inadequacy of per capital rankings - a cross-country study. *Crime Science*, 10:27.
- Robert, J.; Fischer, D.C.; and Walters, (2019) MI5: British Security Service Operations, 1909–1945: The True Story of the Most Secret counter-espionage Organisation in the World. Pen and Sword.
- Schur, E. (1965) Crimes without Victims: Deviant behaviour and public policy. Englewood Cliffs NJ: Prentice-Hall.
- Schur, E.M. and Bedau, H.A. (1974) Victimless Crimes: Two Sides of a Controversy. Englewood Cliffs: Prentice-Hall.
- Scott, G. (2022) Protecting Yourself Against Personal Crimes. <https://www.grabellaw.com/protecting-yourself-against-personal-crimes.html>

- Shang, C. and You, F. (2019) Data analytics and machine learning for smart process manufacturing: recent advances in the big data era. ScienceDirect Elsevier Engineering, Vol. 5, Issue 6, Pp. 1010-1016.
- Sowmya, T. (2014) Crime: A Conceptual Understanding. Indian Journal of Applied Research 4(3):196-198.
- Williamson, R. (1957) Crime in South Africa: some aspects of causes and treatment. Journal of Law and Criminology, Vol. 48, Issue 2, 185-192.
- Zhou, Q. and Mathuthu, N. (2019) Crime in South Africa. Journal of Crime, Law, and Social Changes in South Africa., Vol. 1, Issue 1.

**IMPACT OF TRAJECTORY LENGTH ON SYBIL ATTACK DETECTION IN
VEHICULAR NETWORKS**

BENADLA Sarra

Dr., Higher School of Management, Department of first cycle, TLEMCEN ALGERIA

DEBBAL Mohammed

Dr., Ain Temouchent University, Science and Technology Faculty, Department of of Electronics and
Telecommunications, AIN TEMOUCHENT ALGERIA

BENADLA Nadjat

Dr., Abou Bakr Belkaid University, Technology Faculty, Department of Electronic, TLEMCEN ALGERIA

ABSTRACT

As our reliance on transportation systems grows, the widespread use of vehicular networks brings significant challenges, especially in mitigating Sybil attacks. In a Sybil attack, a malicious vehicle broadcasts multiple false identities to deceive the network, leading to issues such as traffic mismanagement and false event reporting. To address this, researchers have proposed using vehicle trajectories as location proofs, based on data collected by roadside units (RSUs) during vehicle journeys. These trajectories are critical for verifying vehicle identities and ensuring the integrity of information shared within the network.

However, the predefined length of these trajectories can limit their effectiveness in detecting Sybil attacks. In this paper, we specifically analyze how varying the trajectory length impacts the accuracy and reliability of Sybil attack detection systems. By studying different trajectory lengths, we assess their influence on the system's performance in terms of detection accuracy, false positive and false negative rates, and overall computational efficiency.

Our findings suggest that there is an optimal trajectory length that maximizes detection accuracy while minimizing false positives and computational costs. Shorter trajectories may lead to higher false negatives, whereas longer trajectories can increase system overhead. This study offers valuable insights for enhancing vehicular network security by refining the use of vehicle trajectories for Sybil attack detection. Ultimately, our work contributes to the development of more secure and efficient vehicular communication systems, addressing a critical threat to the future of intelligent transportation networks.

Keywords: Sybil attack, Vehicular Networks, Security, Trajectory.

ECOFRIENDLY SYNTHESIS OF MAGNETIC COMPOSITES LOADED ON RICE HUSKS FOR ACID BLUE 25 DECONTAMINATION: ADSORPTION KINETICS, THERMODYNAMICS, AND ISOTHERMS

Hafiza Komal Naeem

Superior Group of Colleges, Campus for University Program, Mandi Bahaudin, Pakistan)

ABSTRACT

Addressing the growing need for methods for ecofriendly dye removal from aqueous media, this study explores the potential of rice husks coated with iron oxide (Fe₂O₃@RH composites) for efficient Acid Blue 25 decontamination. The adsorption potential of Acid Blue 25 is analyzed using raw rice husks and Fe₂O₃ nanoparticles in the literature, but their enhanced removal capacity by means of Fe₂O₃@RH composites is reported for the first time in this study. Fe₂O₃@RH composites were analyzed by using analytical techniques such as TGA, SEM, FTIR, BET, and the point of zero charge (pH(PZC)). The Acid Blue 25 adsorption experiment using Fe₂O₃@RH composites showed maximum adsorption at an initial concentration of Acid Blue 25 of 80 ppm, a contact time of 50 min, a temperature of 313 K, 0.25 g of Fe₂O₃@RH composites, and a pH of 2. The maximum percentage removal of Acid Blue 25 was found to be 91%. Various linear and nonlinear kinetic and isothermal models were used in this study to emphasize the importance and necessity of the adsorption process. Adsorption isotherms such as the Freundlich, Temkin, Langmuir, and Dubinin–Radushkevich (D–R) models were applied. The results showed that all the isotherms were best fitted on the data, except the linear form of the D–R isotherm. Adsorption kinetics such as the intraparticle kinetic model, the Elovich kinetic model, and the pseudo-first-order and pseudo-second-order models were applied. All the kinetic models were found to be best fitted on the data, except the PSO model (types II, III, and IV). Thermodynamic parameters such as DG° (KJ/mol), DH° (KJ/mol), and DS° (J/K*mol) were studied, and the reaction was found to be exothermic in nature with an increase in the entropy of the system, which supported the adsorption phenomenon. The current study contributes to a comprehensive understanding of the adsorption process and its underlying mechanisms through characterization, the optimization of the conditions, and the application of various models. The findings of the present study suggest practical applications of this method in wastewater treatment and environmental remediation.

Keywords: Toxic Dye Adsorbent; Iron Oxide; Rice Husk; Acid Blue 25; Fe₂O₃@Rh Composites

**SIGNIFICANCE OF HEAT SOURCE/SINK ON
ELECTROMAGNETOHYDRODYNAMICS NATURAL CONVECTION FLOW
WITH ELECTROOSMOTIC EFFECT**

Usman S. Rilwan

Department of Mathematics, Ahmadu Bello University 1, Zaria, Kaduna State, 810107, Nigeria.

Michael O. Oni

Department of Mathematics, Ahmadu Bello University 1, Zaria, Kaduna State, 810107, Nigeria.

ABSTRACT

This work carried out a study on the role of heat source/sink on transient electromagnetohydrodynamics (EMHD) free (natural) convection flow in a vertical micro-channel with electroosmotic effect. The governing energy and momentum equations are converted from partial differential equation (PDE) into ordinary differential equation (ODE) using Laplace transformation technique in order to obtain fluid temperature and velocity in Laplace domain. The Riemann sum approximation method was applied for arriving at the semi-analytical solutions of the temperature distribution and velocity profile. Hence a MATLAB program was coded to study the influence of Prandlt number (Pr), Hartmann number (Ha), electric field strengths on x and z directions (Ex and Sz) and Grashoff number (Gr) on fluid velocity, temperature, skin-friction and mass flow in terms of line graphs. Result shows that the role of heat source/sink parameter has significant impact in the temperature distribution and velocity of the flow. Finally, it is also observed that the governing parameters contribute to the flow formation.

Keywords: EMHD; EOF; Natural Convection; Heat Source/Sink

**ENERGY STORAGE APPLICATION OF BOROPHENE COATED COPPER FOIL
ELECTRODES**

Mehmet BAY

Dr., Eskişehir Technical University, Porsuk Vocational School, Department of Electronics and Automation

ORCID ID: 0000-0001-6447-6460

ABSTRACT

Borophene, one of graphene-related materials, has attracted considerable attention due to its material properties such as surface energy, surface tension, capacitance, and tensile strength. Additionally, borophene has many device applications, including energy storage and supercapacitors, making it a subject of research and development. A range of synthesis techniques, including chemical etching, mechanical exfoliation, physical vapor deposition (PVD), and chemical vapor deposition (CVD), have been explored. CVD is a versatile method with many parameters such as pressure, gas flow rate, temperature range, reaction periods, etc. These parameters can be optimized to grow various two-dimensional materials. In this study, 1.2 cm diameter copper foil disc electrodes were coated with borophene using the chemical vapor deposition technique. Microcharacterizations were conducted using optical microscopy (OM), scanning electron microscopy (SEM), X-ray diffraction (XRD) analysis, atomic force microscopy (AFM), energy-dispersive X-ray spectroscopy (EDX), and Raman spectroscopy to examine the borophene structures on copper foil electrodes. After these analyses, borophene-coated copper electrodes were used for device fabrication of energy storage. A 1 M NH₄ (ammonium) soaked membrane was used as a separator between two borophene-coated copper foil electrodes. Performance tests were conducted and determined, including a specific capacitance of 68.6 mF/cm at a scan rate of 5 mV/s. After 1250 cycles, the retention of the charge capacity was found to be 90%. The current density was found to be 2.2 A/g.

Keywords: Borophene, Supercapacitor, Chemical Vapor Deposition.

**ATIK SU ARITIM SİSTEMİNDEKİ KOAGÜLASYON SÜRECİ İÇİN BİTKİ BAZLI
BİYOMALZEMELERİN POTANSİYELİ: FECL₃'E ALTERNATİF OLARAK
OPUNTIA FICUS-INDICA**

THE POTENTIAL OF PLANT-BASED BIOMATERIALS FOR THE COAGULATION
PROCESS OF WASTEWATER TREATMENT SYSTEMS: OPUNTIA FICUS-INDICA AS
AN ALTERNATIVE TO FeCl₃

Yaşar KARADAL

Seval Kablo, Denizli, Türkiye.

ORCID ID: 0000-0001-8922-3187

Beyza KAHRAMAN

Seval Kablo, Denizli, Türkiye.

ORCID ID: 0009-0008-0158-9132

ÖZET

Doğal koagülantlar, bol miktarda bulunmaları, çevre dostu ve biyolojik olarak parçalanabilir olmaları, toksik etkilere sahip olmamaları, düşük maliyetleri, yerel olarak temin edilebilir olmaları ve daha az çamur üretebilmeleri gibi avantajları sayesinde atık su arıtımında demir(III) klorür (FeCl₃) gibi inorganik koagülantlara göre daha sürdürülebilir koagülant kaynaklarıdır. Bu çalışmada bakır tel çekme proseslerinde kullanılan atık bor yağlı emisyon sızılarını, bakır katotların sülfirik asit banyolarından kaynaklanan atık suları, ters ozmoz sistemlerinden çıkan kireç içerikli atık suları ve kalaylama prosesinde bakır tellerin temizlenmesi sonucunda oluşan atık suların arıtımında kullanılan kimyasal bir koagülant olan FeCl₃ yerine *Opuntia ficus-indica* meyvesinin kabuğundan elde edilen zamksı yapının biyokoagülant olarak değerlendirilmesi ve FeCl₃ ile karşılaştırılması incelenmiştir. Bu atık sular, çevresel açıdan değerlendirildiğinde, ağır metal, kireç, organik ve inorganik maddeler içermesi nedeniyle su ve toprak kirliliğine yol açabilmektedir. Bu tür atıkların çevreye salınımının önlenmesi, sürdürülebilir üretim süreçlerinin geliştirilmesi ve çevresel yasal düzenlemelere uygunluğu kritik öneme sahiptir. Çalışmanın devamında biyokoagülant için optimum koagülant dozajı, suyun bulanıklığı ve çamur miktarı analizleri yapılmış ve FeCl₃ ile karşılaştırılmıştır. Biyokoagülantın yapısını ve atık su kirleticileriyle etkileşimini karakterize etmek için Fourier Dönüşümlü Kızılötesi Spektroskopisi (FTIR) yöntemi kullanılmıştır. Bulanıklığın gidiremi için optimum koşul, pH 10'da 14 mg/L'lik bir koagülant dozu olarak belirlenmiştir. Optimal değerler için biyokoagülant ve FeCl₃ sırasıyla bulanıklık için %89 ve %77 maksimum giderim sağlanmıştır. Biyokoagülantın koagülasyon mekanizmasının adsorpsiyon, FeCl₃'ün ise yük nötralizasyonu olduğu sonucuna varılmıştır. Elde edilen sonuçlardan sanayi atık suyu arıtımında daha sürdürülebilir bir kaynak olarak FeCl₃ yerine alternatif bir koagülant olarak kullanılabileceğini göstermiştir.

Anahtar Kelimeler: *Opuntia ficus-indica*, atık su arıtma, biyokoagülant, sürdürülebilirlik.

ABSTRACT

Natural coagulants, due to their abundance, eco-friendliness, biodegradability, non-toxic effects, low cost, local availability, and the ability to produce less sludge, present a more sustainable alternative to inorganic coagulants like iron(III) chloride (FeCl_3) in wastewater treatment. In this study, the gum-like structure obtained from the peel of the *Opuntia ficus-indica* fruit was evaluated as a bio-coagulant in the treatment of wastewaters such as waste oil emulsions used in the copper wire drawing processes, wastewaters from sulfuric acid baths used in copper cathode processes, lime-containing wastewater from reverse osmosis systems, and wastewaters produced from the cleaning of copper wires during the tinning process, comparing it to the chemical coagulant FeCl_3 . From an environmental perspective, these wastewaters may cause water and soil pollution as they contain heavy metals, lime, organic, and inorganic substances. Preventing the release of such wastes into the environment, developing sustainable production processes, and ensuring compliance with environmental regulations are of critical importance. In the following phase of the study, analyses of optimal coagulant dosage, water turbidity, and sludge volume for the bio-coagulant were conducted and compared with FeCl_3 . Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize the structure of the bio-coagulant and its interaction with wastewater contaminants. The optimal condition for turbidity removal was determined to be a coagulant dosage of 14 mg/L at pH 10. Under optimal conditions, the bio-coagulant and FeCl_3 achieved maximum turbidity removals of 89% and 77%, respectively. It was concluded that the coagulation mechanism of the bio-coagulant was adsorption, whereas for FeCl_3 , it was charge neutralization. The results demonstrated that the bio-coagulant could serve as an alternative coagulant to FeCl_3 , providing a more sustainable source for industrial wastewater treatment.

Keywords: *Opuntia ficus-indica*, wastewater treatment, bio-coagulant, sustainability.

**HAVALANDIRMA SİSTEMLERİNDE ELEKTRONİK KONTROLÇÜLER İÇİN
UYARLAMALI DENETLEYİCİ TASARIMI**
ADAPTIVE CONTROLLER DESIGN FOR ELECTRONIC CONTROLLERS IN
VENTILATION SYSTEM

Enes BİGA

Ege University, Graduate School of Natural and Applied Sciences, Department of Electrical and Electronics
Engineering

ORCID ID: 0009-0005-6313-5724

Musa ALCI

Prof. Dr., Ege University, Faculty of Engineering, Department of Electrical and Electronics Engineering

ORCID ID: 0000-0002-5382-3460

ÖZET

Bu çalışma kapsamında, günümüz havalandırma sistemlerinde kullanılan fan motorlarının kontrol algoritmalarında yaygın olarak kullanılan klasik Oransal-Integral-Türev (PID) denetleme yöntemine alternatif olarak değişken sistem dinamiklerine uyum sağlayabilen ve yapay zeka alt dallarından biri olan pekiştirmeli öğrenme tabanlı uyarlamalı bir denetleyici kullanılarak sistemin kararlı ve sürekli rejime daha hızlı ulaşmasını sağlamak, aynı zamanda da bu kontrol yöntemi ile sistemin enerji verimliliğinin artırılması amaçlanmaktadır. Bu çalışmada bir kanal ve bir fan ile kurgulanmış taze hava kanalında kullanılan elektronik kontrol cihazlarına programlanmış olan sistem modeline bağımlı klasik PID kontrol algoritmalarının yerine havalandırma kanalındaki farklı statik basınç kayıp değerleri için sistemin uygun ve kararlı bir şekilde çalışabilmesini sağlayacak sistem modelinden bağımsız çalışabilen uyarlamalı bir denetleyici tasarımı yapılması ve elektronik kontrol cihazlarına programlanması hedeflenmiştir. Çalışma gerçekleştirilirken, havalandırma sistemlerinde kullanılan bir fanın debi-basınç eğrilerinden elde edilmiş veriler MATLAB ortamına aktarılmış, bu ortamda oluşturulmuş oransal bir kontrol algoritmasının kazanç parametreleri bu fan verilerini kullanarak pekiştirmeli öğrenme yöntemi ile eğitilmiştir. Yapılan benzetim çalışmalarında tasarlanan kontrolcünün kazanç parametrelerinin, farklı statik basınç değerleri karşısında dinamik olarak değiştiği, sistemi istenilen hedef debi değerine hızlı bir şekilde ulaştırdığı ve sistemin sürekli bir rejimde çalışmasını sağladığı gözlemlenmiştir. Bu çalışma doğrultusunda yapılan benzetim çalışmaları ile önerilen alternatif uyarlamalı denetleyicinin havalandırma sistemlerinde bulunan fan motorlarının kontrolünde kullanımının, aynı fan verileri kullanılarak kazanç parametreleri sabit klasik PI kontrolcü ile denetimine kıyasla % 6'ya kadar enerji tasarrufu sağlandığı sonucuna varılmıştır.

Anahtar kelimeler: Yapay Zeka, Adaptif Kontrolcü, Pekiştirmeli Öğrenme, Enerji Verimliliği.

ABSTRACT

Within the scope of this study, as an alternative to the classical Proportional-Integral-Derivative (PID) control method, which is widely used in the control algorithms of fan motors used in today's ventilation systems, it is aimed to ensure that the system reaches the stable and continuous regime faster by using a reinforcement learning-based adaptive controller, which can adapt to variable system dynamics and is one of the sub-branches of artificial intelligence, and at the same time to increase the energy efficiency of the system with this control method. In this study, instead of the classical PID control algorithms that are dependent on the system model, which are programmed to the electronic control devices used in the an air duct constructed with a duct and a fan, it is aimed to design an adaptive controller that can work independently from the system model and programmed to the electronic control devices to ensure that the system can operate appropriately and stably for different static pressure loss values in the ventilation duct. During the study, the data obtained from the flow-pressure curves of a fan used in ventilation systems are transferred to MATLAB environment, and a proportional control algorithm created in this environment is trained by reinforcement learning method using this fan data with gain parameters. In the simulation studies, it is observed that the gain parameters of the designed controller change dynamically against different static pressure values, the system reaches the desired target flow rate value quickly and the system operates in a continuous regime. With the simulation studies carried out in line with this study, it is concluded that the use of the proposed alternative adaptive controller in the control of fan motors in ventilation systems provides energy savings up to 6% compared to the control of fan motors with a classical PI controller with constant gain parameters using the same fan data.

Keywords: Artificial Intelligence, Adaptive Controller, Reinforcement Learning, Energy Efficiency.

GİRİŞ

Günümüz endüstriyel kontrol sistemlerinde kullanılan pek çok kontrol yöntemi bulunmaktadır. Bu yöntemler arasında yaygın olarak kullanılan Oransal-İntegral-Türev (PID) kontrol yöntemi (Müftü, 2023; Kocakaya, 2023; Yavuzsoy, Sargın, Yaren ve Kızır, 2023); havalandırma sektörü başta olma üzere elektronik kontrol cihazları, mekanik sistemler, hidrolik-pnömotik sistemler gibi kontrol-otomasyon sistemlerinde kullanılan bir denetleme mekanizmasıdır. Kontrol sisteminin düzgün ve kararlı çalışabilmesi için PID denetleyici performansını etkileyen temel parametrelerin en uygun biçimde belirlenmesi önem arz etmektedir. Bu parametrelerin belirlenmesinde sık kullanılan klasik yöntemler mevcuttur. Fakat, gelişen sistemlerin de etkisiyle günümüz kontrol algoritmalarının bu sistemleri istenilen rejim ve sürede kontrol etmesi karmaşık bir hale gelmiştir. Bu durum, PID parametrelerinin klasik yöntemler ile belirlenmesini zorlaştırmış ve farklı dış etmenler altında

bu parametrelerin optimize edilmesi ihtiyacını doğurmuştur. Bir diğer yandan farklı denetleyicilerin de ele alınması ihtiyacını gündeme getirmiştir.

Bu çalışmada, bir kanal ve bir fan ile kurgulanmış bir havalandırma sisteminde kullanılan elektronik kontrol cihazlarına programlanmış olan klasik PID kontrol algoritmasına alternatif olarak havalandırma kanalındaki farklı karşı toplam statik basınç kayıp değerleri için sistemin dinamiklerine uyum sağlayacak yapay zeka alt dallarından olan pekiştirmeli öğrenme tabanlı uyarlamalı bir denetleyici tasarımı yapılması ve fan kontrolünde bu denetleyici algoritmasının kullanılması hedeflenmiştir. Bu kapsamda bilimsel yazın incelemesi yapıldığında; Budak, Sungur ve Durdu (2022), yaptıkları çalışmada MATLAB ortamında bir sıvı tankı modellemiş ve sıvı seviye kontrolü için pekiştirmeli öğrenme yöntemini önermişlerdir. Yaptıkları benzetimde pekiştirmeli öğrenme algoritmalarından TD3 (ikiz-gecikmeli derin deterministik politika gradyanı) ve DDPG (derin deterministik politika gradyanı) algoritmalarını kullanarak tanktaki sıvı seviyesini kontrol etmişlerdir. Önerdikleri sistemin performansını kıyaslamak için aynı zamanda bir PID denetleyici ile de sıvı seviye kontrolünün benzetimini gerçekleştirmişlerdir. Elde ettikleri bulgular sonucunda önerdikleri yöntemin sistemin geçici durum ile kalıcı durum performansını iyileştirebileceğini ve klasik PID ile karşılaştırıldığında TD3 ve DDPG algoritmalarının kontrol performanslarının daha düzgün ve verimli olduğunu gözlemlemişlerdir. Aydın (2022), yaptığı çalışmada DC motor hız kontrolünü gerçekleştirmek için pekiştirmeli öğrenme tabanlı uyarlamalı PID denetleyici tasarlamış ve bunu gerçek zamanlı bir sisteme uyarlamıştır, tasarımını yaparken pekiştirmeli öğrenme algoritmalarından biri olan Q-Öğrenme algoritmasını kullanmıştır. Elde ettiği sonuçlar doğrultusunda tasarlamış olduğu denetleyici model tabanlı bir klasik PID denetleyiciye yakın sonuçlar verdiğini gözlemlemiş ve karmaşık sistemlerde bu metodun uygulanabileceğini belirtmiştir. Kılıç (2022), yaptığı çalışmada vektör kontrollü asenkron motor sürücülerinde PI hız denetleyicinin parametrelerini pekiştirmeli öğrenme yöntemi algoritmalarından olan TD3 algoritmasını kullanarak optimize etmiştir. Sistemi farklı referans hızlarda ve yük koşulları altında test etmiştir. Elde ettiği sonuçlar arasında TD3 algoritması kullanılarak optimize edilmiş PI denetleyicinin vektör kontrollü asenkron motor sürücülerinde benzetim ortamında yükselme zamanı, yerleşme zamanı, aşım ve sifıra yakın kararlı hal hatası ile yük bozucu etkisi karşısında da iyi bir performans gösterdiğini tespit etmiştir.

Bu çalışma kapsamında bilimsel yazın incelemesi sonucu elde edilen bulgular ve sonuçlar doğrultusunda önerilen alternatif uyarlamalı denetleyici ile sistemin farklı dış etmenlere uyum sağlaması, sistemin kararlı ve sürekli rejime daha hızlı ulaşmasını sağlamak ve bütün bunlara ek olarak bu kontrol yöntemi ile havalandırma sisteminin enerji verimliliğinin artırılması amaçlanmaktadır.

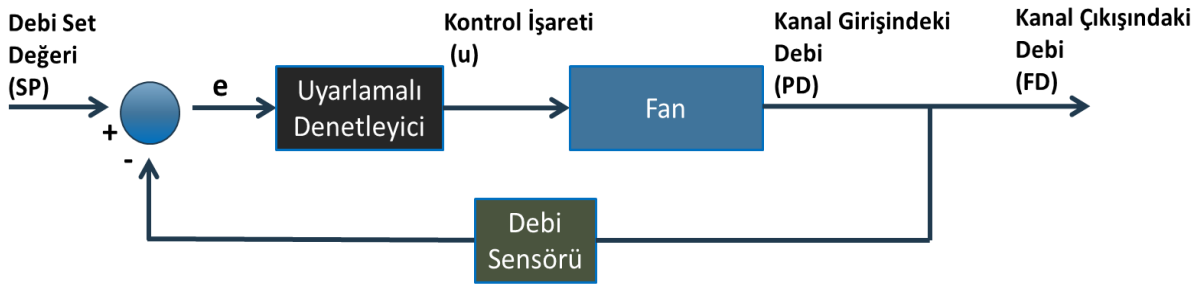
YÖNTEM

Günümüz havalandırma ve iklimlendirme sektöründe kullanılan sistemlerin ana kontrolcüsü, otomasyon sistemlerinin vazgeçilmezi olan PLC' lerdir. (Sugarman, 2020) Bu cihazlar

programlayıcısı tarafından oluşturulan senaryo ve algoritmalar doğrultusunda sistemi kontrol edecek sinyaller üretmektedir. Mevcut durumda bu PLC' ler de kullanılan PID algoritmalarına ait parametreler klasik yöntemlerle belirlenmektedir. (Gidemen ve Fırat, 2015) Bunun yanı sıra deneme yanılma metodu iklimlendirme ve havalandırma sektöründe en sık kullanılan metottur. Deneyin yapıldığı zamandaki şartlara bağlı olarak uygun bir çıktı verebilir. Ancak bu yöntemin kullanımı tecrübeye dayalıdır, doğruluğunun bilimsel bir alt yapısı bulunmamaktadır. Sistemin tüm dinamiklerini dikkate alan uygun parametreler yakalanmamış olabilir. Diğer metotlar ise parametre hesaplamaları tablolar ile verilmektedir ancak kesin sonuçlar vermemektedir. Hesaplanan parametre değerleri ancak sistemin başlangıç değerleri olarak kullanılabilir. (Akay, 2006; Doğan, 2006) Ayrıca deneme yanılma metodunda da olduğu gibi, herhangi bir sistemin değişen koşullar altında dinamik olarak PID parametre optimizasyonunu gerçekleştiremezler.

Bu çalışma kapsamında PLC ile kontrol edilen havalandırma cihazlarında klasik PID denetleyici algoritmaları yerine yenilikçi yaklaşım olan yapay zekâ algoritmalarından yararlanılarak uyarlamalı bir denetleyici tasarımı yapılmış ve tasarlanan bu denetleyici MATLAB ortamında benzetim çalışmaları ile desteklenmiştir. Bu denetleyici tasarlanırken makine öğrenmesi alt dallarından pekiştirmeli öğrenme yöntemi ele alınmıştır.

Bir havalandırma cihazı; temelde (i) fan, (ii) hava kanalı, (iii) debi sensörü olmak üzere üç ana donanımdan oluşmaktadır. Çalışma kapsamında tasarlanan uyarlamalı denetleyici algoritması ile sistemin kanal çıkışında bulunan bir basınç fark sensör verisiyle istenilen debi kıyaslanarak fanın devir ve debi kontrolü yapılacaktır. Bu algoritma ile kanaldaki farklı dış statik basınç değerine bağlı olarak fanın kontrolünü gerçekleştirilecektir. Sistemin çalışmasını gösteren blok diyagramı Şekil 1'de gösterilmiştir.



Şekil 1. Havalandırma cihazı ve kontrolünü gösteren blok diyagramı

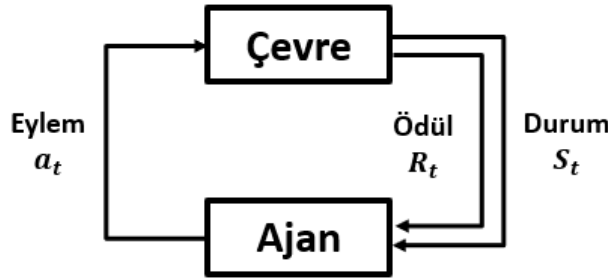
Bu çalışma kapsamında ele alınan metodun avantajı klasik kontrol yöntemlerine kıyasla bir sistem modeline ihtiyaç duyulmamasıdır. Makine öğrenmesi alt dallarından olan pekiştirmeli öğrenme yöntemi modelden bağımsız çalışabilen algoritmalar barındırmaktadır. Pekiştirmeli öğrenme metodu, bir ajanın kendi eylem ve deneyimleri ışığında edindiği geri bildirimleri kullanarak maksimum ödüle ulaşmayı amaçlamaktadır. Pekiştirmeli öğrenme algoritmaları çevrim bitince veya çevrim boyunca her durum geçişi için değer fonksiyonunu güncellemektedir. Güncellenen değer fonksiyonları ışığında hatanın mutlak değerinde azalma

gözleniyorsa ajan pozitif ödüllendirilirken, tersi durumda ise negatif ödüllendirilmektedir. (Jang, Sun and Mizutani, 1997; Sutton and Barto, 2011)

Pekiştirmeli öğrenme algoritmaları Tablo 1’de gösterilmiştir. Pekiştirmeli öğrenme temel çalışması gösteren diyagram Şekil 2’de verilmiştir.

Tablo 1. Pekiştirmeli öğrenme yöntemi, modele bağımlı ve modelden bağımsız algoritmalar

Pekiştirmeli Öğrenme				
Modelden Bağımsız Algoritmalar			Model Tabanlı Algoritmalar	
Politika Optimizasyonu	Q-Öğrenme	Politika Optimizasyonu-Q-Öğrenme Birleşimi	Öğrenilmiş Model	Verilmiş Model
Politika Gradyanı A2C/A3C PPO TRPO	DQN C51 QR-DQN HER	DDPG TD3 SAC	World Models I2A MBMF MBVE	AlphaZero



Şekil 2. Pekiştirmeli öğrenme temel çalışma diyagramı

Çalışma kapsamında denetleyici tasarımı yapılırken pekiştirmeli öğrenme yöntemlerinden sistem modelinden bağımsız olduğu için Zamansal-fark yaklaşımının bir alt kırılımı olan Q-Öğrenme ve Politika Optimizasyonu algoritmalarından, Derin Q Network (DQN) ve Politika Gradyanı algoritmasının birleşiminden oluşan ve bilimsel yazın taramasında da belirtildiği gibi sürekli uzayda hassasiyetinden dolayı DDPG (Deep Deterministic policy Gradient) algoritması kullanılmıştır. DDPG algoritmasının öğrenme yöntemi Bellman denklemine dayanır. (Lillicrap, Hunt, Pritzel, Heess, Erez, Tassa, Silver and Wierstra, 2015; Li, 2023) Bu denklem, Denklem 1’de gösterilmiştir.

$$Q^\mu(S_t, a_t) = E[(R_t + \gamma Q^\mu(S_{t+1}, \mu(S_{t+1})))] \quad (1)$$

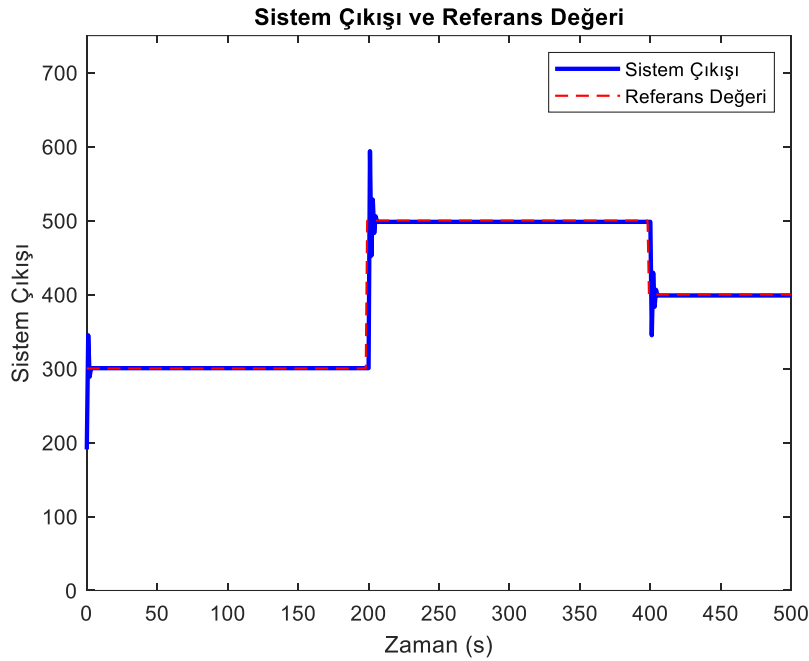
Bu kapsamda benzetim çalışması yapılabilmesi için havalandırma sistemlerinde kullanılan EC (Electronically Commutated) Plug bir fanın debi-basınç eğrilerinden elde edilmiş veriler MATLAB ortamına aktarılmış ve bu ortamda oluşturulmuş oransal bir kontrol algoritmasının

kazanç parametreleri bu fan verilerini kullanarak pekiştirmeli öğrenme yöntemi ile DDPG algoritması kullanılarak eğitilmiştir. Yapılan benzetim çalışmaları sonucunda elde edilen bulgular kaydedilmiştir.

BENZETİM ÇALIŞMALARI

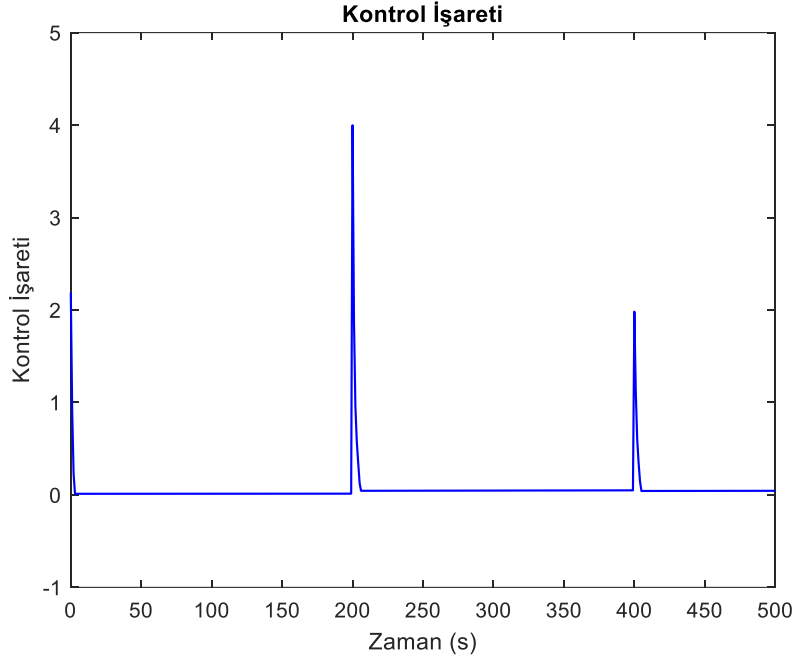
Çalışma gerçekleştirilirken, havalandırma sistemlerinde kullanılan EC Plug fan verileri MATLAB ortamına aktarılmış ve farklı kontrol voltajı karşısında çıkış debilerine göre belirlenmiş kanal ölçülerine karşın basınç değerleri dinamik olarak değişen bir algoritma ile benzetim çalışması kurgulanmıştır.

Öncelikle, MATLAB ortamına aktarılmış fan verileri ile kazanç parametreleri deneme-yanılma metodu ile belirlenmiş klasik PI algoritması ile sistem benzetim çalışması yapılmış, benzetim çalışması 500 saniye boyunca devam etmiş, bu süre zarfında hedef debi değerleri belli aralıklarla değiştirilerek sistem dinamikleri değiştirilmiştir. Benzetim çalışması sonucu elde edilen Debi- Zaman grafiği Şekil-3' te gösterilmiştir.



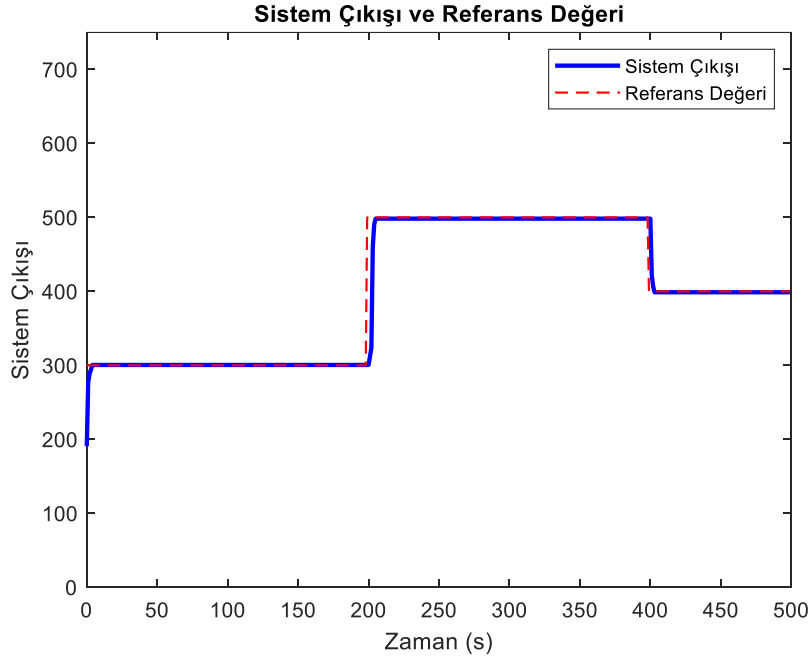
Şekil 3. Kazanç parametreleri sabit klasik PI denetleyici ile kontrolü gerçekleştirilmiş sistemin Debi-Zaman grafiği

Benzetim çalışması sonucu elde edilen kontrol işareti zamana bağlı değişim grafiği Şekil-4' te gösterilmiştir.



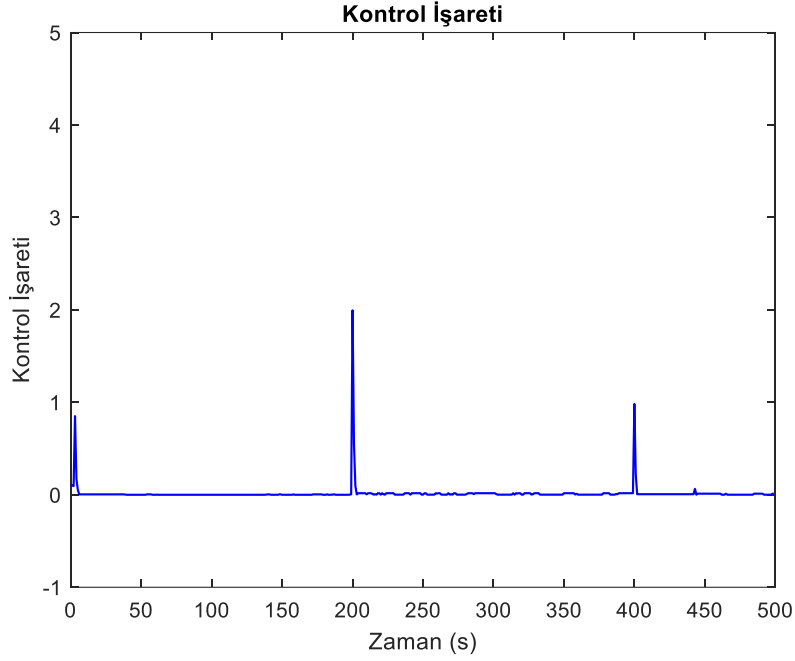
Şekil 4. Kazanç parametreleri sabit klasik PI denetleyici ile kontrolü gerçekleştirilmiş sistemin zamana bağlı kontrol işareti

Daha sonra, aynı fan verileri ile çalışma kapsamında önerilen uyarlamalı denetleyici ile benzetim çalışması yapılmış, 500 saniye boyunca devam etmiş, bu süre zarfında hedef debi değerleri belli aralıklarla değiştirilerek sistem dinamikleri değiştirilmiştir. Benzetim çalışması sonucu elde edilen Debi- Zaman grafiği Şekil-5' te gösterilmiştir.



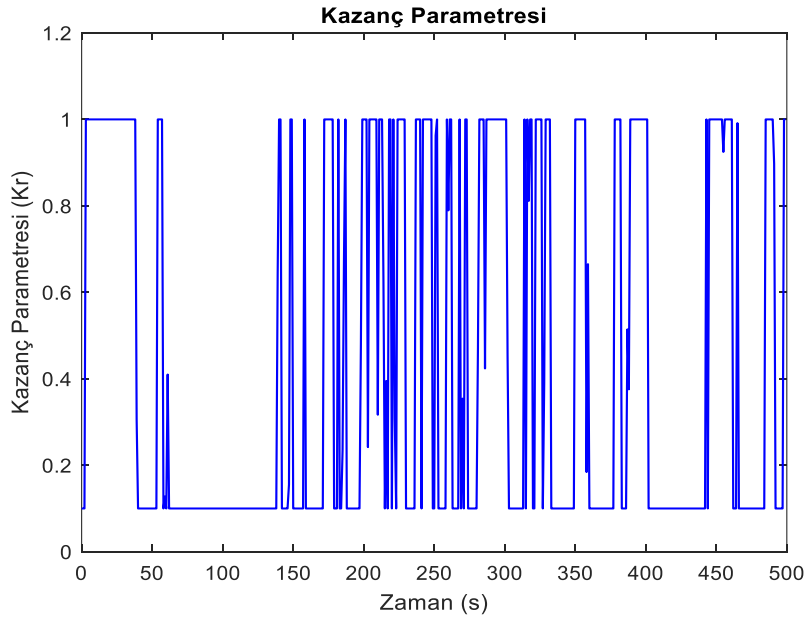
Şekil 5. Kazanç parametresi dinamik olarak değişen uyarlamalı denetleyici ile kontrolü gerçekleştirilmiş sistemin Debi-Zaman grafiği

Benzetim çalışması sonucu elde edilen kontrol işareti zamana bağlı değişim grafiği Şekil-6' da gösterilmiştir.



Şekil 6. Kazanç parametresi dinamik olarak değişen uyarlamalı denetleyici ile kontrolü gerçekleştirilmiş sistemin zamana bağlı kontrol işareti

Uyarlamalı denetleyici kazanç parametresinin zamana bağlı değişim grafiği Şekil-7' de gösterilmiştir.



Şekil 7. Kazanç parametresi dinamik olarak değişen uyarlamalı denetleyici ile kontrolü gerçekleştirilmiş sistemin kazanç parametrelerinin zamana bağlı değişim grafiği

TARTIŞMA VE YORUM

Yapılmış olan iki benzetim çalışması karşılaştırıldığında, çalışma kapsamında tasarlanmış olan uyarlamalı denetleyici ile aynı sistemin kontrolü gerçekleştirilirken sistemin kazanç parametrelerinin dinamik olarak değiştiği, istenilen debi değerine sistemin daha az salınım yaparak ulaştığı, hedef değere hızlı ve kararlı bir şekilde ulaştığı gözlemlenmiştir.

Yapılan benzetim çalışmaları doğrultusunda tasarlanan kontrolcünün gerçek bir havalandırma sistemine entegre edilmesi ve kullanılması sonucunda; klasik PID ile kontrolü gerçekleşen sistemlere kıyasla kazanç parametreleri belirlenmesi için ek bir zaman ihtiyacı olmayacağı, sistemin istenilen debi değerinde sürekli bir rejimde çalışacağı, sistemin daha az salınım ile istenilen debiye ulaştığı ve bu doğrultuda enerji tasarrufu sağlayacağı düşünülmektedir. Bu kanı, yapılan çalışma ile desteklenmiştir.

SONUÇ

Çalışma kapsamında MATLAB ortamına aktarılmış bir havalandırma sisteminde kullanılan aynı fan verileri ile iki farklı benzetim çalışması yapılmıştır. Yapılan ilk benzetim çalışmasında, kazanç parametreleri sabit klasik PI denetleyici ile sistem kontrolü gerçekleştirilmiş ve sistemin istenilen debi değerlerine ulaşırken salınım yaptığı gözlemlenmiştir. Yapılan diğer benzetim çalışmasında ise aynı sistemin çalışma kapsamında tasarlanan pekiştirmeli öğrenme tabanlı uyarlamalı denetleyici ile kontrolü gerçekleştirilmiştir. Benzetim çalışması sonucu sistemin değişken basınç değerlerine karşın kontrolcü kazanç parametrelerinin dinamik olarak değişerek hedef debi değerine salınım yapmadan hızlı bir şekilde ulaştığı ve bu değerde sürekli rejimde çalışmasına devam ettiği gözlemlenmiştir.

Sistem benzetim çalışmasında debi-basınç eğrileri kullanılan fanın, benzetim çalışmalarından elde edilen sistem debi çıkışlarına göre güç tüketimleri hesaplanmıştır. Elde edilen bulgulara göre aynı sistemin klasik PI denetleyiciye kıyasla çalışma kapsamında tasarlanmış uyarlamalı denetleyici ile kontrolü gerçekleştiğinde % 6' ya kadar enerji tasarrufu sağlandığı sonucuna ulaşılmıştır.

KAYNAKLAR

- Akay, R., 2006, Memetik Algoritma Kullanarak PID Denetleyici Tasarımı, Yüksek Lisans Tezi, Erciyes Üniversitesi, 123s (Yayınlanmamış).
- Aydın, B. M., 2022, Pekiştirmeli Öğrenme Yöntemi ile Optimal DC Motor Hız Kontrolcüsünün Tasarlanması, Yüksek Lisans Tezi, Sakarya Üniversitesi, 59s (yayınlanmamış).
- Budak, S., Sungur, C. ve Durdu, A., 2022, Pekiştirmeli Öğrenme ile Endüstriyel Proses Kontrolü, Fırat Üniversitesi Uzay ve Savunma Teknolojileri Dergisi, 1(1):370-374s.

- Control Tutorials for MATLAB and Simulink (CTMS),
<https://ctms.engin.umich.edu/CTMS/index.php?example=Introduction§ion=ControlPID> (Erişim tarihi: Mayıs 2023).
- Control Water Level in a Tank Using a DDPG Agent,
<https://www.mathworks.com/help/reinforcement-learning/ug/control-water-level-using-ddpg-agent.html> (Erişim tarihi: Mayıs 2024).
- Deep Deterministic Policy Gradient (DDPG) Agent,
<https://www.mathworks.com/help/reinforcement-learning/ug/ddpg-agents.html>
(Erişim tarihi: Mayıs 2024).
- Doğan, M., 2006, Öz Ayarlamalı PID Kontrolör (PLC Uygulaması), Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi, 46s (yayımlanmamış).
- Gidemen, G. ve Furat, M., 2015, PID Parametrelerinin Ayarlama Yöntemleri: 2. Derece Sistem Modeline Uygulanması ve Karşılaştırılmalı Olarak Değerlendirilmesi, Çukurova Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, 30(2):355-362s.
- Jang, J. S. R., Sun, C. T. and Mizutani, E., 1997, Neuro-Fuzzy and Soft Computing, A Computational Approach to Learning and Machine Intelligence, Prentice Hall, New Jersey, 640p.
- Kılıç, E., 2022, Asenkron Motor Sürücülerinde Pekiştirmeli Öğrenme Tabanlı PI Hız Denetleyici Optimizasyonu, International Symposium on Advanced Engineering Technologies (ISADET), Kahramanmaraş, 7s.
- Kocakaya, T., 2023, Farklı CPU'lu PLC'lerin Hidrolik Oransal Valf Sisteminde PID Kontrol Performanslarının Karşılaştırılması, Yüksek Lisans Tezi, Karabük Üniversitesi, 100s (Yayımlanmamış).
- Li, S. E., 2023, Reinforcement Learning for Sequential Decision and Optimal Control, Springer, Beijing, 484p.
- Müftü, S., 2023, İki Uzuvlu Bir Robot Kolunun Pozisyon Kontrolü İçin Optimize Edilmiş PID Kontrolcü Tasarımı, Yüksek Lisans Tezi, Necmettin Erbakan Üniversitesi, 81s (Yayımlanmamış).
- Sugarman, S. C., 2020, HVAC Fundamentals, River Publishers, Gistrup, 508p.
- Sutton, R. S. and Barto, A. G., 2011, An introduction to reinforcement learning, The MIT Press, Cambridge, 551p.
- T.P. Lillicrap, J.J. Hunt, A. Pritzel, N. Heess, T. Erez, Y. Tassa, D. Silver and D. Wierstra, 2015, Continuous control with deep reinforcement learning, ICLR 2016, London, 14p.
- Train DDPG Agent for Path-Following Control,
<https://www.mathworks.com/help/reinforcement-learning/ug/train-ddpg-agent-for-path-following-control.html> (Erişim tarihi: Mayıs 2024).
- Yavuzsoy, A., Sargın, H., Yaren, T. ve Kizir, S., 2023, Model Referans Uyarlamalı PID Denetleyici Tasarımı ve Denetleyici Parametrelerinin Sistem Davranışına Etki Analizi: DC Motor Konum Kontrolü, Konya Mühendislik Bilimleri Dergisi, 11(3):730-747s.

**ŞOK EMİCİLİ GEMİ MONTE VİNÇLERİNİN MATEMATİKSEL MODELLEMESİ
VE ANALİZİ**

**MATHEMATICAL MODELING AND ANALYSIS OF SHIP-MOUNTED CRANES WITH
SHOCK ABSORBER**

Onur ERDOĞAN

Gebze Teknik Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü
Gebze Technical University, Faculty of Engineering, Department of Mechanical Engineering

ORCID ID: 0009-0000-5950-6151

Saeed LOTFAN

Dr. Öğr. Üyesi, Gebze Teknik Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü
Assist. Prof. , Gebze Technical University, Faculty of Engineering, Department of Mechanical Engineering

ORCID ID: 0000-0001-8616-2120

ÖZET

Bu çalışma, kaldırma ekipmanlarına ilişkin klas kurallarının ayrıntılı bir analizini yapmayı, bu kuralların iyileştirilmesine teknik destek sağlamayı ve sistemin hassas dinamik modeli geliştirilerek gelecekteki formül iyileştirmeleri ve deneysel çalışmalar için bir referans oluşturmayı amaçlamaktadır. Açık deniz yapılarında gerçekleştirilen kaldırma operasyonları, karadaki operasyonlardan farklıdır ve sürekli hareket eden ortamlar için vinç tasarımları gerektirir. Dalga yüksekliği, kanca hızı, vinç yay sabiti ve kaldırılan yük gibi faktörler, vinç tasarımını etkileyen çeşitli yük kombinasyonlarını ortaya çıkarır. Amortisörler, kaldırma kapasitesine, yorulma direncine ve operasyonel güvenliğe olumlu katkı sağlar. Buna bağlı olarak, bu çalışmada dalga uyarımı altında vinç için dinamik kütle-yay-amortisör modeli matematiksel durum uzayı denklemleri aracılığıyla geliştirilmiştir. Çalışma, sınıflandırma kurallarına uymakta ve 16 farklı vinç ve 3 farklı amortisör için yay ve sönümleme katsayılarını belirlemek amacıyla bir vinç tasarım programı geliştirmektedir. Programın doğruluğu Sonlu Elemanlar Analizi (FEA) ile doğrulanmıştır. Sonuçlar, amortisörsüz vinçlerin sınıflandırma kurallarına göre tasarlanan yük azaltma faktörleri ile simülasyon sonuçları arasında önemli bir fark olmadığını göstermektedir. Ancak, bir amortisörün doğrudan bir yay olarak ele alınması güvenilir değildir; rezonans ve sönümleme etkileri dikkate alınmalıdır. Diğer bir bulgu, dinamik sistem modellemesinde bom uzunluğunun ve ağırlığının artmasının gerilimleri artırdığı yönündedir. Bom ağırlığı, yük azaltma katsayısı formülünde bir yük olarak dahil edilmemektedir. Bu bağlamda, gelecekteki çalışmalar, gerinim ölçerlerle donatılmış vinçlerle yapılacak ayrıntılı deneysel çalışmalar ve zamana bağlı FEA analizlerini içerebilir.

Anahtar Kelimeler: Kaldırma donanımları, Şok sönümleyici, Dinamik sistem modellemesi, Deniz durumu, Klas kuruluşu tabanlı vinç tasarımı.

ABSTRACT

This study aims to conduct a detailed analysis of the classification rules for lifting equipment, provide technical support for the improvement of these rules, and serve as a reference for future formula enhancements and experimental studies, based on the development of the precise dynamic model of the system. Lifting operations in offshore structures differ from those onshore, requiring crane designs for continuously moving environments. Factors such as wave height, hook speed, crane spring constant, and lifted load combine to create various load combinations affecting crane design. Shock absorbers positively contribute to lifting capacity, fatigue resistance, and operational safety. Accordingly, in this study, the dynamic mass-spring-damper model of the crane under base excitation is developed via mathematical state-space equations. This study adheres to classification rules and develops a crane design program to determine spring and damping coefficients for 16 different cranes and 3 different shock absorbers. The accuracy of the program is validated through Finite Element Analysis (FEA). Results show no significant difference between the load reduction factors of cranes without shock absorbers, as designed according to classification rules, and simulation results. However, treating a shock absorber directly as a spring is unreliable; resonance and damping effects must be considered. Another finding reveals that in dynamic system modeling, an increase in boom length and weight results in an increase in stresses. The boom weight is not included as a load in the load reduction coefficient formula. In this context, future studies may include detailed experimental work with cranes equipped with strain gauges and time-

Keywords: Lifting appliances, Shock absorber, Dynamic system modeling, Sea state, Class society-based crane design.

**DYNAMIC BEHAVIOR OF ROTOR SYSTEMS WITH SUPPORT
NONLINEARITIES**

Murat KUTLU

Gebze Technical University, Department of Mechanical Engineering, TÜRKİYE

Saeed LOTFAN

Dr., Gebze Technical University, Department of Mechanical Engineering, TÜRKİYE

ABSTRACT

Nonlinearity in rotating machinery support is an important issue affecting both rotating components and their foundations. It is particularly critical and frequently encountered. This study numerically investigates the dynamic characteristics of a flexible shaft–disk rotor system with support nonlinearity. The system incorporates Belleville washers, which exhibit nonlinear force-deflection behaviour, attached to the bolted joints between the bolts and the pedestal. The impact of the nonlinear spring force exerted by Belleville washers is studied. The disk is considered to be rigid, while the shaft is represented as a beam with a circular cross-section using Euler-Bernoulli beam theory, with considerations for rotary inertia, gyroscopic effects, and rotor mass imbalance. The weak-form of the governing differential equation of motion is derived using Hamilton's Principle. In-plane and out-of-plane transverse displacements are expanded via the Rayleigh–Ritz method, followed by discretization of the weak-form. The Harmonic Balance Method (HBM) is employed to solve the dynamic response of the single-disk rotor system. The frequency responses of both linear and nonlinear systems across various rotor speeds are compared, and Campbell plots are generated to illustrate backward and forward whirl speeds.

Keywords: Shaft–disk rotor, Nonlinear Support, Harmonic Balance Method (HBM), Weak form.

GERÇEK ZAMANLI UYGULAMA PERFORMANSI ÖLÇÜMLEME
REAL TIME APPLICATION PERFORMANCE MEASUREMENT

Uğur ERDAL

Senior Frontend Developer Cimri Information Technologies and Systems Inc., Istanbul, Türkiye.

ORCID ID: 0009-0004-5092-900X

ÖZET

Ticari amaçlı web siteleri için performans, kullanıcı deneyimi ve seo gibi konular çok önemlidir. Bu konularda iyi olunması, arama motorlarında kullanıcıların yapmış olduğu aramalardaki öne çıkma istatistiğini de aynı oranda arttıracaktır. Aylık 30 milyonu aşan kullanıcı sayısına sahip olan Cimri, 2 milyarın üzerinde veri işlemektedir. Kullanıcıların yaklaşık %70'lik kısmı Google aramaları üzerinden Cimri'ye ulaşırken bu anlamda sektörün en güçlü SEO altyapılarından birine sahiptir. Seo altyapısının sürekli iyileştirilmesi için en önemli faktörlerden biri olan ön yüz teknolojilerinin ve performansının da geliştirilmesidir. 'Cimri' önyüz performansının 300 ms ortalamasıyla içerdiği veri ve üçüncü partileri düşünüldüğünde sektörün çok önünde yer almaktadır. Bu yapıyı sürdürülebilir kılmak için önyüz yazılım geliştirme iş hattına 'lighthouse' isimli genel geçer sayfa performans ve seo metriklerini ölçen modül yerleştirilmiştir. Google Lighthouse kullanıcı deneyimi, performans ve seo açılarından web sayfalarının değerlendirilmesini sağlayan bir metrikleme sistemidir. Bu metrikleme sisteminin önyüz geliştirme iş hattında otomatize şekilde tüm yapılan geliştirmeleri denetlemesi, iyi ya da kötü sonuçları bildirmesi ve düzeltme önerileri vermesi amaçlanmıştır. Uçtan uca bu sistemin otomatize şekilde kurulması Cimri için seo anlamında önemli katkılar sağlamaktadır. Ayrıca sadece iş hattına yerleştirmek operasyonel olarak her bir işin tamamlanmasında, geliştirme maliyeti çıkaracağı için tüm süreç lighthouse ölçüm modülü ile birlikte otomatize edilmiştir.

Yüksek trafik altında çalışan, çok kullanıcıya sahip dijital ürünler ve altyapılar için bu yapının uçtan uca minimum teknik gereksinim ile kurulması önemli bir değer katmıştır. Lighthouse ayrıca, geliştirilmesi ile iş hattında her bir iş için otomatik şekilde tüm kullanıcı deneyimini ve seo performans metriklerinin ölçülmesini, sorun olduğunda alarm üretilip, sorunların tespit edilmesini ve çözüm için öneri sunulmasını sağlayacaktır.

Sonuç olarak; 28 gün beklemeden uygulamaya yeni bir özellik yayınlandığı anda bile gerçek zamanlı verileri görüntüleyerek hızlı bir şekilde aksiyon alınabilir.

Anahtar Kelimeler: seo, önemli web verileri, optimizasyon, performans, kullanıcı deneyimi, performans ölçümlerme

ABSTRACT

For commercial websites, issues such as performance, user experience and SEO are very important. Being good at these issues will also increase the statistics of prominence in searches made by users in search engines at the same rate. Having over 30 million users per month, Cimri processes over 2 billion data. While approximately 70% of users reach Cimri through Google searches, it has one of the strongest SEO infrastructures in the sector in this sense. One of the most important factors for the continuous improvement of SEO infrastructure is the development of front-end technologies and performance. Considering the data and third parties it contains with an average of 300 ms of front-end performance, 'Cimri' is far ahead of the sector. In order to make this structure sustainable, a module called 'lighthouse' measuring general page performance and SEO metrics has been placed in the front-end software development line of workflow. Google Lighthouse is a metrication system that allows web pages to be evaluated in terms of user experience, performance and SEO. This metrication system is intended to automatically control all developments made in the frontend development line of work, report good or bad results, and provide correction suggestions. The automated installation of this end-to-end system provides significant contributions to Cimri in terms of SEO. In addition, since just placing it in the line of work will create development costs in the completion of each job operationally, the entire process has been automated with the Lighthouse measurement module. For digital products and infrastructures operating under high traffic and having many users, the end-to-end installation of this structure with minimum technical requirements has added significant value. Lighthouse will also enable the automatic measurement of all user experience and SEO performance metrics for each job in the line of work, generate alarms when there is a problem, detect problems, and provide suggestions for solutions.

Keywords: seo, core web vitals, optimization, performance, user experience, performance metrics

**SABİT KAMERA GÖRÜNTÜLERİ ÜZERİNDE HAREKETLİ NESNE TESPİTİ İÇİN
PERFORMANS İYİLEŞTİRME VE KARŞILAŞTIRMALI ANALİZ**
PERFORMANCE IMPROVEMENT AND COMPARATIVE ANALYSIS FOR MOVING
OBJECT DETECTION ON FIXED CAMERA IMAGES

Şule Nur AKÇA

Gazi University, Graduate School of Natural And Applied Sciences, Department of Electrical and Electronics
Engineering, Ankara, Türkiye.

ORCID NO: 0000-0001-9444-5171

Derya YILMAZ

Assoc. Prof. Dr., Gazi University, Faculty of Engineering, Department of Electrical and Electronics Engineering,
Ankara, Türkiye.

ORCID NO: 0000-0002-1903-7132

ÖZET

Hareketli nesnelerin tespiti ve tanınması özellikle toplumsal ve askeri alanlardaki uygulamalarda önemli bir çalışma alanıdır. Bu alandaki çalışmalar birden fazla nesnenin tespiti, değişen hava koşulları, aydınlanma seviyesindeki değişkenlik ve arka plan değişimleri kaynaklı zorlukların çözümü üzerinde yoğunlaşmakta olup kullanılan yöntemler farklı performanslar sergileyebilmektedir. Hareketli nesne tespitinde çerçeve farkı ve arka plan çıkarımı en yaygın kullanılan yöntemlerdir. Çerçeve farkı yöntemi, sabit kameralarla elde edilen görüntülerde başarılı sonuçlar vermekle beraber dinamik çevre koşullarında ve ışık değişikliklerinde performansı düşmektedir. Bu zorlukların üstesinden gelebilmek için önerilen arka plan çıkarımı yöntemi bir arka plan modeli oluşturularak hareketli nesnelere tespiti çalışır ancak zorlukların dinamik olması oluşturulan arka plan modelinin de başarımını sınırlandırmaktadır. Literatürde arka plan çıkarımı yönteminin tespit başarımını etkileyen bu durumun giderilmesi amacıyla, arka plan modelinin her yeni görüntüde güncellenmesi yaklaşımı önerilmiştir. Bu çalışmada, sabit kameralardan alınan görüntülerdeki hareketli nesnelerin tespiti için arka plan çıkarım yöntemi, arka plan modeli güncelleme işleminde bir dinamik aralık parametresi kullanılarak iyileştirilmeye çalışılmış, bu amaçla algoritmanın farklı versiyonları oluşturularak denenmiş ve elde edilen sonuçlar çerçeve farkı yönteminin sonuçları ile karşılaştırılarak performansı değerlendirilmiştir. Çalışmada BMC2012 sentetik veri setindeki dört farklı senaryo ile oluşturulmuş videolardaki sabit kameralardan alınan görüntülerdeki hareketli nesnelerin tespiti yapılmış ve algoritmaların başarım metrikleri hesaplanmıştır. Yapılan karşılaştırmalı analizlerde elde edilen sonuçlar arka plan çıkarım yönteminin iyileştirilmesi için önerilen yaklaşımın kullanıldığı ve arka plan çıkarımının tekrar edilmediği versiyonun daha yüksek performans sağladığını göstermektedir. Gerçekleştirilen çalışma, sabit kameralardan alınan görüntülerde hareketli nesne tespiti için önerilen arka plan

çıkarmı yaklaşımının, özellikle arka planın sabit ancak hava deęişimlerinden kaynaklı dinamik koşullarda yüksek doğruluk sağladığını ortaya koymaktadır.

Anahtar kelimeler: Hareketli Nesne Tespiti, Arka Plan Çıkarmı Yöntemi, Çerçeve Farkı Yöntemi, Dinamik Aralık, Arka Plan Modeli.

ABSTRACT

The detection and recognition of moving objects is an important area of study, especially in social and military applications. The studies in this field focus on the solution of difficulties caused by the multiple objects detection, changing weather conditions, illumination changes and dynamic background and the methods used can exhibit different performances. The frame difference and the background subtraction are the most commonly used methods in moving object detection. Although the frame difference method yields successful results in images obtained with fixed cameras, its performance decreases in dynamic environmental conditions and illumination changes. In order to overcome these difficulties, the proposed background subtraction method attempts to detect moving objects by creating a background model, however, the dynamic nature of these difficulties also limits the success of the created background model. In order to eliminate this situation, which affects the detection performance of the background subtraction method, the approach of updating the background model in each new image has been proposed in the literature. In this study, the background subtraction method for the detection of moving objects in images taken from fixed cameras is tried to be improved by using a dynamic range parameter in the background model update process, for this purpose, the different versions of the algorithm were tested and the obtained results were compared with the results of the frame difference method and its performance was evaluated. In the study, the moving objects in images taken from fixed cameras in videos created with four different scenarios in the BMC2012 synthetic dataset were detected and the success metrics of the algorithms were calculated. The results obtained in the comparative analysis show that the proposed approach is used to improve the background subtraction method and the version in which the background subtraction is not repeated provides higher performance. The study revealed that the proposed background subtraction approach for moving object detection in images taken from fixed cameras provides high accuracy, especially in conditions where the background is stable but dynamic due to weather changes.

Keywords: Moving Object Detection, Background Subtraction Method, Frame Difference Method, Dynamic Range, Background Model.

GİRİŞ

Hareketli nesnelerin tespiti ve tanınması özellikle toplumsal ve askeri alanlardaki uygulamalarda önemli bir çalışma alanıdır. Tespit etme işleminin doğru ve hızlı bir şekilde

yapılması çalışmanın önemli bir motivasyonunu oluşturmakta ve bunun için birden çok yöntemler geliştirilmektedir. Literatürde, çerçeve farkı ve arka plan çıkarımı en yaygın olarak kullanılan yöntemlerdir. Bu yöntemlerin başarımı, birden fazla nesnenin tespiti, değişen hava koşulları, aydınlanma seviyesindeki değişkenlik, kameranın sabit/hareketli olması ve arka plan değişimleri gibi çeşitli zorluklara bağlı olarak farklılıklar sergileyebilmektedir. Karşılaşılan zorlukların, çerçeve farkı ve arka plan çıkarımı yöntemlerinin beraberinde ön-işlem/son-işlem teknikleri veya ayarlanabilir eşik değeri gibi farklı yaklaşımlarında kullanılması performanslarını arttırmada büyük ölçüde katkı sağlamaktadır. Hanchinamani ve ark., hareketli nesne tespiti için hareketli pencere yaklaşımı ile birlikte ayarlanabilir eşik değeri kullanarak yüksek hızlı bir arka plan çıkarma yöntemi önermişlerdir [1]. Önerdikleri yöntemin daha etkili olması için öncesinde ön-işlem tekniği olan evrişim süzgeci ile görüntü üzerindeki gürültü yok edilmiş, ardından hareketli pencere yaklaşımıyla birlikte arka plan çıkarımı yöntemi kullanılmıştır. Ardından son-işlem tekniği olan evrişim süzgeci ile en son tespit edilen nesne üzerinde yapay bozulmuş pikseller yok edilmiştir. Böylece, önerdikleri yöntemin görüntü kalitesi ve işlem hızı açısından daha iyi olduğunu belirtmişlerdir [1]. Husein ve ark. tarafından yapılan bir çalışmada karşılaşılan zorluklar arasında gölgeler, sabit nesnelerin hareket etmesi, görüntü gürültüsü ve aydınlatma koşullarından bahsetmişlerdir [2]. Bu zorluklar için sabit kameradan alınan görüntüler üzerinden hareketli nesnelerin tespiti için çerçeve farkı ve arka plan çıkarımı yöntemlerini kullanmışlardır. Çerçeve farkı yöntemiyle hareketli nesneler tespit edilmiş ama bu yöntemle göre daha gelişmiş olan arka plan çıkarımı yöntemiyle daha etkili ve hassas sonuçlar elde edilmiştir. Ayrıca ışık değişiminin eşik değerine önemli ölçüde etkisi olduğundan piksellerin bulunduğu aralığın %15'ine denk gelen değerlerin yani en mümkün eşik değerinin 35 olarak seçilmesini önermişlerdir [2]. Arka plan çıkarımı yöntemi kullanan Xu ve ark., aydınlatma değişimleri, hareketli arka plan, durağan ön plan nesneleri ve hayalet nesneler gibi zorlukların olduğu durumlarda bu yöntemin performansında istenmeyen sonuçlar verdiğini ve hareketli bir arka plana sahip görüntüler üzerinden arka plan modeli oluştururken hayalet nesnelerin veya önplan bölgesinde yer alan sabit nesnelerin olması arka plan çıkarımı yönteminin güvenilirliğini olumsuz etkilediğini belirtmişlerdir [3]. Bu durumun olmasını engellemek için arka plan çıkarımı yöntemi iki aşamada gerçekleştirilmiştir. İlk aşamada, hareketli nesnelerin bulunduğu potansiyel alanların kabaca tespit edilmesi amacıyla geliştirilmiş çerçeve farkı yöntemi, blok tabanlı görüntü bölme algoritması ve çok ölçekli bölge tabanlı yöntemleri kullanılarak hareket bölgesi tahmini gerçekleştirilmiştir. Böylece, hareketli nesnelerin bulunduğu olası bölgeler daha doğru bir şekilde belirlenmiştir. İkinci aşamada ise, hassas hareketli nesne tespiti için Vibe algoritması uygulanmıştır. Bu algoritmayı geliştirmek için ayarlanabilir mesafe eşiği ve her piksel için zaman altörnekleme faktörü parametreleri kullanılmıştır. Önerdikleri yöntemin, klasik arka plan çıkarma yöntemlerine kıyasla daha az işlem süresi ile daha yüksek doğrulukta hareketli nesne tespiti yaptığını belirtmişlerdir. Xu ve ark.'nın çalışmasında, kullanılan yöntemlerin birleştirilmesi ile aydınlatma değişimleri ve hareketli arka plan gibi zorlu senaryolarda hareketli nesnelerin daha güvenilir bir şekilde tespit edildiği vurgulanmıştır [3]. Arka plan

çıkarma yönteminin uygulandığı bir diğer çalışmada Tao ve ark., arka plan modellerinin elde edilmesinde arka plan varyasyonlarına izin veren belirli bir eşik aralığı oluşturmuşlardır [4]. Oluşturulan eşik aralığının geniş tutulduğu bölgelerdeki piksellerde tespit hassasiyeti azalmış, dar bir izin aralığında tutulan piksellerde tespit hassasiyetinin arttığını gözlemlemişlerdir. Bu eşik aralığının daraltma işlemi, yüksek korelasyona sahip komşu görüntü bloklarının varyans özelliklerine dayanarak gerçekleştirilmiştir. Bu yaklaşım, korelasyon-tabanlı blok eşleme yöntemi olarak adlandırılmakta olup, yöntemin iç mekanlardaki karmaşık ortamlarda daha etkili olduğu belirtilmiştir [4]. Renkli görüntüler üzerinden yapılan hareketli nesne tespit çalışmalarından olan Manipriya ve ark.'nın çalışmasında, çerçeve farkı kullanılarak uzamsal arka plan çıkarımı yöntemi ve histogram farkı kullanılarak uzamsal arka plan çıkarımı yöntemlerinin renk bilgilerini yeteri kadar koruyamadığı için genişletilmiş çerçeve farkı yöntemi ve genişletilmiş histogram farkı yöntemleri önerilmiştir [5]. Önerdikleri yöntemlerin amacı, uzamsal renk bilgilerini kullanarak nesne tespitinde hesaplama verimliliğini ve doğruluğunu arttırmaktır. Bu yöntemlerin, ışık değişimleri, hava koşulları gibi zorlukların olduğu gerçek zamanlı görüntüler üzerinden hareketli nesne tespitinin yapıldığı ve HSV uzamsal renk bilgisi kullanıldığında daha iyi performans gösterdiğini belirtmişlerdir [5].

Çerçeve farkı yöntemi, sabit kameralarla elde edilen görüntülerde başarılı sonuçlar vermekle beraber dinamik çevre koşullarında ve ışık değişikliklerinde performansı düşmektedir. Bu zorlukların üstesinden gelebilmek için önerilen arka plan çıkarımı yöntemi bir arka plan modeli oluşturarak hareketli nesnelere tespit etmeye çalışır ancak zorlukların dinamik olması oluşturulan arka plan modelinin de başarımını sınırlandırmaktadır. Sobral ve ark., BMC veri setlerini kullanarak BGSLibrary'de gerçekleştirilen 29 farklı yöntemi karşılaştırmışlardır [6]. Özellikle arka plan çıkarımı yönteminde arka plan görüntüsünü elde etmek için yaygın olarak kullanılan Gauss Karışım Modelinin, düşük ışık değişimlerinin olduğu dışarı sahne görüntülerinde başarılı bir performans gösterdiğini belirtmişlerdir. Ayrıca, ışık değişimlerinde yaşanan ani değişiklikler ve gölgeler gibi zorlukların olduğu durumlarda hareketli nesnelere tespit edilmesinde problemlerin devam ettiğini de belirtmişlerdir [6].

Literatürde arka plan çıkarımı yönteminin tespit başarımını etkileyen dinamik zorlukların giderilmesi amacıyla, arka plan modelinin her yeni görüntüde güncellenmesi yaklaşımı önerilmiştir. Dinamik çevre koşulları üzerinden gerçekleştirilen bir çalışma olan Savaş ve ark., blok-tabanlı uyarlanabilir yöntemin parametreleri ile arka plan çıkarımı uygulamışlardır [7]. Blok-tabanlı uyarlanabilir yöntem, belirli blokların bir araya getirilmesiyle oluşturulan bir yaklaşımdır. Her blok, bir fonksiyonu temsil etmekte ve bu bloklar bir araya gelerek algoritmanın genel işleyiş mantığını oluşturmaktadır. Onların çalışmasında gri seviyeli, arka plan hareketli görüntüler üzerinde kullanılan ayarlanabilir eşik değeri parametre yapısı, değişen çevre koşullarına uyum sağlayabilmek amacıyla basit bir sayaç modeli ile tasarlanmıştır. Böylece arka plan modeli güncellenirken ayarlanabilir eşik parametrelerinin kullanımı ile işlem süresi önemli ölçüde azaltılmıştır. Ayrıca, blok-tabanlı yapı sayesinde arka

plan modeli oluşturulurken depolama gereksinimi ve kare işleme süresini de optimize etmişlerdir [7].

Literatürdeki çalışmaların ışığında bu çalışmada, hareketli nesnelerin tespiti için literatürde sıklıkla kullanılmış olan arka plan çıkarım yöntemi, arka plan modeli güncelleme işleminde bir dinamik aralık parametresi kullanılarak iyileştirilmeye çalışılmıştır. Bu amaç için algoritmanın farklı versiyonları oluşturulmuş ve denenmiştir. Elde edilen sonuçlar, çerçeve farkı yönteminin sonuçları ile karşılaştırılarak performansı değerlendirilmiştir. Çalışmada BMC2012 sentetik veri setindeki dört farklı senaryo ile oluşturulmuş videolardaki sabit kamera görüntülerindeki hareketli nesnelerin tespiti yapılmış ve algoritmaların başarımları metrikleri hesaplanmıştır.

YÖNTEM

Çerçeve Farkı Yöntemi

Çerçeve Farkı yöntemi ile görüntülerdeki piksellerin parlaklık değerleri üzerinden fark görüntüsü elde edilerek mutlak değeri alınmakta ve görüntüdeki piksellerden hesaplanan eşik değeri ile karşılaştırma yapılarak binarize görüntü üzerinden hareketli nesne tespiti yapılmaktadır [2]. Bu yöntemin iyi sonuç vermesi için sabit bir kameradan alınan, karmaşık bir arka plana sahip olmayan görüntülerin üzerinden uygulanması gerekmektedir.

Çerçeve Farkı yöntemi, matematiksel formül ile,

$$F_t(x, y) = |I_t(x, y) - I_{t-1}(x, y)| \quad (1)$$

şeklinde ifade edilmektedir. Denklem (1)' de, x değerleri piksellerin yatay konumunu, y değerleri piksellerin dikey konumunu, $I_t(x, y)$ t anındaki şimdiki görüntüyü, $I_{t-1}(x, y)$ t-1 anındaki önceki görüntüyü, $F_t(x, y)$ t anındaki fark görüntüsünü ifade etmektedir [2]. Elde edilen fark görüntüsü $F_t(x, y)$, eşik değeri ile karşılaştırılmaktadır.

$$D_t(x, y) = \begin{cases} 1, & F_t(x, y) \geq \epsilon_t \\ 0, & F_t(x, y) < \epsilon_t \end{cases} \quad (2)$$

Denklem (2)' de, $D_t(x, y)$ görüntüsü t anındaki binarize edilmiş görüntüyü, ϵ_t değeri ise ayarlanabilir eşik değerini ifade etmektedir [2]. Bu çalışmada, ayarlanabilir eşik değeri belirlemek için Otsu'nun eşik değeri yöntemi kullanılmıştır. Otsu'nun eşik değeri yöntemi ile fark görüntüsünün histogram değerleri üzerinden ağırlık, ortalama ve varyans hesaplanarak oluşturulmaktadır [9]. $F_t(x, y)$ fark görüntüsündeki piksel değerleri, eğer eşik değeriyle aynı veya eşik değerinden büyükse hareketli nesnelerin olduğu bölgeleri beyaz olarak eğer eşik değerinden küçükse hareketli nesnelerin olmadığı sabit bölgeleri siyah olarak $D_t(x, y)$ binarize görüntüde gösterilmektedir. Çerçeve Farkı yöntemi, yavaş hareketlerde veya önde bulunan nesnenin durması gibi durumlarda ön plandaki görüntüde delikler oluşturabilmektedir.

Arka Plan Çıkarım Yöntemi

Arka Plan Çıkarım yöntemi ile görüntü üzerinden medyan süzgeci veya görüntülerin ortalaması alınarak arka plan modeli elde edilmektedir. Bu arka plan modeline referans görüntü de denilmektedir. Bu yöntemde görüntülerdeki zorluk durumlarına göre ilk gelen görüntü üzerinden bir seferlik arka plan görüntüsü veya tekrarlı olarak her yeni gelen görüntüden arka plan görüntüsü elde edilebilmektedir. Tekrarlı olarak elde edilen arka plan görüntüsü sonucun daha etkili ve doğru olmasını sağlamaktadır. Sonraki işlem basamakları Çerçeve Farkı yöntemi ile benzer şekilde ilerlemektedir. Görüntülerdeki piksellerin parlaklık değerleri üzerinden fark görüntüsü elde edilerek mutlak değeri alınmakta ve görüntüdeki piksellerden hesaplanan eşik değeri ile karşılaştırma yapılarak binarize görüntü üzerinden hareketli nesne tespiti yapılmaktadır [2]. Bu yöntemin, yavaş hareketlerde veya önplan bölgesinde bulunan nesnenin sabit olması gibi durumlarda daha etkili bir çözüm sunmakta ama farklı senaryolarda arka plan modelinin her görüntü için yinelenmemesi ve az üretilmesinden kaynaklı hatalara neden olabilmektedir.

Arka Plan Çıkarım yönteminde, t anında gelen $I_t(x, y)$ görüntüsünden, 3×3 'lük medyan süzgeci veya bütün görüntülerin toplamının ortalamasından arka plan görüntüsü ya da diğer bir adıyla referans görüntüsü elde edilmektedir.

$$B(x, y) = \text{median} \{I_t(x, y)\}, t = 1, 2, \dots, N. \quad (3)$$

$$B(x, y) = \frac{1}{N} \sum_{t=1}^N I_t(x, y) \quad (4)$$

Denklem (3)' de medyan süzgeci ile $B(x, y)$ referans görüntüsü, "median" medyan süzgecinin fonksiyonudur [3]. Burada elde edilen arka plan görüntüsü bir seferlik elde edilmektedir ve arka plan çıkarımı yöntemi boyunca arka plan görüntüsü güncellenmemektedir. Bu durum, arka plan görüntüsünün sabit olduğu anlarda etkili bir çözüm sağlamaktadır. Denklem (4)' de bütün görüntülerin toplamının ortalaması ile $B(x, y)$ referans görüntüsü elde edilmektedir.

Sabit kameralardan alınan görüntülerdeki arka planın sürekli değişkenlik gösterdiği bir durumda, arka plan görüntüsünün belli bir oran değerinde t anında gelen yeni görüntü ile $t-1$ anında elde edilen arka plan görüntüsünün karıştırılması ile her yeni gelen görüntü üzerinden sürekli olarak güncellenerek oluşturulması daha etkili çözüm sağlamaktadır [6].

$$B_{t+1}(x, y) = b * B_t(x, y) + (1 - b) * I_t(x, y), t = 1, 2, 3, \dots, N \quad (5)$$

Denklem (5)' de, b oran değeri, $B_{t+1}(x, y)$ ($t+1$) anında gelen görüntü, $B_t(x, y)$ t anında medyan süzgeci ile elde edilmiş arka plan görüntüsü ve $I_t(x, y)$ t anında alınan görüntüdür [6]. Bu denklem ile her t anında alınan görüntü ile bu görüntü üzerinden 3×3 'lük medyan süzgeci ile elde edilmiş arka plan görüntüsü belli bir oran değerinde karıştırılarak $t+1$ anında arka plan görüntüsü elde edilmektedir. Böylece arka planda sürekli değişkenlik gösteren faktörler bu yöntem ile yok edilerek hareketli nesnelerin tespiti sağlanmaktadır.

Arka plan görüntüsü elde edildikten sonra t anında gelen $I_t(x, y)$ görüntüsünden arka plan görüntüsü çıkarılır ve mutlak değeri alınarak fark görüntüsü oluşturulur.

$$F_t(x, y) = |I_t(x, y) - B_t(x, y)| \quad (6)$$

Denklem (6)' da, $F_t(x, y)$ t anında elde edilen fark görüntüsü, $I_t(x, y)$ t anında gelen görüntü, $B_t(x, y)$ t anında elde edilen arka plan görüntüsüdür [2].

Önerilen Yaklaşım

Çalışmamızda, arka plan çıkarımı yöntemine yeni bir yaklaşım olarak dinamik aralık parametresi yeniden ayarlama uygulanmıştır. Bu yaklaşım ile fark görüntüsünün histogramları üzerinden minimum ve maksimum piksel değerleri belirlenmiş, yoğunluğun olduğu piksel değerleri arasında manuel seçim yapılarak dinamik aralığı değiştirilmiştir. Çevresel faktörlerden kaynaklı zorluklar nedeniyle görüntüdeki hareketli nesnelerin parlaklık değerleri histogram değerlerinde düşük tarafta yer alabilmekte ve bu durumda nesnelerin tespit edilmesi zorlaşmaktadır. Bu sebepten dolayı dinamik aralık parametresi değiştirilerek yeni bir yaklaşım önerilmiştir. Dinamik aralık değerler ilk önce 60-80 arası seçilmiş ve ardından 55-150 arası olacak şekilde seçilmiştir. Böylece fark görüntüsündeki piksel değerleri dinamik aralığa uygun atanmış ve yeni fark görüntüsü elde edilmiştir.

Bu yeni yaklaşımla elde edilen fark görüntüsündeki piksel değerleri ile Otsu'nun eşik değeri yöntemi kullanılarak oluşturulan eşik değeri karşılaştırılmaktadır. Eğer fark görüntüsüne ait piksel değerleri eşik değerinden büyük veya eşit ise hareketli nesnelerin olduğu bölgeleri beyaz olarak, eğer piksel değerleri eşik değerinden küçükse hareketli nesnelerin olmadığı sabit bölgeleri siyah olarak $D_t(x, y)$ binarize görüntüde gösterilmektedir.

$$D_t(x, y) = \begin{cases} 1, & F_t(x, y) \geq e_t \\ 0, & F_t(x, y) < e_t \end{cases} \quad (7)$$

Denklem (7)' de, $D_t(x, y)$ görüntüsü t anındaki binarize edilmiş görüntüyü, e_t değeri ise ayarlanabilir eşik değerini ifade etmektedir [2].

Başarım Metrikleri

MATLAB ortamında BMC2012 sentetik veriseti üzerinde koşturulan hareketli nesne tespit algoritmaları ile elde edilen binarize görüntüler, zemingerçek (groundtruth) görüntüleri ile karşılaştırılarak başarımleri hesaplanmıştır. Bu çalışmada hareketli nesne tespit etme algoritmalarının performanslarının değerlendirilmesi için kullanılan başarımleri, özgüllük, doğruluk, kesinlik, duyarlılık, F1_skoru, yanlış sınıflandırma oranı, yanlış pozitif oranı, yanlış negatif oranıdır.

$$\text{Özgüllük (Sp)} = \frac{TN}{TN+FP} \quad (8)$$

$$\text{Doğruluk (Ac)} = \frac{TP+TN}{TP+TN+FP+FN} \quad (9)$$

$$\text{Kesinlik (Pr)} = \frac{TP}{TP+FP} \quad (10)$$

$$\text{Duyarlılık (Re)} = \frac{TP}{TP+FN} \quad (11)$$

$$F1_skor = 2 \times \frac{\text{Kesinlik} \times \text{Duyarlılık}}{\text{Kesinlik} + \text{Duyarlılık}} \quad (12)$$

$$\text{Yanlış Sınıflandırma Oranı (PWC)} = \frac{FP+FN}{TP+TN+FP+FN} \times 100 \quad (13)$$

$$\text{Yanlış – Pozitif Oranı (FPR)} = \frac{FP}{FP+TN} \quad (14)$$

$$\text{Yanlış – Negatif Oranı (FNR)} = \frac{FN}{TP+FN} \quad (15)$$

Denklem (8) ile denklem (15) arasındaki formüllerde yer alan TP, doğru pozitif yani gerçek hareketli nesnelerin doğru tespitini; TN, doğru negatif yani gerçekten hareketsiz nesnelerin doğru tespiti; FP, yanlış pozitif yani hareketsiz bir nesnenin hareketli olarak tespitini; FN ise yanlış negatif yani hareketli bir nesnenin tespit edilememesi durumunu ifade etmektedir [3].

ARAŞTIRMA BULGULARI VE TARTIŞMA

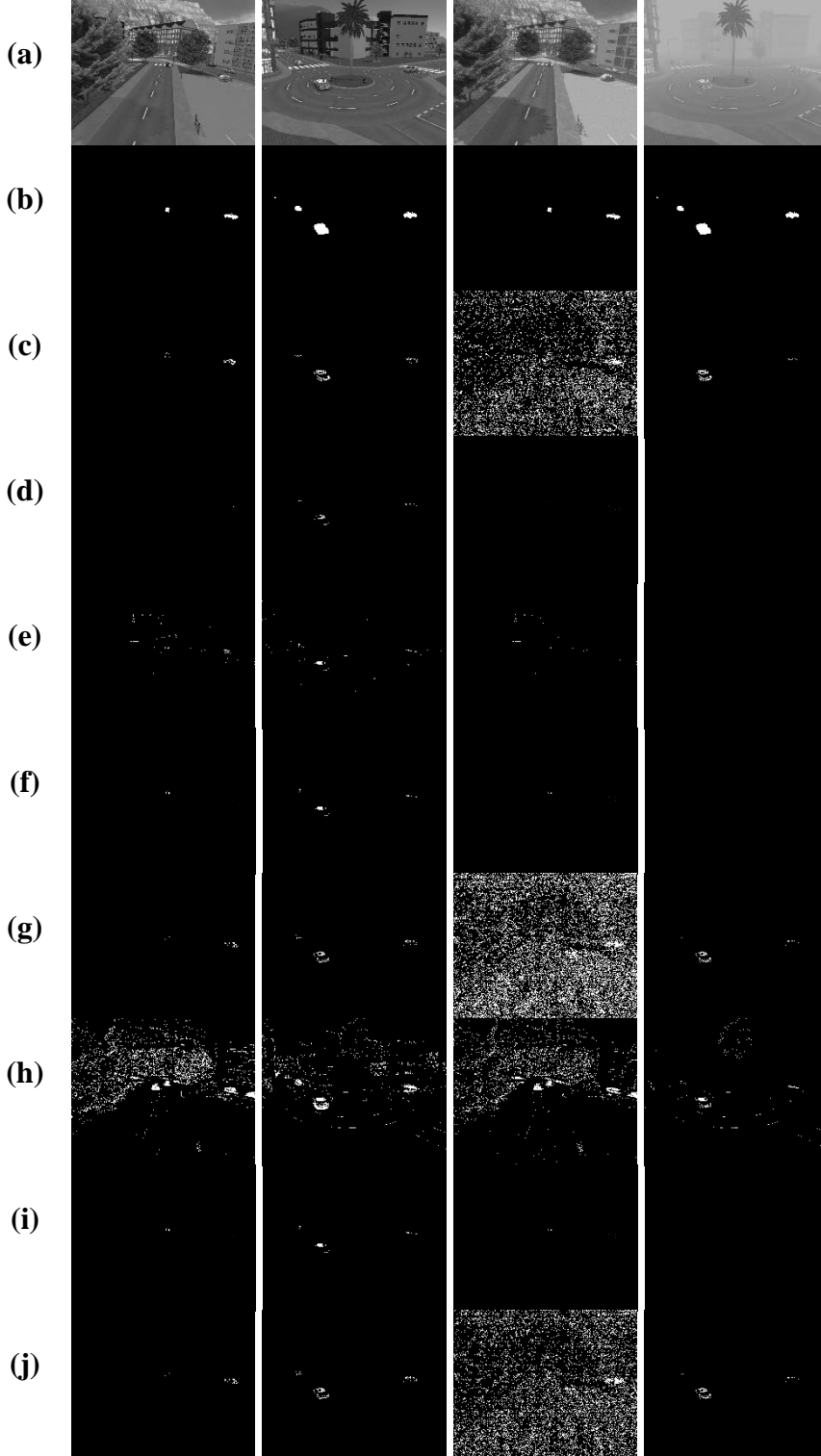
BMC2012 Veriseti

Vacavant ve ark., arka plan çıkarımı yönteminde kullanılması için uygun koşulları sağlayan BMC2012 sentetik verisetini önermişlerdir [8]. Sabit kameradan alınan kentsel sahneleri gösteren video serisi, kavşak ve sokak olarak iki türden oluşturulmuş sentetik görüntülere sahiptir. Bu görüntülere, arka plan çıkarımında karşılaşılan zorlu faktörler de eklenerek SiVIC simülasyonu ile video haline çevirmişlerdir [8]. Bu çalışmada, değişken zorluklara karşı kullanılan yöntem ve yaklaşımların başarımleri metrikleri karşılaştırılarak en etkili yöntemi belirleyebilmek için BMC2012 verisetindeki farklı senaryolarla oluşturulan videolardan 111.mp4, 121.mp4, 311.mp4 ve 421.mp4 videoları seçilmiştir. 111.mp4 ve 121.mp4 videoları normal kavşak ve sokak görüntülerden, 311.mp4 videosu güneşli sokak görüntülerinden, 421.mp4 videosu sisli kavşak görüntülerinden oluşmaktadır. Seçilen videoların diğer önemli özellikleri ise 640x480 çözünürlükte 25fps RGB görüntülerdir. Bu görüntüler, MATLAB ortamında gri seviyeli görüntülere dönüştürülerek çalışmada kullanılmıştır.

Önerilen Yaklaşımın Uygulanması ve Çıktılar

Hareketli nesne tespiti için önerilen yaklaşımlardan, 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama), 55-150 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama), güncellenmeyen arka plan çıkarımı (ortalama), 55-150 dinamik aralıklı güncellenmeyen arka plan çıkarımı (medyan süzgeci) yöntemleri, sırasıyla 111.mp4, 121.mp4, 311.mp4 ve 421.mp4 videolarının 770. çerçevelerine uygulandığında, gerçekzemin görüntüsüne en yakın sonucu vermiş olup, diğer yöntemlerin ise hareketli nesnelere tam tespit edemediği veya arka planda yer alan sabit nesnelere de tespit ettiği görülmektedir (Şekil 1). Aynı yöntemler, sırasıyla 111.mp4, 121.mp4, 311.mp4 ve 421.mp4 videolarından alınan

1300. çerçevelerine uygulandığında da yine gerçekzemin görüntüsüne en yakın sonuçları vermişlerdir. Ayrıca, güncellenen arka plan çıkarımı (medyan süzgeci), güncellenmeyen arka plan çıkarımı (medyan süzgeci), güncellenmeyen arka plan çıkarımı (ortalama) yöntemlerinin özellikle sisli kavşak görüntülerinde düzgün çalışmadığı da görülmektedir (Şekil 2).



Şekil 1. BMC2012 veri setlerinden alınan soldan sağa sırasıyla 111.mp4, 121.mp4, 311.mp4, 421.mp4 videolarından alınan görüntüler ve uygulanan yöntemlerle elde edilen görüntüler;

(a) 770. çerçeveleri,

(b) Zemingerçek

(c) Çerçeve farkı,

(d) Güncellenen arka plan çıkarımı (medyan süzgeci),

(e) Güncellenmeyen arka plan çıkarımı (medyan süzgeci),

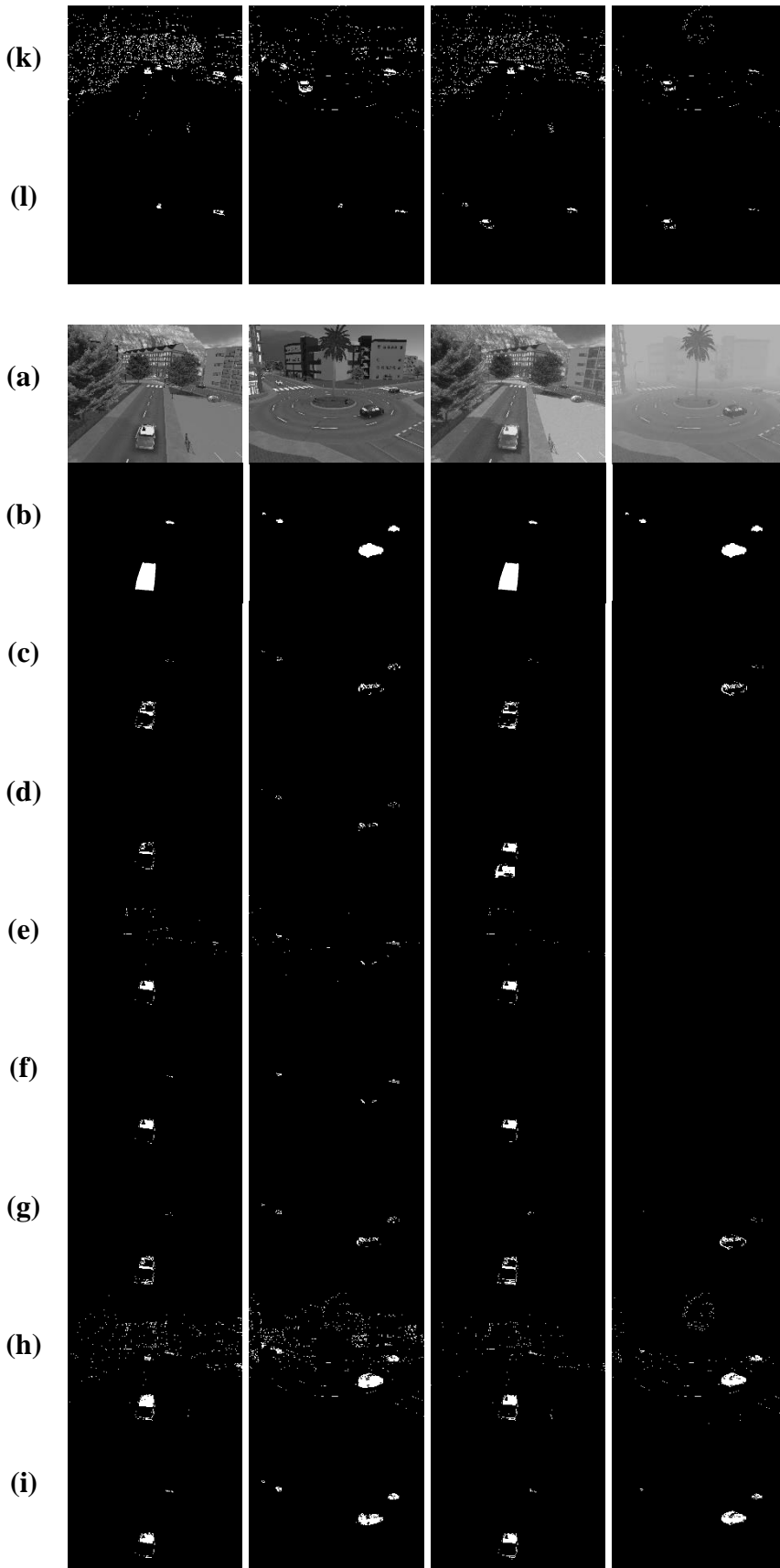
(f) Güncellenmeyen arka plan çıkarımı (ortalama),

(g) 60-80 dinamik aralıklı güncellenen arka plan çıkarımı (medyan süzgeci),

(h) 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (medyan süzgeci),

(i) 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama),

(j) 55-150 dinamik aralıklı güncellenen arka plan çıkarımı (medyan süzgeci),



(k) 55-150 dinamik aralıklı güncellenmeyen arka plan çıkarımı (medyan süzgeci),

(l) 55-150 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama).

Şekil 2. BMC2012 veri setlerinden alınan soldan sağa sırasıyla 111.mp4, 121.mp4, 311.mp4, 421.mp4 videolarından alınan görüntüler ve uygulanan yöntemlerle elde edilen görüntüler;

(a) 1300. çerçeveleri,

(b) Zemingerçek

(c) Çerçeve farkı,

(d) Güncellenen arka plan çıkarımı (medyan süzgeci),

(e) Güncellenmeyen arka plan çıkarımı (medyan süzgeci),

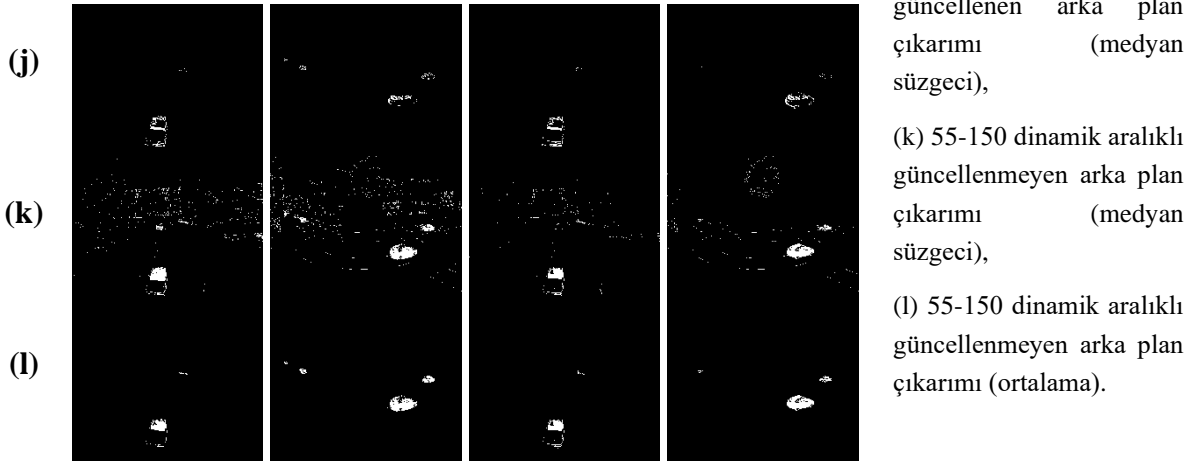
(f) Güncellenmeyen arka plan çıkarımı (ortalama),

(g) 60-80 dinamik aralıklı güncellenen arka plan çıkarımı (medyan süzgeci),

(h) 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (medyan süzgeci),

(i) 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama),

(j) 55-150 dinamik aralıklı



(j) güncellenen arka plan çıkarımı (medyan süzgeci),

(k) 55-150 dinamik aralıklı güncellenmeyen arka plan çıkarımı (medyan süzgeci),

(l) 55-150 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama).

111.mp4 videosu için en uygun başarıım metriği veren algoritma, 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama)'dır. Diğer algoritmaların başarıım metrikleri ile karşılaştırıldığında özgüllük, doğruluk değerlerinde %100 performans ile arka plan piksellerinin iyi sınıflandırıldığını ve tüm tespitlerin doğru olduğunu, duyarlılık değerinde %71 ve kesinlik değerinde %79 performansları ile hareketli nesnelere doğru tespit ettiğini ve tespit ettiği nesnelere gerçek hareketli nesnelere olduğunu, F1_skor değerinin %75 performansı ile yüksek kesinlik ve yüksek duyarlılık arasındaki dengeyi tuttuğunu, PWC değeri ile bu yöntemin hatalı sınıflandırma oranının %26 performansı ile hatalı sınıflandırmanın düşük olduğunu göstermektedir (Tablo 1). 111.mp4 videosu üzerinde gerçekleştirilen 60-80 dinamik aralıklı güncellenmeyen arka plan çıkarımı (ortalama) algoritması, diğer algoritmalara göre hedefteki nesnelere daha doğru bir şekilde tespit etmektedir.

Tablo 4. 111.mp4 Videosu Üzerinden Kullanılan Yöntemlerin Başarıım Metriklerinin Karşılaştırılması

	Sp	Ac	Pr	Re	F1	PWC	FPR	FNR	Zaman (s)
Çerçeve Farkı	1.00	1.00	0.84	0.27	0.41	0.43	0	0	301.32
Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	1.00	0.88	0.13	0.23	0.49	0	0	108.71
Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.39	0.18	0.24	0.61	0	0	348.42
Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	1.00	0.97	0.17	0.30	0.46	0	0	333.97
60-80 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.60	0.27	0.37	0.50	0	0	339.53
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.96	0.96	0.10	0.77	0.18	3.81	0.04	0	117.33
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	1.00	0.79	0.71	0.75	0.26	0	0	196.35

55-150 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.40	0.27	0.33	0.62	0	0	115.77
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.96	0.96	0.11	0.76	0.19	3.62	0.04	0	159.49
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	1.00	0.66	0.72	0.69	0.36	0	0	111.91

121.mp4 videosu için en uygun başarımları veren algoritmalar, 55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama) ve 60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)'dır. Bu iki algoritma, diğer algoritmaların başarımları ile karşılaştırıldığında özgüllük, doğruluk, duyarlılık, kesinlik ve F1_skor değerleri bakımından yüksek performans ile hareketli nesnelere daha doğru bir şekilde tespit etmektedirler. Bu iki algoritma, zaman bakımından karşılaştırıldığında 55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama) algoritmasının daha hızlı olduğu görülmektedir (Tablo 2).

Tablo 5. 121.mp4 Videosu Üzerinden Kullanılan Yöntemlerin Başarımları Metriklerinin Karşılaştırılması

	Sp	Ac	Pr	Re	F1	PWC	FPR	FNR	Zaman (s)
Çerçeve Farkı	1.00	0.99	0.85	0.26	0.39	0.68	0	0.01	226.12
Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.89	0.12	0.21	0.77	0	0.01	159.97
Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.51	0.14	0.21	0.86	0	0.01	170.08
Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	0.99	0.94	0.13	0.24	0.75	0	0.01	192.69
60-80 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.85	0.26	0.40	0.68	0	0.01	238.24
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.98	0.98	0.25	0.71	0.37	2.04	0.02	0	124.38
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	1.00	0.84	0.66	0.74	0.40	0	0	105.10
55-150 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.85	0.26	0.40	0.68	0	0.01	87.12
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.98	0.98	0.26	0.69	0.38	1.95	0.02	0	86.31
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	1.00	0.84	0.67	0.74	0.40	0	0	85.76

311.mp4 videosu için en uygun başarımları veren algoritma, güncellenmeyen arka plan çıkarımı (ortalama)'dır. Bu algoritma ile özgüllük, doğruluk, kesinlik değerleri bakımından yüksek performans elde edilmiştir. PWC değerinin %48 çıkmasıyla en düşük hatalı

sınıflandırma yapma yüzdesine sahiptir. İşlem süresi uzun sürmesine rağmen hareketli nesnelere tespit doğruluğu açısından en iyi sonuçlara sahip olduğunu göstermektedir (Tablo 3).

Tablo 6. 311.mp4 Videosu Üzerinden Kullanılan Yöntemlerin Başarım Metriklerinin Karşılaştırılması

	Sp	Ac	Pr	Re	F1	PWC	FPR	FNR	Zaman (s)
Çerçeve Farkı	0.87	0.87	0.01	0.29	0.02	13.44	0.13	0	272.99
Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.85	0.06	0.11	0.52	0	0.01	115.43
Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0.55	0.14	0.23	0.54	0	0	117.97
Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	1.00	0.98	0.14	0.24	0.48	0	0	255.92
60-80 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	0.79	0.79	0.01	0.42	0.02	20.98	0.21	0	132.39
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.96	0.95	0.08	0.65	0.13	4.58	0.04	0	93.41
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	0.85	0.85	0.02	0.64	0.05	15.07	0.15	0	94.93
55-150 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	0.89	0.89	0.01	0.29	0.03	11.30	0.11	0	96.09
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.97	0.97	0.10	0.62	0.18	3.18	0.03	0	117.08
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	0.96	0.95	0.06	0.54	0.11	4.62	0.04	0	118.06

421.mp4 videosu için en uygun başarım metriği veren algoritma, 55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)'dir. Diğer algoritmalar ile karşılaştırıldığında başarım metriklerinde yüksek performans sağlamaktadır. Ayrıca bu algoritmanın, zaman açısından kısa sürmesi ve hareketli nesnelere tespit doğruluğu açısından en iyi sonuçların olduğu görülmektedir (Tablo 4).

Yapılan karşılaştırmalı analizlerde elde edilen sonuçlar arka plan çıkarımı yönteminin iyileştirilmesi için önerilen yaklaşımın kullanıldığı ve arka plan çıkarımının tekrar edilmediği versiyonun daha yüksek performans sağladığını göstermektedir. Gerçekleştirilen çalışma, sabit kameralardan alınan görüntülerde hareketli nesne tespiti için önerilen arka plan çıkarımı yaklaşımının, özellikle arka planın sabit ancak hava değişimlerinden kaynaklı dinamik koşullarda yüksek doğruluk sağladığını ortaya koymaktadır.

Tablo 4. 421.mp4 Videosu Üzerinden Kullanılan Yöntemlerin Başarım Metriklerinin Karşılaştırılması

	Sp	Ac	Pr	Re	F1	PWC	FPR	FNR	Zaman (s)
Çerçeve Farkı	0.94	0.94	0.04	0.29	0.07	6.29	0.06	0.01	193.49
Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	1.00	0	0	0.86	0	0.01	85.59
Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	1.00	0.99	0	0	0	0.86	0	0.01	105.04
Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	1.00	0.99	-	0	-	0.86	0	0.01	104.82
60-80 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	0.91	0.90	0.04	0.38	0.06	9.53	0.09	0.01	86.03
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.98	0.97	0.19	0.65	0.30	2.67	0.02	0	85.37
60-80 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	0.92	0.92	0.07	0.64	0.12	8.10	0.08	0	84.77
55-150 dinamik aralıklı Güncellenen Arka Plan Çıkarımı (Medyan Süzgeci)	0.94	0.93	0.04	0.30	0.07	6.80	0.06	0.01	85.25
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Medyan Süzgeci)	0.99	0.99	0.49	0.56	0.52	0.88	0.01	0	86.75
55-150 dinamik aralıklı Güncellenmeyen Arka Plan Çıkarımı (Ortalama)	0.95	0.94	0.09	0.61	0.16	5.67	0.05	0	86.56

SONUÇ

Hareketli nesnelerin tespiti ve tanınması özellikle toplumsal ve askeri alanlardaki uygulamalarda önemli bir çalışma alanıdır. Bu alandaki çalışmalar birden fazla nesnenin tespiti, değişen hava koşulları, aydınlanma seviyesindeki değişkenlik ve arka plan değişimleri kaynaklı zorlukların çözümü üzerinde yoğunlaşmakta olup kullanılan yöntemler farklı performanslar sergileyebilmektedir. Hareketli nesne tespitinde çerçeve farkı ve arka plan çıkarımı en yaygın kullanılan yöntemlerdir. Bu çalışmada, sabit kameralardan alınan görüntülerdeki hareketli nesnelerin tespiti için kullanılan arka plan çıkarım yöntemi ve bu yöntemin arka plan modelinin farklı yaklaşımlarla elde edildiği yöntemler ve elde edilen yöntemlerin dinamik aralık parametresinin değiştirilerek farklı versiyonları ile elde edilen sonuçlar çerçeve farkı yönteminin sonuçları ile karşılaştırılarak performansları değerlendirilmiştir. Çalışmada BMC2012 sentetik veri setindeki dört farklı senaryo ile oluşturulmuş videolardaki sabit kameralardan alınan görüntülerdeki hareketli nesnelerin tespiti yapılmış ve algoritmaların başarım metrikleri hesaplanmıştır. Yapılan karşılaştırmalı analizlerde elde edilen sonuçlar arka plan çıkarımı yönteminin iyileştirilmesi için önerilen

yaklaşımın kullanıldığı ve arka plan çıkarımının tekrar edilmediği versiyonun daha yüksek performans sağladığını göstermektedir.

KAYNAKLAR

- [1] Hanchinamani, S., R., Sarkar, S. and Bhairannawar, S. 2016. Design and Implementation of High-Speed Background Subtraction Algorithm for Moving Object Detection. 6th International Conference On Advances In Computing & Communications, ICACC, Vol. 93, 367-374.
- [2] Husein, A., M., Calvin and Halim, D. 2019. Motion detect application with frame difference method on a surveillance camera. Journal of Physics Conference Series, 1230:012017.
- [3] Xu, Y., Ji, H., and Zhang, W. 2020. Coarse-to-fine sample-based background subtraction for moving object detection. Optik, vol. 207, pp. 164-195.
- [4] Tao, J. and Yu, C. 2008. Real-time detection and tracking of moving object. Intelligent Information Technology Application. UTA '08. Second International Symposium on Volume 2, 20-22 Page(s):860 – 863.
- [5] Manipriya, S., Mala, C., and Mathew, S. 2014. Performance analysis of spatial color information for object detection using background subtraction. IERI Procedia, 10:63–69.
- [6] Sobral, A. and Vacavant, A. 2014. A comprehensive review of background subtraction algorithms evaluated with synthetic and real videos. Computer Vision and Image Understanding, vol. 122, pp. 4–21.
- [7] Savaş, M.F., Demirel, H. and Erkal, B. 2018. Moving object detection using an adaptive background subtraction method based on block-based structure in dynamic scene. Optik 168:605–618.
- [8] Vacavant, A., Chateau, T., Wilhelm, A., and Lequievre, L. 2012. A benchmark dataset for outdoor foreground/background extraction. In: Background Models Challenge (BMC) at Asian Conference on Computer Vision (ACCV), LNCS, vol. 7728, Springer, pp. 291-300.
- [9] Yousefi, J. 2011. Image binarization using Otsu thresholding algorithm. University of Guelph, Ontario, Canada, 1-4.

HAVA ARAÇLARINDA KULLANILAN BONDING JUMPER MALZEMELERİ
BONDING JUMPER MATERIALS USED IN AIRCRAFTS

Burak GÜLER

Erciyes Üniversitesi Fen Bilimleri Enstitüsü Havacılık Elektrik ve Elektronik ABD, Kayseri/TÜRKİYE

ORCID NO: 0000-0002-2971-9858

Veysel ERTURUN

Doç. Dr., Erciyes Üniversitesi Havacılık ve Uzay Bilimleri Fakültesi Uçak Gövde ve Motor Bakımı,
Kayseri/TÜRKİYE

ORCID NO: 0000-0003-2201-3411

Faruk KOCA

Erciyes Üniversitesi Fen Bilimleri Enstitüsü Uçak Mühendisliği ABD, Kayseri/TÜRKİYE

ORCID NO: 0009-0004-0864-3657

ÖZET

Bu çalışmada hava araçlarını yıldırımdan koruyan yapı olan bonding jumper ürününde kullanılan malzemeler ele alınmıştır. Kullanılan malzemeler birbirleriyle karşılaştırılmıştır. Eksiklikler belirtilmiş, bu konuda yapılacak çalışmalara teşvik ve ilham kaynağı olmuştur. Son zamanlarda bu konuda bir çalışma yapılmamış olmasından dolayı literatüre bu alanda bir çalışma kazandırılmıştır.

Anahtar kelimeler: Havacılık, bonding jumper, bakır tel kaplama, yıldırımdan korunma.

ABSTRACT

In this study, the materials used in the bonding jumper product, which is the structure that protects aircraft from lightning, are discussed. The materials used were compared with each other. Deficiencies have been stated and it has been a source of encouragement and inspiration for the studies to be carried out on this subject. Since there has not been a study on this subject recently, a study in this field has been added to the literature.

Keywords: Aviation, bonding jumper, plating of copper wire, protection of lightning strike.

BONDING JUMPER

Bonding jumper'lar, havacılık endüstrisindeki hava araçlarında kullanılan önemli elektriksel bağlantı elemanlarından. Bu parçalar, bir uçağın içerisinde yer alan sayısız elektrik devresi ve yapının arasındaki iletim sorununu çözmek amacıyla tasarlanmışlardır (Fisher vd., 1989).

Genellikle ince elektrik tellerinden oluşan örüntülerle üretilen bonding jumper'lar, uçaktaki milyonlarca bileşenin birbirine bağlanmasını sağlayarak, tüm sistemin elektriksel bütünlüğünün korunmasında etkin rol oynar. Yapıları, yüzlerce adet küçük çaplı telin bir araya getirilmesiyle oluşturulur. Bu sayede uçakta yer alan farklı devre ve sistemler arasındaki iletkenlik sorunsuz bir şekilde gerçekleşir. Bonding jumper'ların bu özelliği, havacılık sektöründe güvenli uçuş için büyük önem taşımaktadır (Federal aviation administration, 1977).

Hava araçlarında kullanılan Bonding jumper tel malzemeleri genellikle şu şekildedir (Glenair, 2017):

- Saf bakır
- Kalay kaplı bakır
- Nikel kaplı bakır
- Gümüş kaplı bakır
- Paslanmaz çelik
- Alüminyum

Bonding jumper parçalarının üretiminde kullanılan malzeme seçimi, performans ve maliyet gibi faktörlere bağlı olarak değişebilmektedir. Bonding jumper yapılarının bağlandığı terminallerin malzeme seçimi de önem taşımaktadır. Farklı metal malzemelerin bir araya gelmesi durumunda, aralarındaki elektriksel potansiyel farklılığı nedeniyle galvanik korozyon meydana gelebilir. Bu sebeple, bonding jumper malzemesi ile terminaller arasında benzerlik gösteren elektriksel özellikte malzemeler tercih edilmektedir. Böylece anot ve katot oluşumunun önüne geçilip, korozyon riski en aza indirgenebilmektedir. Terminallerin uçak gövdesi ile bağlantısı için de aynı hassasiyet gösterilir. Malzeme uyumluluğu sayesinde galvanik korozyonun engellenmesi, bonding jumper parçalarının ve uçak yapısının ömrünü uzatmasının yanı sıra uçuş emniyeti açısından da büyük önem taşımaktadır (DEHN, 2014).

TEL KAPLAMA YÖNTEMLERİ

Tel kaplamalarında en çok akımlı ve akımsız kaplama yöntemleri kullanılmaktadır. Kaplama yöntemlerinin temel amacı, malzemeyi aşınmaya, korozyona, yüksek sıcaklıklara ve diğer dış etkenlere karşı koruyarak malzemenin ömrünü ve performansını artırmaktır (Çapkin, 2014).

Akımlı Kaplama Yöntemi (Current Plating Method)

Akımlı kaplama/elektroliz süreci, iki farklı metal elektrot ve bunlar arasında bir akım kaynağı kullanılarak bir elektrolit içerisinde gerçekleştirilen bir kimyasal reaksiyondur. Söz konusu deneysel düzenekte, elektrolit özelliği gösteren tuz çözeltisi veya erimiş tuz yatağı kullanılmaktadır. Elektrotların bu çözeltiliye batan kısımlarında, elektrolitin iletkenliği sayesinde akım geçişiyle birlikte bazı kimyasal değişimler meydana gelmektedir. Bu süreç sonucunda elektrot yüzeylerinde oksidasyon ve indirgenme tepkimeleri gerçekleşir. Elektrotlar arasında kontrollü bir şekilde aktarılan elektronlar aracılığıyla gelişen bu kimyasal

değişimler bütününe "elektroliz" ismi verilmektedir. Elektroliz sayesinde farklı metallerin elde edilmesi gibi uygulamalar gerçekleştirilebilmektedir. Elektroliz sürecinin başlaması için katot ve anot arasında yeterli düzeyde bir potansiyel farkının oluşturulması gerekmektedir. Bu minimum potansiyel fark değerine literatürde "ayırışma potansiyeli" denilmektedir. Aksi takdirde kimyasal tepkimeler meydana gelmeyecektir. Deneysel düzeneğin elektrot malzemelerine ve kullanılan elektrolite bağlı olarak değişebilen bu ayırışma potansiyeli, sistemin elektrokimyasal dengesinin bozulması ve iyonların indirgenme-oksidasyon tepkimelerine girmesi için gereken asgari gerilim değerini ifade etmektedir. Deneysel koşulları optimize edilirken elektrotlar arasındaki potansiyel farkın bu eşik değerin üzerinde tutulması sağlanmaktadır. Böylece beklenen elektrolitik reaksiyonların başlaması ve sürdürülebilirliği hedeflenmektedir (Tan, 2022).

Elektroliz sırasında iyonların elektrotlara göç hareketi meydana gelmektedir. Pozitif yüklü iyonlar (katyonlar) elektriksel çekim etkisiyle negatif kutuptaki katoda, negatif yüklü iyonlar (anyonlar) ise pozitif kutuptaki anoda doğru hareket ederler. Bu iyonik hareket sonucunda, elektrot yüzeylerinde redoks reaksiyonları gerçekleşir. Katoda göçen katyonlar burada indirgenirken, anyonların gitmesine paralel olarak anot yüzeyinde oksidasyon tepkimesi meydana gelir. Böylece elektrotlarda farklı kutuplarda yer alan kimyasal değişimler sayesinde, sistemdeki iyonların yeni bileşiklere dönüşümü sağlanmış olur. Elektroliz esnasında iyonik taşınım ve elektrot yüzeylerinde gerçekleşen redoks mekanizması, bu tür deneysel düzeneklerin temel işleyiş prensibini oluşturmaktadır. Elektroliz sürecinde, iyonların elektrotlara göçüyle birlikte kimi redoks reaksiyonlarının meydana geldiği bilinmektedir. Pozitif yüklü iyonlar (katyonlar) negatif kutuptaki katoda ulaştığında, burada elektron alarak indirgenirler. Benzer şekilde, negatif yüklü iyonlar (anyonlar) ise pozitif kutuptaki anoda geldiklerinde, elektronlarını vererek oksidasyon geçirirler. Başka bir deyişle, katyonlar katot yüzeyinde elektron kazanarak yüklerini dengelemekte; anyonlar da anotta elektron kaybederek yük değiştirmektedir. Bu elektrokimyasal mekanizma neticesinde iyonların farklı bileşiklere dönüştüğü gözlemlenmektedir. Sonuç olarak, elektroliz sayesinde iyonların redoks tepkimelerine uğrayarak bileşenlerinin değişebildiği anlaşılmaktadır (Aydın, 2021).

Deneysel sistemin elektrot malzemeleri ve kullanılan elektrolitin kimyasal koşullarına bağlı olarak gerçekleşen bu reaksiyonlar neticesinde, yeni kimyasal maddeler elde edilebilmektedir. Elektroliz hücresinde meydana gelen redoks reaksiyonlarında birden fazla iyonun rol alabileceği bilinmektedir. Literatürde standart elektrot potansiyeli olarak adlandırılan minimum ayırışma potansiyellerinin karşılaştırılması, elektrotlarda öncelikle hangi iyon reaksiyonuna gireceğini tahmin etmede yardımcı olmaktadır. Örneğin, elektrolit içerisinde hem katyon hem de anyonların bulunduğu kompleks bir sistemde; anot ve katottaki ilk oksidasyon/indüksiyon tepkimelerini belirlemek amacıyla, söz konusu iyonların standart elektrot potansiyel değerleri mukayese edilmektedir. Potansiyeli düşük olan iyon reaksiyona ilk olarak girecektir. Böylelikle elektrot yüzeyinde meydana gelecek kimyasal değişimin seyrini tahmin etmek mümkün olmaktadır. Bu yaklaşım sayesinde, elektroliz sistemlerinin

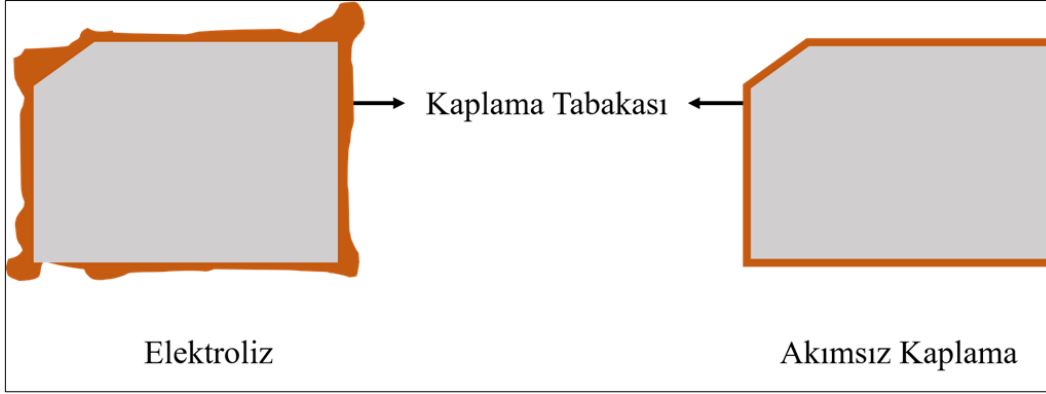
daha iyi anlaşılması hedeflenmektedir. Elektroliz kaplamada kaplanacak iyonun sağlanma yöntemleri hakkında iki olası yol bulunmaktadır. Birinci yöntem, elektrolit çözeltisine dışarıdan ilave edilen bir metal tuzunun çözünmesiyle iyon elde etmeyi kapsamaktadır. Böylece çözeltiliye istenilen elementin iyonları eklenmiş olur. İkinci yöntem ise, anottaki metalik malzemenin elektroliz esnasında çözünmesiyle iyon kaynağını oluşturma prensibine dayanır. Buradaki mekanizma, anottaki metalin oksidasyon geçirerek çözeltiliye iyon salınmasını ifade etmektedir. Her iki yaklaşım da literatürde kullanılmakta olup, kaplama yapılacak elemente, elektrot malzemelerine ve çözelti koşullarına bağlı olarak tercih edilmektedir. Amacın istenilen metal iyonlarını kaplama alanına ulaştırarak kaplama reaksiyonunu gerçekleştirmek olduğu belirtilebilir (Temelkuran, 1997).

Akımsız Kaplama Yöntemi

Elektrik akımına gerek duymadan gerçekleştirilen akımsız kaplama yöntemi, otokatalitik kimyasal indirgeme reaksiyonunun temelini oluşturmaktadır. Bu teknikte, metal yüzeylere kaplanacak atomlar kendiliğinden bir redoks reaksiyonu sonucu indirgenerek yüzeye birikebilmektedir. Literatürde sıklıkla rastlanan bu yaklaşım, elektriksel devre kurmama avantajı sunmakta, ancak indirgeme reaksiyonunun kontrol altında tutulması gerekmektedir (Eraslan, 2010).

Akımsız kaplamada, katalizör olarak elektroda uygulanan iyonların, kendilerinden sonra gelen iyonları indirgeyerek yüzeyde birikmesini sağlayan otokatalitik mekanizma etkilidir. Böylece düzenli bir kaplama tabakası elde edilebilmektedir. Kimyasal yolla gerçekleşen bu süreç, çeşitli endüstriyel uygulamalarda maliyet avantajı sunmakta, fakat kinetik parametrelerin iyi ayarlanmasını gerektirmektedir. Tipik bir akımsız kaplama çözeltisinin temel bileşenleri bulunmaktadır. Bunlar; kaplanacak metal iyonlarını sağlayan metal tuzu, iyonların indirgenmesini sağlayan redüktans ajan, iyonların stabil kompleksler oluşturmasını ve çözelti içinde homojen dağılımını sağlayan kompleks ajanı ile kaplama reaksiyonunun seyrini kontrol altında tutan stabilizatördür. Bu bileşenler arasındaki kimyasal etkileşimler sonucunda, yüzeye kaplanmak istenen elementlerin iyonları yüzeye düzenli biçimde birikerek kaplama tabakası oluştururlar. Optimum koşulların ayarlanması sayesinde istenilen incelikte ve yapıdaki kaplama elde edilmesi amaçlanır. Literatürde yer alan birçok çalışmada, farklı metal tuzu, redüktans ve kompleks ajanlarının deneysel parametrelerdeki etkisi incelenmiştir. Böylece akımsız kaplamanın kontrollü bir şekilde gerçekleştirilebilmesi hedeflenmektedir. Akımsız kaplamalarda genellikle homojen kaplama yapılmaktadır (Algül, 2020).

Şekil 1’de görüldüğü gibi akımsız kaplamada, akımlı kaplamaya göre daha pürüzsüz ve daha homojen bir kaplama meydana gelmektedir (Akçay, 2021).



Şekil 1. Akımlı ve akımsız kaplama yöntemi

KULLANILAN MALZEMELER

1 numaralı başlık altında en çok kullanılan bonding jumper malzemeleri sıralanmıştır. Bu malzemeler sırasıyla 3 numaralı başlığın alt başlıklarında incelenmektedir.

Saf Bakır

Saf bakır tel, % 99.5 ile % 99.95 arasında olan oksijensiz bakır telden biraz daha düşük bir bakır içeriğine sahiptir. Diğer safsızlıklar demir ve oksijen gibi bazı metallerdir. Saf bakır tel, mükemmel iletkenliğe, termal iletkenliğe, plastisiteye sahiptir ve preslenmesi kolaydır (Akkaş “akımsız kaplama yöntemi”, 2011).

Bakır $8,9 \text{ g/cm}^3$ yoğunluğa sahiptir. Erime noktası $1083 \text{ }^\circ\text{C}$ 'dir. Oda sıcaklığındaki elektrik direnci $1,68 \times 10^{-8} \Omega\text{m}$ 'dir. Yumuşaktır ve işlenebilirdir (Vikipedi “bakır”, 2024).

Saf bakır tel $8,9 \text{ g/cm}^3$ yoğunluğa sahiptir. Elektrik iletkenliği uluslararası tavllanmış bakır standardına göre %103 civarındadır ve değeri yaklaşık olarak $58,5 \text{ m/Ohm.mm}^2$ ($1,7 \times 10^{-8} \Omega\text{m}$)'dir. Çekme dayanımı yaklaşık 244 MPa 'dır. Max çalışma sıcaklığı $0,381 \text{ mm}$ 'den küçük teller için $60 \text{ }^\circ\text{C}$ iken $0,381 \text{ mm}$ 'den büyük çaptaki teller için $200 \text{ }^\circ\text{C}$ 'dir (Raougui, 2023).

Kalay Kaplı Bakır

Kalay kaplı bakır tel, elektrik ve elektronik endüstrisinde geniş bir kullanım alanına sahip olan önemli bir malzemedir. Bu tel türü, bakır telin yüzeyine kalay tabakası uygulanarak elde edilir. Kalay kaplamanın temel amacı, bakır telin korozyona karşı direncini artırmak, kaynaklanabilirliğini iyileştirmek, estetik bir görünüm sağlamak ve lehimleme işlemlerinde kolaylık sağlamaktır. Kalay kaplı bakır telin özellikleri incelendiğinde, elektrik iletkenliğinin bakır telin iletkenliğiyle benzer olduğu görülür. Ancak kalay kaplamanın getirdiği avantajlar arasında korozyona karşı dayanıklılık ve lehimleme işlemlerinde kolaylık vardır. Kalay kaplama, bakır telin yüzeyini koruyarak oksidasyonu engeller ve telin ömrünü uzatır. Elektronik devrelerde ve iletişim sistemlerinde kullanılan kalay kaplı bakır tel, sinyal iletiminde yüksek performans sağlar. Ayrıca, lehimlenmesi kolay olduğundan montaj süreçlerinde verimliliği artırır. Endüstriyel uygulamalarda da sıklıkla tercih edilen bu

malzeme, güçlü iletkenlik özellikleriyle elektrik ve elektronik sistemlerde güvenilir bir performans sunar (Aerumtec “material for”, 2024; Harput ve Onuk, 2011).

Kalayın yoğunluğu 7.265 g/cm^3 'tür. Erime noktası $231,93 \text{ }^\circ\text{C}$ 'dir. Oda sıcaklığındaki elektrik direnci $8,69 \text{ m}/\Omega\text{mm}^2$ ($11,5 \times 10^{-8} \Omega\text{m}$)'dir. Yumuşaktır ve işlenebilirdir. Korozyona karşı dirençlidir (Vikipedi “kalay”, 2024).

Yaklaşık 2-3 μm kaplama kalınlığına sahip kalay kaplı bakır tel, $8,9 \text{ g/cm}^3$ yoğunluğa sahiptir. Elektrik iletkenliği uluslararası tavllanmış bakır standardına göre %97 civarındadır ve değeri yaklaşık olarak $58,5 \text{ m}/\text{Ohm}.\text{mm}^2$ ($1,7 \times 10^{-8} \Omega\text{m}$)'dir. Çekme dayanımı yaklaşık 210 MPa'dır. Termal iletkenliği iyidir. Max çalışma sıcaklığı 0,381 mm'den küçük teller için $150 \text{ }^\circ\text{C}$ iken 0,381 mm'den büyük çaptaki teller için $200 \text{ }^\circ\text{C}$ 'dir (Sumitomo electric “electroplated wire”, 2024; Wagner “materials”, 2013).

Nikel Kaplı Bakır

Nikel kaplı bakır tel, elektrik ve elektronik endüstrisinde çeşitli uygulamalarda kullanılan önemli bir malzemedir. Bu tel türü, bakır telin yüzeyine nikel tabakası uygulanarak elde edilir. Nikel kaplamanın temel amacı, bakır telin korozyona karşı direncini artırmak, mekanik dayanıklılığını yükseltmek, sıcaklık dayanımını artırmak ve estetik bir görünüm sağlamaktır. Nikel kaplı bakır telden beklenen özellikler incelendiğinde, bu malzemenin yüksek korozyona karşı direnç sağladığı görülür. Nikel tabakası, telin yüzeyini oksidasyona karşı korur ve telin ömrünü uzatır. Ayrıca, nikel kaplama telin mekanik dayanıklılığını artırır ve telin bükülme ve gerilme streslerine karşı daha dirençli hale gelmesini sağlar (Güler, 2023; Onan vd., 2022).

%27 oranında kaplama kalınlığı 750°C 'ye kadar ulaşan sıcaklık koruması sağlar. Kaplama ayrıca -60°C 'ye kadar düşük negatif sıcaklıklarda korozyona karşı üstün direnç sağlar. Nikel ayrıca alkaliler, indirgeyici kimyasallar ve tuz spreylere gibi elementlere karşı da yüksek dirence sahiptir (Nassau electrical supply “good reason”, 2024; My material “when to”, 2023).

Nikelin yoğunluğu $8,90 \text{ g/cm}^3$ 'tür. Erime noktası $1455 \text{ }^\circ\text{C}$ 'dir. Oda sıcaklığındaki elektrik direnci $13,9 \text{ m}/\text{Ohm}.\text{mm}^2$ ($6,93 \times 10^{-8} \Omega\text{m}$)'dir (Vikipedi “nikel”, 2024).

Standart bakır tel üzerine nikel kaplamada yaklaşık %27 oranında nikel kullanılır. Yaklaşık 2-3 μm kaplama kalınlığına sahip nikel kaplı bakır tel, $8,9 \text{ g/cm}^3$ yoğunluğa sahiptir. -60°C - $+750^\circ\text{C}$ sıcaklıklara dayanıklıdır. Elektrik iletkenliği uluslararası tavllanmış bakır standardına göre %70 civarındadır ve değeri yaklaşık olarak $2,42 \times 10^{-8} \Omega\text{m}$ 'dir. Çekme dayanımı 300 MPa'dır. Max çalışma sıcaklığı $550 \text{ }^\circ\text{C}$ 'dir (Little false alloys “use nickel”, 2011; Anomet products “nickel clad”, 2015; Gem electromechanicals “nickel plated”, 2018).

Gümüş Kaplı Bakır

Gümüş kaplamalı bakır teller çıplak bakır tellere göre birçok avantaj sağlar çünkü gümüş metaller arasında bilinen en iyi ısı ve elektrik iletkenidir, bakır ise ikinci en iyi iletkenidir.

Gümüş kaplama daha yüksek iletkenlik ve korozyon direnci sağlarken, bakır çekirdek yüksek süneklik ve gerilme mukavemeti sunar. Gümüş kaplamalı bakır tel, gümüşün iletkenliğini bakırın dayanıklılığı ile saf gümüş telden daha düşük bir maliyetle birleştirir. Yüksek iletkenlik, korozyon direnci ve dayanıklılığın gerekli olduğu elektrik kabloları, elektronik, mücevher ve tıbbi cihazlarda uygulamaları vardır (Varol vd. 2021).

Gümüşün yüksek korozyon direnci, bakır telin kimyasal dayanımını olumlu yönde etkileyerek ömrünü uzatmaktadır. Gümüş katmanın bakır tellere eklenmesi, bakırın mekanik özelliklerini olumlu yönde etkilemektedir. Bu durum, gümüş kaplamalı bakır telin daha yüksek bir sünekliğe sahip olabileceğini gösterir. Süneklik, bir metalin şekil değiştirebilme kabiliyetini ifade eder ve bu özellik, metalin büyük elektrik akımlarını taşıma kapasitesini artırır. Dolayısıyla, gümüş kaplı bakır tel, özellikle yüksek akım taşıma gerektiren uygulamalarda çıplak bakır tellere ve elektrik konnektörlerine tercih edilebilecek bir alternatif olmaktadır (Çukul, 2013).

Gümüş kaplama termal hasarlara ve korozyona yol açan oksidatif hasarlara karşı direnç sağlar. Yüksek sıcaklıklara karşı direnç, gümüşü 650 °C'ye kadar sıcaklıklara maruz kalan yüzeylerde yüksek sürtünmeli uygulamalarda kullanılan bakır teller için tercih edilen kaplama malzemesi yapar. Sinyal iletim hızı, bakır tellerin direncini de azalttığı için gümüş kaplama ile önemli ölçüde artar. Dış yüzeyleri parlak, ışıltılı ve gümüş rengindedir, bu da onları daha estetik kılar (Hebei yuguang welding “nikel kaplama”, 2023).

Gümüşün yoğunluğu 10,49 g/cm³'tür. Erime noktası 961,8 °C'dir. Oda sıcaklığındaki elektrik direnci 1,59x10⁻⁸ Ωm'dir (Vikipedi “gümüş”, 2024).

Yaklaşık 2-3 µm kaplama kalınlığına sahip nikel kaplı bakır tel, 8,9 g/cm³ yoğunluğa sahiptir. Elektrik iletkenliği uluslararası tavllanmış bakır standardına göre %103 civarındadır ve değeri yaklaşık olarak 1,72 x10⁻⁸ Ωm'dir. Max çalışma sıcaklığı 200 °C'dir. Çekme dayanımı yaklaşık 244 MPa'dır (Harput ve Ayhan, 2012; Sumitomo electric “electroplated wire”, 2024).

Paslanmaz Çelik

Krom, çeliğin paslanmazlık yeteneğini sağlayan temel bir elementtir. Kromun çeliğe katılması, çeliğin paslanmazlık özelliğini artırır. Çeliğe eklenen krom, atmosferdeki oksijenle etkileşime geçerek yüzeyinde krom oksit tabakası oluşturur. Bu ince tabaka, çeliğin havayla temasını engelleyerek koruyucu bir bariyer oluşturur. Krom oksit tabakasındaki bağlar belirli bir miktarda dayanıklılığa sahiptir; ancak aşırı korozif ortamlarda bu bağlar zayıflayabilir ve paslanma meydana gelebilir. Korozyona karşı direncin artırılması için çeliğin içindeki krom miktarı artırılabilir. Bu, çeliğin daha fazla koruyucu krom oksit tabakası oluşturmasına ve daha etkili bir paslanmazlık sağlamasına yardımcı olabilir (Kayır, 2007).

304 ve 316 paslanmaz çelik bağlantı teli mükemmel dayanıklılığa sahiptir ve 870°C'ye kadar yüksek sıcaklıklara dayanabilir. Paslanmaz çelik bağlantı teli daha yüksek karbon içeriğine

sahipse 925°C'ye kadar sıcaklıklara dayanabilir. Bu ürünler sadece son derece esnek olmakla kalmaz, aynı zamanda manyetik geçirgenliğe ve olağanüstü mukavemete sahiptir (Saklakoğlu vd., 2016; Özakin ve Kurgan, 2022).

Paslanmaz çelik tel, 7,93 g/cm³ yoğunluğa sahiptir. Elektrik iletkenliği uluslararası tavllanmış bakır standardına göre %20 civarındadır ve değeri yaklaşık olarak $70 \times 10^{-8} \Omega m$ 'dir. Max çalışma sıcaklığı 300 °C'dir. Erime noktası 1390°C'dir. Çekme dayanımı yaklaşık 670 MPa'dır (Scott precision wire "stainless", 2024; Vikipedi "paslanmaz", 2024).

Alüminyum

Alüminyum, doğada boksit cevheri formunda bulunur ve dünya genelinde en yaygın elementlerden biridir. Ayırıştırılarak elde edilen alüminyum, elektroliz yöntemiyle işlenir. Saf alüminyum yumuşak bir yapıya sahipken, alaşımları saf formunun 15 katı kadar dayanıklı olabilir. Alüminyumun çelik ve bakırdan üçte biri kadar ağırlığı vardır. Bu metal kolayca dövülebilir, işlenebilir ve şekillendirilebilir. Ayrıca yüksek düzeyde korozyon direncine sahiptir ve zehirleyici değildir; ayrıca manyetik özellik göstermez. Geri dönüştürülebilir bir metal olan alüminyum çevreci bir seçenektir. Geri dönüşüm süreci, ilk üretim enerjisinin sadece yüzde 5'ine ihtiyaç duyar (Yağcı vd., 2021).

Alüminyum, düşük yoğunluğa sahip bir elementtir ve çeliğin yaklaşık üçte biri kadar ağırlıktadır, bu da onu son derece hafif bir metal yapar. Alüminyumun hafif olması, üretim süreçlerinde kullanılan malzeme miktarını azaltarak genel üretim maliyetlerini düşürebilir. Ayrıca, alüminyum yüksek derecede sünek bir özelliğe sahiptir. Bu özellik, alüminyumun kolayca şekillendirilmesine, bükülmesine ve dövülmesine olanak tanır. Ayrıca, alüminyumun ince levhalara dövülebilme yeteneği, çeşitli uygulamalarda kullanım esnekliği sağlar. Alüminyum, saf formda bulunduğu yüzeyinde doğal olarak oluşan ince oksit tabaka sayesinde etkili bir korozyon direncine sahiptir. Bu koruyucu oksit filmi, alüminyumun yüzeyini çevresel etkilere karşı korur ve korozyona karşı direncini artırır (Çağan vd., 2017).

Alüminyum tel, 2,70 g/cm³ yoğunluğa sahiptir. Elektrik iletkenliği uluslararası tavllanmış bakır standardına göre %61 civarındadır ve değeri yaklaşık olarak $2,65 \times 10^{-8} \Omega m$ 'dir. Max çalışma sıcaklığı 70-90 °C'dir. Erime noktası 660°C'dir. Çekme dayanımı yaklaşık 310 MPa'dır (Vikipedi "alüminyum", 2024; The Engineering Toolbox "Aluminum", 2014).

SONUÇ

Bonding jumper parçalarının üretiminde kullanılan malzeme seçimi, performans ve maliyet gibi faktörlere bağlı olarak değişebilmektedir. Kullanılan her malzemenin ayrı avantajı ve performans sınırları mevcuttur.

Tablo 1, bonding jumper ürününde kullanılan malzemelerin birbirleriyle karşılaştırmasını içermektedir.

Tablo 1. Malzeme Karşılaştırma Tablosu

Malzeme	Yoğunluk (g/cm ³)	Elektrik Direnci (x10 ⁻⁸ Ωm)	Erime Sıcaklığı (°C)
Saf Bakır	8,9	1,68	1083
Kalay	7,2	11,5	231,93
Nikel	8,9	6,93	1455
Gümüş	10,49	1,59	961,8
Paslanmaz Çelik	7,9	70	1390
Alüminyum	2,7	2,65	660

Tablo 1 incelendiğinde en hafif malzeme alüminyum iken en ağır malzeme gümüştür. Elektrik direnci en düşük malzeme saf bakır iken en yüksek olan malzeme paslanmaz çeliktir. Erime sıcaklığı en yüksek malzeme nikel iken en düşük malzeme kalaydır. Tüm malzemeler ayrı ayrı avantaj ve dezavantajlara sahip olmakla birlikte özgündür. Bonding jumper yapılarında hafif, elektrik direnci düşük ve erime sıcaklığı yüksek malzeme olması istenmektedir. İstenen bu özellikler ele alındığında ana/çekirdek malzemenin saf bakır malzemesi olması daha verimlidir. Ana/çekirdek malzeme üzerine kaplama yapılması daha verimli olacaktır.

Tablo 2 bonding jumper ürünlerinde kullanılan tel malzemelerinin karşılaştırılmasını içermektedir.

Tablo 2. Tel Malzemesi Karşılaştırma Tablosu

Tel Malzemesi	Yoğunluk (g/cm ³)	Elektrik Direnci (x10 ⁻⁸ Ωm)	Çekme Dayanımı (MPa)	Max Çalışma Sıcaklığı (°C)
Saf Bakır	8,9	1,7	244	60
Kalay Kaplı Bakır	8,9	1,7	210	150
Nikel Kaplı Bakır	8,9	2,4	300	550
Gümüş Kaplı Bakır	8,9	1,7	244	200
Paslanmaz Çelik	7,9	70	670	300
Alüminyum	2,7	2,6	310	90

Tablo 2 incelendiğinde en hafif malzeme alüminyum iken en ağır malzeme bakır ve kaplanmış bakırdır. Elektrik direnci en düşük malzeme saf bakır, kalay kaplı bakır ve gümüş kaplı bakır iken en yüksek olan malzeme paslanmaz çeliktir. Max çalışma sıcaklığı en yüksek

malzeme nikel kaplı bakır iken en düşük malzeme saf bakırdır. Çekme dayanımı en yüksek malzeme paslanmaz çelik iken en düşük malzeme kalay kaplı bakırdır. Tüm malzemeler ayrı ayrı avantaj ve dezavantajlara sahip olmakla birlikte özgündür. Bonding jumper yapılarında hafif, elektrik direnci düşük, max çalışma sıcaklığı yüksek ve çekme dayanımı yüksek malzeme olması istenmektedir. İstenen bu özellikler ele alındığında ana/çekirdek malzemenin bakır, kaplama malzemesinin çalışma ortamına göre kalay, gümüş ve nikel olması daha verimli olmaktadır.

Genel havacılık uygulamalarında maliyet unsurlarının ön planda tutulduğu durumlarda, kalay kaplı bakırdan imalat tercih edilmektedir. Kalay, oksidasyona neden olan elementlere karşı yüksek dirence sahip olduğu için korozyonun kablo üzerindeki etkisini etkili bir şekilde azaltır. Bununla birlikte, kalay sadece yaklaşık 150°C'ye kadar oksidasyonu azaltmada etkili kalır.

Askeri havacılık gibi yüksek performans gerektiren alanlarda ise; gümüş kaplı bakır kullanımı ile 200°C'ye varan sıcaklıklara dayanım ve yüksek iletkenlik sağlanabilmektedir. Yakıt tankları için ise; kromatlama veya alüminyum kaplamalı malzemeler yakıt ile olası reaksiyon riskini düşürmek üzere seçilmektedir. Nikel kaplı bakır ise, diğer malzemelere göre daha yüksek sıcaklıklarda (-65°C ila 260°C arası) performans gösterebilmesi sebebiyle zorlayıcı çalışma şartlarında tercih edilmektedir. Malzeme seçimi, uygulama alanının özellikleri doğrultusunda planlanmaktadır (Glenair, 2017).

BİLGİ

Bu çalışma Doç. Dr. Veysel ERTURUN danışmanlığındaki Erciyes Üniversitesi Havacılık Elektrik ve Elektronik ABD öğrencisi Burak GÜLER'in doktora tez çalışmasının bir kısmını içermektedir.

TEŞEKKÜR

Bu çalışma Erciyes Üniversitesi, Bilimsel Araştırma Projeleri tarafından FDK-2024-13911 Nolu Araştırma Projesi olarak desteklenmiştir.

KAYNAKLAR

- Aerumtec, Material for electroplating:tin (2024). Erişim adresi <https://aerumtec.com/tin/>
- Akçay, S., Akımsız kaplama yöntemi (2021). Erişim adresi <https://malzemebilimi.net/akimsiz-kaplama-yontemi.html>
- Akkaş, C. (2011). Oksitli bakır cevherlerinden bakır kazanımı (Doktora tezi, Fen Bilimleri Enstitüsü).
- Algül, H. (2020). Akımsız kaplama yöntemi ile seramik partikül takviyeli nikel esaslı kompozit kaplamaların geliştirilmesi.

- Anomet products, Nickel clad copper (2015). Erişim adresi <https://www.anometproducts.com/content/nickel-clad-copper>
- Aydın, M. (2021). Dupleks Ni-P/Ni-Mo Bn (h) kompozit kaplamaların aşınma özelliklerinin incelenmesi (Yüksek lisans tezi, Sakarya Üniversitesi).
- Çağan, S. Ç., Uğurlu, M., Buldum, B. B., & Sevim, İ. (2017). Alüminyum ve alaşımlarının asker araçlarda kullanımı. II Uluslararası Savunma Sanayi Sempozyumu, 06-08.
- Çapkın, M. S. (2014). Akımsız kaplama tekniği kullanılarak ASTM A105 kalitede çeliğin nikel kaplanması; mikro yapısına, korozyon direncine ve sertliğine ısıl işlem etkisinin incelenmesi (Yüksek lisans tezi, Bilecik Şeyh Edebali Üniversitesi, Fen Bilimleri Enstitüsü).
- Çukul, D. (2013). Teknik ipliklerde son yıllardaki gelişmelere örnekler. Tekstil ve Mühendis, 20(91), 49-63.
- DEHN (2014). Lightning protection guide. DEHN + SÖHNE.
- Eraslan, S. (2010). Akımsız Ni-B kaplama sistemlerine W ilavesinin kaplama özellikleri üzerindeki etkisinin incelenmesi.
- Federal Aviation Administration (1977). Florida Institute of Technology workshop on grounding and lightning protection. Federal Aviation Administration.
- Fisher, F. A., Plumer, J. A., & Perala, R. A. (1989). Aircraft lightning protection handbook (No. DOT/FAA/CT-89/22).
- GEM Electromechanical, Nickel plated wires (2018). Erişim adresi <https://www.gemelectro.com/nickel-plated-wires.html>
- Glenair (2017). Braided wire protection. Glenair.
- Güler, O. (2023). Akımsız nikel kaplama süresinin yeni tür dentritik bakır-nikel alaşım tozlarının özellikleri üzerine etkisi. Niğde Ömer Halisdemir Üniversitesi Mühendislik Bilimleri Dergisi, 12(3), 1013-1020.
- Harput, S., Onuk, A. G. (2011). Bakır lamalarda bağlantı yüzeylerinin elektriksel temas direnci üzerindeki olumsuz etkileri ve bunların azaltılmasına yönelik çözüm yollarının araştırılması. Sarkuysan Elektrolitik Bakır Sanayii ve Ticaret A.Ş.
- Harput, S., Ayhan, C. (2012). Nikel kaplı bakır telin kullanım alanları. Sarkuysan Elektrolitik Bakır Sanayii ve Ticaret A.Ş.
- Hebei Yuguang Welding, Gümüş kaplama bakır tel kullanmanın avantajları nelerdir? (2023). Erişim adresi <https://tr.ygcladmetals.com/info/what-is-advantages-of-using-silver-plated-copp-88085345.html#:~:text=G%C3%BCm%C3%BC%C5%9F%C3%BCn%20daha%20g%C3%BCzel%20ve%20parlak,daha%20verimli%2C%20dayan%C4%B1kl%C4%B1%20ve%20esnektir.>
- Kayır, Y. Z. (2007). Türkiye paslanmaz çelik üretebilir mi?. Metalurji dergisi, (146).
- Little false alloys, Use nickel plated copper wires in harsh conditions (2011). Erişim adresi <https://www.lfa-wire.com/plated-wire/use-nickel-plated-copper-wires-in-harsh-conditions/>

- My material, When to use nickel-plated copper wire (2023). Erişim adresi https://www.mymmaterial.com/news_detail/26.html
- Nassau electrical supply, Good reasons why nickel plated copper cables perform well in harsh environments (2023). Erişim adresi <https://www.nassaelectrical.com/pages/good-reasons-why-nickel-plated-copper-cables-perform-well-in-harsh-environments>
- Onan, M., Topkaya, A. C., & Öksüztepe, E. (2022). Kaplamalı Terminal Blok Ucunda Tasarımsal Değişim Yapılarak Mekanik Özelliklerinin Araştırılması. Gazi Mühendislik Bilimleri Dergisi, 8(1), 103-109.
- Özakın, B., & Kurgan, N. (2022). AISI 304 paslanmaz çelik sac malzemelere temper haddeleme ile pürüzlülük transferinde haddeleme parametrelerinin etkisinin incelenmesi. Politeknik Dergisi, 25(3), 1201-1209.
- Raougui, J. (2023). Soğuk çekilmiş elektrolitik bakır tellerin yeniden kristallenme kinetiğinin incelenmesi= Investigation of effects of cold drawn on mechanical properties and recrystallization of electrolytic copper wire (Yüksek lisans tezi, Sakarya Üniversitesi).
- Saklakoğlu, N., İrizalp, S. G., Gökdemir, Z. E., & Polat, S. (2016). AISI 304 ve 316 paslanmaz çeliğinin HCl ve H₂SO₄ çözeltilerindeki gerilim korozyon çatlama davranışı. Dicle Üniversitesi Mühendislik Fakültesi Mühendislik Dergisi, 7(1), 139-149.
- Scott Precision Wire, Stainless steel 304L (2024). Erişim adresi <https://www.scottprecisionwire.com/technical-data/alloy-data-sheets/stainless-steel-304l-wire/#:~:text=The%20resistivity%20of%20stainless%20steel%20304L%20at%2020%20C%20B0C,104%2D135%20B5%20F0%2D%209B%2080.cm>.
- Sumitomo electric, Electroplated wire (2024). Erişim adresi <https://global-sei.com/electroplated-wire/technical/>
- Tan, S. (2022). Ultrasonik destekli akımlı kaplama tekniği ile üretilen ni-w-tio₂ kaplamaların tribolojik davranışlarının incelenmesi= Pulse electrodeposition of ni-w-tio₂ composite coatings under ultrasonic power: Effect of tio₂ concentration and ultrasound power on the high-temperature wear and electrochemical properties.
- Temelkuran, T. (1997). Elektroliz ile nikel-krom kaplamalar (Yüksek lisans tezi, Marmara Üniversitesi (Turkey)).
- The Engineering Toolbox, Aluminum and Copper Wires - Electrical Resistance vs. Cross-Sectional Area (2014). Erişim adresi https://www.engineeringtoolbox.com/copper-aluminum-conductor-resistance-d_1877.html
- Varol, T., Akçay, S., & Güler, O. (2021). Akımsız kaplama yöntemi ile Cu-Ag bimetal parçacıkların üretimi ve karakterizasyonu. Gümüşhane Üniversitesi Fen Bilimleri Dergisi, 11(2), 586-596.
- Vikipedi, Alüminyum (2024). Erişim adresi <https://tr.wikipedia.org/wiki/Al%C3%BCminyum>
- Vikipedi, Bakır (2024). Erişim adresi <https://tr.wikipedia.org/wiki/Bak%C4%B1r>

- Vikipedi, Gümüş (2024). Erişim adresi <https://tr.wikipedia.org/wiki/G%C3%BCm%C3%BC%C5%9F>
- Vikipedi, Kalay (2024). Erişim adresi <https://tr.wikipedia.org/wiki/Kalay>
- Vikipedi, Nikel (2024). Erişim adresi <https://tr.wikipedia.org/wiki/Nikel>
- Vikipedi, Paslanmaz çelik (2024). Erişim adresi https://tr.wikipedia.org/wiki/Paslanmaz_%C3%A7elik
- Wagner, Materials (2013). Erişim adresi <http://www.rexess.com/copper-wire-materials.html>
- Yağcı, T., Cöcen, Ü., Çulha, O., & Korkmaz, A. (2021). Alüminyum döküm alaşımlarına dair son yıllardaki akademik ve endüstriyel gelişmelere genel bakış ve değerlendirme. Uludağ Üniversitesi Mühendislik Fakültesi Dergisi, 26(3), 1191-1210.

**SÜRÜ DAVRANIŞLARI İLE TERMODİNAMİK PARÇACIK TOPLULUKLARI
ARASINDAKİ BENZERLİK**
ANALOGY BETWEEN SWARM BEHAVIOR AND THERMODYNAMIC PARTICLE
ASSEMBLY

Tarık Kunduracı

Dr., Manisa Celal Bayar Üniversitesi, Akhisar MYO, Elektrik ve Enerji Bölümü

Dr., Manisa Celal Bayar University, Akhisar Vocational High School, Department of Electricity and Energy

ORCID ID: 0000-0002-1854-1361

ÖZET

Bu bildiride, sürülerin merkezi olmayan birkaç basit hareket kuralı çerçevesinde toplu davranışlarının, termodinamik kanunları ile belirli ısı dengesi şartları olan bir parçacık topluluğunun davranışları arasındaki benzerliğe dikkat çekmek istenmektedir.

Sürü davranışlarının incelenmesinde kullanılan başlıca yöntemlerden birisi Vicsek Modelidir. Bu model, iki ve üç-boyutlu ortam içerisindeki sürü elemanlarının tabii olduğu yöresel hareket kuralları çerçevesinde toplu olarak bir sürünün nasıl toplu hareket deseni oluşturacağını iyi bir şekilde kestirmektedir. Bu modelde, herhangi bir sürü elemanının bir sonraki zaman adımında hızının ve konumunun ne olması gerektiği, bu elemanın şimdiki zamanda komşuluğundaki diğer elemanların hız ve konum bilgileri ile belirlenir. Ayrıca, bu sürünün hareketi harici birtakım kuvvetlerin de etkisi altında olacağından, bu kuvvetleri temsilen bir gürültü parametresi de ilave edilmiştir. Buna göre bir i elemanın hareketi,

$$\mathbf{x}_{i,j}(t+1) = \mathbf{x}_{i,j}(t) + \mathbf{v}_i \Delta t, \quad j = 1, 2.$$

$$\theta_{i,j}(t+1) = \bar{\theta}_i(t)_r + \Delta \theta_{i,j}$$

ile verilir. Burada j , alt sürü sayısı (burada ikidir), t zaman, Δt adimsal zaman aralığıdır ve genelde 1'e eşit alınır. $\theta_{i,j}$ açısal yönelimken $\Delta \theta_{i,j}$ ise harici etkilerin yönelim üzerindeki tedirgemelerini gösterir ve gürültü parametresi η 'nin rastsal değeri ile ilintilidir.

Bu çalışmada, η parametresi ile termodinamik süreçlerden iyi bilinen T sıcaklık parametresi arasındaki birebir bir ilişkinin olabirliği üzerinde durulacaktır.

Anahtar Kelimeler: Sürü Zekası, Termodinamik Denge, Vicsek Modeli

ABSTRACT

In this paper, it is aimed to draw attention to the similarity between the collective behavior of swarms within the framework of a few simple motion rules that are not centralized, and the

behavior of a particle community with certain thermal equilibrium conditions with the laws of thermodynamics.

One of the main methods used in the study of swarm behavior is the Vicsek Model. This model predicts well how a swarm will collectively form a collective motion pattern within the framework of the local motion rules that swarm individuals in two and three-dimensional environments are subject to. In this model, the speed and position of any swarm individual in the next time step is determined by the speed and position information of other individuals in the neighborhood of this individual at the current time. In addition, since the movement of this swarm will be under the influence of some external forces, a noise parameter has been added to represent these forces. Accordingly, the movement of an element i is given by,

$$x_{i,j}(t+1) = x_{i,j}(t) + v_i \Delta t, \quad j = 1, 2.$$

$$\theta_{i,j}(t+1) = \bar{\theta}_i(t)_r + \Delta\theta_{i,j}$$

Here j is the number of subswarms (here two), t is time, Δt is the step time interval and is generally taken equal to 1. $\theta_{i,j}$ is the angular orientation while $\Delta\theta_{i,j}$ represents the perturbations on the orientation caused by external effects and is related to the random value of the noise parameter η .

In this study, we will focus on the possibility of a one-to-one relationship between the parameter η and the temperature T , which is well known from thermodynamic processes.

Keywords: Swarm Intelligence, Thermodynamic Equilibrium, Vicsek Model.

**UNVEILING CHATGPT'S POTENTIAL: A QUALITATIVE EXPLORATION OF
RESEARCHERS' PERSPECTIVES IN ENHANCING ACADEMIC RESEARCH IN
INDIAN HIGHER EDUCATION**

Preeti Bhaskar

University of Technology and Applied Sciences, Ibra, Oman

Puneet Gupta

ICFAI Business School, ICFAI University, Dehradun, Uttarakhand, India

Priyanka Bhaskar

ICFAI Business School (IBS), Bengaluru, Karnataka, India

Rakhi Shukla

ICFAI Business School, ICFAI University, Dehradun, Uttarakhand, India

ABSTRACT

In recent years, the advent of artificial intelligence (AI) has revolutionized various academic and research processes. Among these advancements, ChatGPT has emerged as a transformative tool for researchers, offering a dynamic platform that enhances efficiency and innovation in academic writing and research tasks. This study explores the role of ChatGPT in academic research by examining its impact on productivity, knowledge augmentation, and time-saving for researchers. Through semi-structured interviews with 56 researchers from various universities in the Uttarakhand region of India, the study employs Interpretative Phenomenological Analysis (IPA) to capture the subjective experiences and perspectives of researchers utilizing ChatGPT. The findings reveal that ChatGPT significantly enhances research processes by providing real-time assistance in drafting manuscripts, conducting literature reviews, and improving linguistic coherence. Additionally, ChatGPT facilitates interdisciplinary knowledge exchange, contributing to more innovative research approaches. Despite these advantages, the study highlights certain limitations, such as the potential for inaccuracy, ethical concerns regarding bias, and limited customization options for specialized research tasks. Researchers also expressed concerns over ChatGPT's reliance on existing datasets, which may perpetuate misinformation or outdated knowledge if not carefully fact-checked. This research offers valuable insights for academic institutions and policymakers on optimizing the use of AI in research while addressing its limitations. By providing a nuanced understanding of ChatGPT's benefits and challenges, this study contributes to the ongoing discourse on AI's role in transforming academic research methodologies.

Keywords: ChatGPT; Artificial Intelligence in Research; Interpretative Phenomenological Analysis (IPA); Universities

**THEORIZING STUDENTS' MATHEMATICAL RESILIENCY AND MATH
PERFORMANCE THROUGH PATH ANALYSIS**

Mariton Mirantes

Don Marcelino National High School

Aldwin T. Miranda

Southern PHILIPPINES, Agri-business and Marine and Aquatic School of Technology

Malita, Davao Occidental, Philippines

ABSTRACT

The study investigated the impact of students' mathematical resiliency on their mathematics performance in the new normal. Through a stratified random sampling technique, 385 respondents from various National High Schools were selected. Findings revealed high levels of mathematical resiliency among students. The students displayed varying levels of mathematics performance, predominantly classified as approaching proficient. Path analysis highlighted a reciprocal relationship among struggle, value, and growth in students' mathematical learning journey, influencing their overall performance. The study emphasizes the need for further research to explore interventions aimed at enhancing students' perceived value of mathematics, fostering a growth mindset, and equipping them with strategies to effectively navigate challenges in their mathematical learning journey amidst the evolving educational landscape

Keywords: Mathematical resiliency, mathematics performance, new normal, path analysis

**EXACT SOLUTION OF MIXED CONVECTION FLOW OF HEAT
GENERATING/ABSORBING FLUID IN A VERTICAL CHANNEL WITH INDUCED
MAGNETIC FIELD AND ELECTROKINETICS**

Michael O. Oni

Department of Mathematics, Ahmadu Bello University, Zaria, Nigeria.

Taiwo, S. Yusuf

Department of Mathematics, Ahmadu Bello University, Zaria, Nigeria.

Junaid M. Abba

Department of Mathematics, Ahmadu Bello University, Zaria, Nigeria.

Baba I. Mundi

Nigerian Institute of Transport Technology, NITT, Zaria, Nigeria.

ABSTRACT

An exact solution for the mixed convection flow of an electrically conducting fluid in a vertical channel filled with porous material is presented in this article. Using the classical Navier-Stokes equations, magnetic induction equation and Debye-Hückel linearization, the governing equations for flow formation, induced magnetic field and heat transfer are obtained and solved exactly to get the electric potential, induced magnetic field, fluid temperature and velocity profile. These solutions have significant applications in the design of electrical appliances both at macro and micro levels. It is found that despite the presence of porous material, fluid velocity, temperature, induced magnetic field and skin friction decrease with an increase in the Debye-Hückel parameter as well as the Hartmann number. Also, flow reversal at the channel wall can be minimised by selecting appropriate values for the governing parameters. Furthermore, magnitude of induce magnetic field is higher when one of the walls is electrically conducting.

Keywords: Heat generating/absorbing fluid; induced magnetic field; mixed convection; exact solution; electrokinetics.

**A COMPARATIVE STUDY OF DETERMINANTS OF CONSUMERS' CHOICES OF
SOME VEGETABLES IN ONDO STATE NIGERIA**

Adenegan-Alakinde

Department of Biology, Adeyemi Federal University of Education, Ondo, Ondo state Nigeria

Taiwo Ayomipo

Department of Biology, Adeyemi Federal University of Education, Ondo, Ondo state Nigeria

Baderinwa-Adejumo

Department of Biology, Adeyemi Federal University of Education, Ondo, Ondo state Nigeria

Adejoke Olusola

Department of Biology, Adeyemi Federal University of Education, Ondo, Ondo state Nigeria

Ojo, Funmilola Mabel

Department of Biological Sciences, Olusegun Agagu University of Science and Technology, Okitipupa. Ondo State, Nigeria.

ABSTRACT

Basella Linn. is an indigenous vegetable with lot of ethno-botanical uses. A survey was carried out to investigate factors that influence consumers' purchase of *Basella*. Well structured questionnaires were randomly distributed in the eighteen local government areas of Ondo State (100 per local government area), 1570 questionnaires were recovered and information gathered was analyzed using simple descriptive statistics.

The study showed that 40.6% are males and 59.4% of the consumers were female; 33.9% were between the ages of 35 – 44 years; and 34.4% were mostly graduates. Consumers indicated their knowledge of two forms of *Basella*; 75% of the respondents noted that availability is a key factor in their choice; 39.7% on easy digestibility and 32.2% in medicinal value influenced their choices. From respondents' views, 88.0% indicated that *Basella* contains proteins while 92.8% noted that the vegetable contains vitamins. High level of literacy was reported in the area despite being rural. The study revealed that availability, easy digestibility and medicinal value of the vegetable are the principal factors that determined the choice of *Basella*. Consumers' knowledge of phytochemical constituents of the vegetable is inadequate. *Basella* is not under utilized in the study area; availability is a key factor in choosing *Basella*, and consumers with more purchasing power are willing to buy more. Therefore there must be an intervention to make *Basella* more available and accessible.

Keywords: Availability, *Basella*, consumers, respondents, vegetables

**MOTIVATIONAL STRATEGIES AND MATHEMATICS PERFORMANCE OF
COLLEGE STUDENTS**

Mark Anthony G. Baclay

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Cristina Dominie M. Cortado

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Aldwin T. Miranda

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

ABSTRACT

This study aims to determine the significant relationship between motivational strategies and the academic performance of first-year college students at a State College in the Davao region, during the first semester of the 2022-2023 school year. The sample size consisted of 330 first-year students randomly selected from a total population of 1,856, determined using the Slovin's formula. Data on motivational strategies and mathematics performance were collected through a survey questionnaire, and analysis involved frequency counts, percentages, means, and Spearman correlation analysis.

Results showed that the overall level of motivational strategies was high. This means that students' motivational strategies involve consistent and enthusiastic effort, driven by a strong desire to achieve personal and learning goals. The mathematics performance of the respondents was at good level implying that they have developed fundamental knowledge and skills but need minimal guidance from the teacher or with peer. Correlational analysis revealed that students' motivational strategies obtained a very high significant correlation to mathematics performance. This indicate that implementing effective motivational strategies can significantly enhance students' success in mathematics.

Keywords: Motivational Strategies, Mathematics Performance in College.

**PROBLEM-SOLVING APPRAISALS AND MATHEMATICS PERFORMANCE OF
COLLEGE STUDENTS**

Chelljoy T. Villegas

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Merie Mae Joy S. Estopa

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Aldwin T. Miranda

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

ABSTRACT

This study aimed to explore the relationship between problem-solving appraisals and mathematics performance of first-year college students. Descriptive correlational research design was employed and stratified random sampling technique was used. A total of three hundred twenty-nine (329) students were subjected to the study. In gathering the data, an adopted survey questionnaire was used. Mean and standard deviation were employed for description of quantitative variables and percentage was used for categorical variables. Spearman correlation analysis was then employed to analyze the relationship among the considered variables. Results revealed that most of the respondents exhibit moderate level of problem-solving appraisals toward learning mathematics. This implies that, students engage in thoughtful analysis and decision-making, but with occasional hesitations or uncertainties. The mathematics performance of most of the respondents belonged to a very good level, implying that students developed fundamental knowledge and skills in mathematics subject. Correlation analysis suggests low but statistically significant correlation between problem-solving appraisals and mathematics performance. This indicates that the way students perceive and evaluate problem-solving situations may have some influence on their performance in mathematics.

Keywords: Problem-solving appraisal, mathematics performance, college students

**EXPLORING STUDENTS' MATHEMATICS PERFORMANCE THROUGH SELF-
REGULATED LEARNING**

Honey Queen A. Lumoto

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Crismar C. Decolas

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Karen E. Cabalquinto

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

Aldwin T. Miranda

Institute of Teacher Education and Information Technology
Southern Philippines Agri-Business and Marine and Aquatic School of Technology

ABSTRACT

This study aimed to explore students' mathematics performance through self-regulated learning among first-year college students at a state college in the southern Philippines. A total of 333 students were selected using stratified random sampling, and data were gathered through surveys and academic records. Results indicated that students had a high level of self-regulated learning and achieved a 'very good' level of mathematics performance. Correlation analysis revealed a significant positive correlation between self-regulated learning and mathematics performance in blended learning. Furthermore, regression analysis identified general self-regulation, goal-setting, resource-seeking, environment management, and time management indicators of self-regulated learning as significant predictors of mathematics performance. Recommendations were made to enhance academic and extracurricular activities by integrating self-regulation strategies through self-reflective workshops, peer mentoring programs, and interactive learning sessions.

Keywords: Self-regulated learning, college mathematics performance, blended learning

**SUSTAINABLE LIGNIN-BASED HYDROGELS: PROPERTIES AND
INNOVATIVE APPLICATIONS**

Gülçin BAYSAL

Lecturer Dr., Eskisehir Technical University, Research-Development, Technology Management and Innovation
Unit, Eskisehir, Türkiye

ABSTRACT

Biomass-derived materials offer eco-friendly alternatives to synthetic plastics and fossil-based materials. In recent years, extensive research has focused on renewable polymers from various natural sources, exploring their potential for diverse applications. Lignin, a major component of lignocellulose, has gained significant attention as a viable substitute for petroleum-based polymers, largely due to its low cost, biocompatibility, sustainability, and antioxidant and antimicrobial properties. These characteristics make lignin particularly advantageous when incorporated into high-value products. Although lignin has long been used for energy and as an additive in cement, adhesives, and dispersants, its application in advanced materials has grown rapidly. Lignin-derived materials are usually low-cost and environmentally sustainable, with diverse applications spanning energy storage, environmental remediation, electronics, and other fields. Thanks to its chemical composition, abundant in hydrophilic and reactive groups like phenolic hydroxyls, carboxyls, and methoxyls, lignin holds considerable promise for producing biodegradable hydrogels. Hydrogels are commonly known as three-dimensional polymer networks that can absorb and expand in water or aqueous solutions by hundreds or thousands of times their original dry weight, without breaking down. Various methods have been employed to create hydrogels from renewable sources like cellulose, hemicellulose, chitosan, starch, pectin, and alginates. Hydrogels derived from these natural polymers offer advantages such as eco-friendliness, biocompatibility, and biodegradability. Lately, bio-based hydrogels have been extensively utilized in various industries such as food, cosmetics, pharmaceuticals, and medical implants. Lignin stands out among these natural polymers as the sole aromatic one, which endows it with considerable potential for developing functional hydrogels. In this study, lignin-based hydrogel preparation methods, properties and innovative applications are presented.

Keywords: Lignin, hydrogels, sustainability, eco-friendly, biodegradable

1. INTRODUCTION

Developing materials from renewable resources using sustainable methods offers a promising way to reduce reliance on fossil fuels, which contributes to greenhouse gas emissions and

climate change (Moreno & Sipponen, 2020). Lignocellulosic biomass, abundant in agricultural waste, can reduce reliance on petrochemicals. Unlike burning for energy, which harms the environment, this biomass is bio-renewable, widely available, and non-competitive with food (Hachimi Alaoui et al., 2023). Biodegradable materials are increasingly used in industry for property development, recyclability, and energy integration. Lignin, a plant-based macromolecule, offers a sustainable solution (Fazeli et al., 2023). Lignin is the second most abundant biopolymer on Earth, following cellulose. It is naturally formed from three primary precursors: p-hydroxyphenyl (H unit), guaiacyl (G unit), and syringyl (S unit) phenylpropanoids. Due to its polyaromatic structure, lignin is less hydrophilic than other biopolymers like cellulose, hemicellulose, starch, alginate, or chitosan. This makes it suitable for applications such as reducing wettability in hydrophilic materials, adding properties like UV protection, antioxidant, and antimicrobial effects, and customizing materials for controlled release, adsorption, or antifouling purposes. However, most lignin applications require chemical modification, often targeting hydroxyl groups through reactions like phosphorylation, sulfo-methylation, esterification, or amination. Lignin can also be modified for use in specialty chemicals or polymers like polyurethanes, epoxides, and phenolic resins, finding applications in foams, adhesives, biocomposites, and coatings. Other uses include controlled-release fertilizers, antifouling membranes, fire retardants, dye sorption, wastewater treatment, and corrosion inhibitors (Ruwoldt et al., 2023). Hydrogels are three-dimensional networks of crosslinked hydrophilic polymers, made from natural or synthetic sources through polymerization and crosslinking of monomers. Their notable properties—swelling, morphology, and compression resistance—are determined by their chemical composition and synthesis conditions (Mondal et al., 2023; Kaur et al., 2021; Rico-García et al., 2020). Lignin stands out among biopolymers as a promising material for developing new hydrogels due to its antioxidant, antimicrobial, anti-inflammatory properties, biocompatibility, and low toxicity. Interest in converting lignin into functional biomaterials like hydrogels is rapidly increasing. In biomedical fields, lignin-based hydrogels have shown potential for tissue engineering, wound healing, drug delivery, 3D bioprinting, and more. (Hachimi Alaoui et al., 2023). Thanks to their diverse functional groups, lignin-based hydrogels can load and deliver a wide range of therapeutic agents, including small molecules, nanoparticles, proteins, enzymes, and nucleic acids. Various innovative physical, chemical, and biological methods have been developed to create these lignin-based hydrogels (Vasile & Baican, 2023). Different forms, innovative applications, structures, and production methods of lignin was given in Fig.1. Studies have shown that lignin's presence in hydrogel systems can improve swelling capacity and thermo-oxidative stability. Lignin-based hydrogels can be produced through different methods, including chemical and physical interactions. In these systems, lignin can function either as a crosslinked unit or as a crosslinking agent. Interest in lignin-based hydrogels has grown significantly in recent years, particularly in the pharmaceutical

and biomedical fields. However, only a few studies over the last five years have reviewed their use in tissue engineering, wound healing, drug delivery, and 3D bioprinting (Hachimi Alaoui et al., 2023). Therefore, this study presents a review summarizing lignin-based hydrogels, their properties, and innovative applications, considering key developments from recent published research within the last five years. Number of articles and citations of lignin-based hydrogels research indexed in Web of Science under the title “lignin hydrogels” between 2019 and 2024 was given in Fig.2.

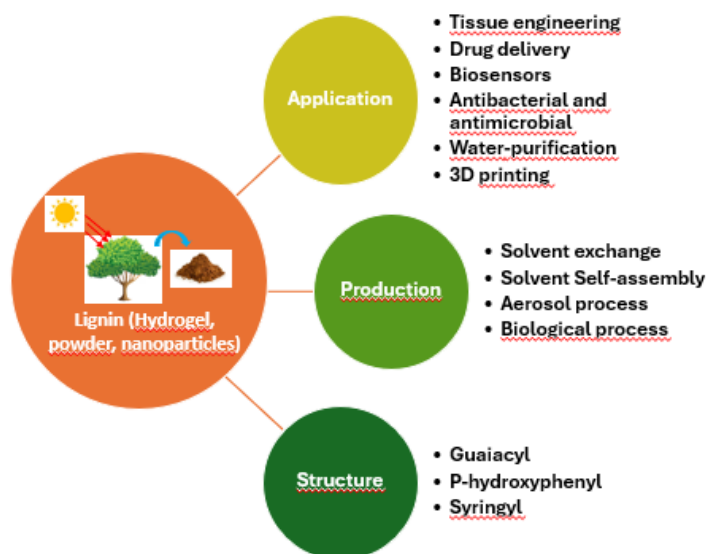


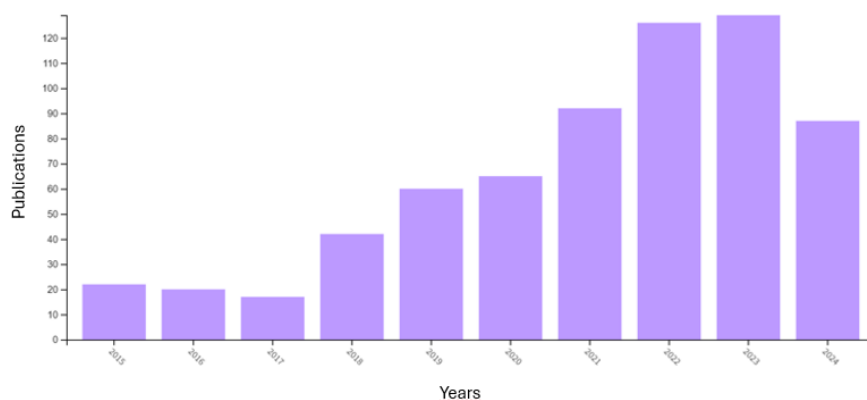
Fig. 1. Lignin hydrogels' structure, production methods, and innovative applications (Bakshi et al., 2024; Khadem et al., 2024)

2. FABRICATION OF LIGNIN-BASED HYDROGELS

Lignin must be extracted from various sources before it can be used in hydrogels. Recent innovations in chemical, biochemical, and physical processing have expanded lignin's potential applications. Common extraction methods include alkaline pulping (kraft, soda), acidic pulping (acid sulfite, hydrolysis), organosolv fractionation, and ionic liquid dissolution. Chemical treatments improve the surface geometry and strength of fibers in waste biomass, while physical treatments reduce particle size, increase surface area, and decrease polymerization degree. Methods like steam explosion, microwave-assisted extraction, homogenization, and ultrasonication can convert lignin into nanoparticles, enhancing reactivity. Biochemical methods, especially enzymatic modifications, precisely alter chemical bonds in lignin, enabling fine-tuning of hydrogel properties (Bakshi et al., 2024). Forest biomass materials like cellulose and hemicellulose are commonly used in hydrogel production, while lignin is emerging as a strengthener, adhesive, or filler for applications like lignin fractionation, electronics, UV shielding, and biomaterials (Ma et al., 2021).

Functionalized lignin, produced by chemical modification, has strong biomimetic potential and offers antioxidant, antibacterial, and anti-UV properties. In plant cells, lignin bonds cellulosic fibers, is insoluble in water, and resists degradation by enzymes, bacteria, chemicals, and digestion (Shafiq et al., 2024). A key property of lignin-based biomaterials is their ability to degrade. Extensive research is focused on effectively breaking down complex lignin molecules, with various fungi being the primary natural decomposers. Lignin is a low-cost, eco-friendly material with potential for biomedical use, but faces challenges like low solubility and high molecular weight. Modifying lignin is key to improving its properties. Chemical modifications, such as adding oxygen, nitrogen, or sulfur groups, enhance solubility, reactivity, and flexibility, making it more compatible with polymers for biomaterial development (Khadem et al., 2024).

a)



b)

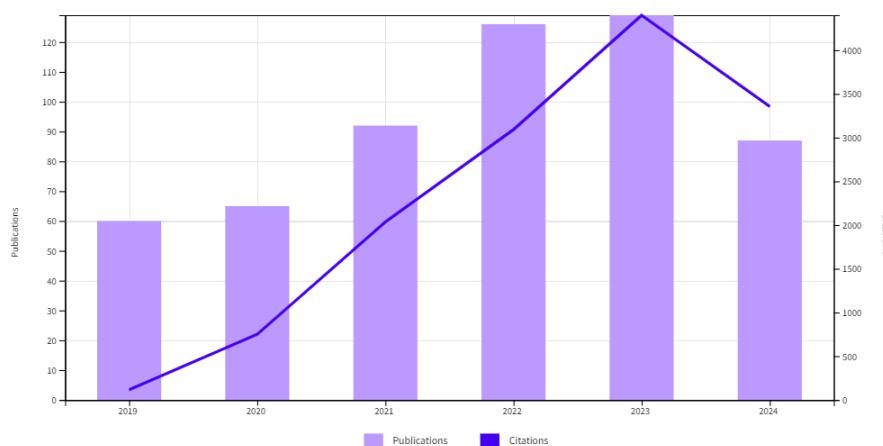


Fig. 2. a) Number of articles and b) citations of lignin-based hydrogels indexed in Web of Science under the title “Lignin Hydrogels” between 2019 and 2024

Lignin is eco-friendly but needs copolymerization to improve water retention and strength in hydrogels. Lignin-based hydrogels are made through physical or chemical crosslinking using

methods like polymer networks, radical polymerization, and monomer crosslinking (Khadem et al., 2024). Chemical crosslinking techniques include free-radical polymerization, grafting, radiation cross-linking, thermos-gelation, enzymatic reactions, and click chemistry (Bakshi et al., 2024; Khadem et al., 2024). Physically crosslinked hydrogels form through intermolecular interactions such as hydrogen bonding, ionic interactions, hydrophobic effects, or Van der Waals forces, without the need for crosslinking agents, making them reversible. Lignin can function as either the crosslinked network or the crosslinking agent in these systems (Khadem et al., 2024). However, chemical processing is the most used approach, with most reported lignin-based hydrogels being fabricated through chemical cross-linking. Lignin cross-linking involves grafting lignin onto a primary chain with unsaturated monomers via esterification of lignin's phenolic groups. This process, when combined with monomers like hydroxyethyl acrylate, creates hydrogels with excellent water retention. Alternatively, lignin-based hydrogels can be made using physical interactions, offering an eco-friendly option compared to chemical methods. These hydrogels, while not as mechanically strong as chemically cross-linked ones, benefit from enhanced mechanical properties and are suitable for applications such as 3D printing and wearable electronics. Physical hydrogels are noted for their cost-effectiveness and environmentally friendly production (Bakshi et al., 2024).

3. PROPERTIES OF LIGNIN-BASED HYDROGELS

Lignin and its derivatives can serve multiple functions in hydrogel preparation, including as fillers, crosslinkers, or adhesives. They can form various nanomaterials like nanoparticles, nanotubes, and nanofibers, depending on extraction, modification, and synthesis methods. Lignin can also enhance adhesion in hydrogels for both hydrophobic and hydrophilic surfaces, but phenolic resins from lignin have limited durability against water and heat (Khadem et al., 2024). Lignin is composed of building blocks connected by linkages like β -aryl ether, phenylcoumaran, and resinol bonds, which greatly influence its properties, such as solubility, density, viscosity, stability, water absorption, mechanical strength, biocompatibility, conductivity, and adhesiveness. These characteristics depend on factors like the lignin source, surface morphology, extraction pretreatment, type of cross-linker, and degree of cross-linking. For example, the lignin content in forest residue-based hydrogels affects properties like stiffness and tensile strength. As lignin increases, cross-linking and stiffness rise, improving mechanical properties but reducing elongation and making the hydrogel more brittle. Diffusion in lignin hydrogels depends on pore size and surface morphology. Pristine hydrogels have larger pores, more swelling, and irregular surfaces, while higher lignin concentration reduces pore size, swelling, and increases hydrophobicity. Hydrogels can absorb up to 10,000 times their dry weight in water, depending on cross-linking, surface morphology, and pore structure. Charge repulsion, ionic strength, and pH changes can alter their swelling behavior. Hydrogels are biodegradable, biocompatible, and non-toxic, making them useful for tissue repair, wound healing, and antimicrobial purposes. Lignin hydrogels are

easy to synthesize, highly cross-linked, and resist microbes. Higher cross-linking reduces pore size, slowing microbial penetration and biodegradation. Conductive polymers and ions enhance lignin hydrogel composites, making them ideal for applications like biosensors, supercapacitors, and tissue engineering. Modified lignin hydrogels offer strong adhesion, conductivity, and versatility. Additives like pectin and acrylic acid improve adhesion for use in electronics. Lignin's complex structure and phenolic groups make it an excellent UV absorber. Its variability in methoxy content and hydrophobicity also enhances its anti-UV potential. Lignin-based hydrogels can be modified to create protective, long-lasting, non-toxic materials with high market value through physical and chemical methods (Bakshi et al., 2024).

4. INNOVATIVE APPLICATIONS OF LIGNIN-BASED HYDROGELS

Flexible supercapacitors and wearable electronics

A biosensor consists of a bioreceptor that detects target biological substances even in the presence of interfering agents, with a transducer converting the signal into an electrical one. Biosensors are categorized as electrochemical, piezoelectric, thermal, or optical based on the transducer type. Lignin, known for its efficient adsorption on sp²-hybridized carbon due to aromatic subunits and its ability to stabilize nanoparticles like silver, is a promising material for biosensing and bioimaging due to its biocompatibility and affordability. Lignin-based biosensors are often integrated with enzymes or peptides, detecting biomolecules like glucose, which trigger measurable changes in the system, such as pH or electrical conductivity (Khadem et al., 2024). Interest in flexible supercapacitors (FSCs) has grown alongside the rise of lightweight portable devices. Researchers are particularly drawn to using renewable materials like cellulose or lignin in FSCs, combined with flexible electrodes and substrates, due to their naturally high power density (Rico-García et al., 2020). Lignin, being sustainable and renewable, offers a promising alternative for future energy needs. Lignin-based hydrogels have garnered significant research interest due to their numerous advantages. The focus on using lignin in flexible supercapacitors is steadily growing (Mondal et al., 2023).

Biomedical applications of lignin-based hydrogels

Drug delivery systems

Lignin has emerged as a promising backbone polymer for hydrogels in various biomedical applications, including tissue engineering, wound dressings, drug delivery systems, and 3D bioprinting (Hachimi Alaoui et al., 2023). Hydrogel-based drug delivery systems are widely studied for their biodegradability, antimicrobial properties, and low cytotoxicity, making them ideal for applications like antimicrobial treatments and wound healing. Lignin, known for being affordable, renewable, and sustainable, also brings antioxidant, eco-friendly, antifungal, and antibacterial benefits to biomedical applications (Mondal et al., 2023). Hydrogels are

widely studied for drug delivery due to their biocompatibility, porosity, and ability to release drugs in a controlled manner. Lignin-based hydrogels, known for their antioxidant, antimicrobial, and low-toxicity properties, have shown significant promise as drug delivery systems. These systems aim to deliver natural compounds precisely to diseased areas with minimal toxic effects. The drug release rate is influenced by the density of the hydrogel network and can follow different mechanisms: (i) swelling-controlled, where the solvent integrates with the polymer to form a gel; (ii) diffusion-controlled, depending on drug movement through the polymer matrix; and (iii) chemically controlled, governed by reactions within the matrix (Hachimi Alaoui et al., 2023). In drug delivery systems, the ability of hydrogels to swell in response to specific stimuli is a key feature, enabling controlled release of active agents in targeted environments (Rico-García et al., 2020). Drug delivery systems enhance drug targeting and reduce side effects by directing medication to specific areas like tumors. They protect drugs from quick degradation and use specific ligands to improve absorption and minimize harm. Lignin is being tested for this purpose in lipid nanoparticles (LNPs) and hydrogels. LNPs, such as nanoparticles and micelles, are effective carriers for drug encapsulation and dispersion (Khadem et al., 2024).

Three-Dimensional (3D) Bioprinting

3D bioprinting presents notable benefits over traditional tissue engineering, especially in regenerative medicine. This technique employs bio-inks to layer materials in patterns that replicate natural tissues and organs. It allows for precise control of cell and biomaterial arrangement to construct anatomically accurate structures both in vitro and in vivo. Recent advances, like microporogen-structured matrices, have improved bioprinting by enhancing rheology, print behavior, and porosity, making it a robust tool for tissue engineering, disease modeling, and drug discovery. Key bioprinting methods include cellular inkjet printing, extrusion, soft lithography, and laser-induced forward transfer. Hydrogels, valued for their bio-functionality and structural support, are commonly used as bio-inks. Lignin, known for its biocompatibility, biodegradability, and strength, is emerging as an effective material for hydrogels in 3D bioprinting, enhancing printability and functionality (Hachimi Alaoui et al., 2023).

Tissue engineering

Tissue engineering aims to create functional structures that repair, preserve, or improve damaged tissues or organs. Lignin, a natural amorphous biopolymer, has attracted interest as a sustainable material for tissue engineering due to its degradability, antioxidant properties, high carbon content, low density, and suitable stiffness (Khadem et al., 2024).

Wound healing

Effective wound dressing requires maintaining moisture at the wound surface and protecting against injury and infection. Lignin-based products for skin wound healing have gained attention due to their notable properties, including biocompatibility, hemocompatibility, antibacterial activity, and excellent tissue adhesion. Lignin, a polyphenolic macromolecule, is renowned for its antioxidant properties, attributed to its radical scavenging and chelation abilities. Studies suggest that lignin's antimicrobial activity is due to its phenolic components, side chain chemical groups, and orthomethoxy groups (Khadem et al., 2024).

Stimuli-responsive and smart hydrogels

The electro-conductive properties of lignin-based substrates arise from the dissociation of hydrophilic groups, such as sulfonic, phenolic hydroxyl, and carboxylic groups. When the hydrogel encounters moist air, water molecules infiltrate it due to its hydrophilic nature, causing the release of protons. These protons then move through the hydrogel along a concentration gradient, producing electricity (Mondal et al., 2023). Some hydrogels can undergo rapid volume changes in response to external stimuli such as pH, temperature, or light. This responsiveness enhances their potential as smart materials in aqueous or wet environments. While several stimuli-responsive lignin-based hydrogels have been developed, their structural limitations compared to synthetic hydrogels might restrict their responsiveness to stimuli (Rico-García et al., 2020).

Wastewater treatments

Lignin polymers contain negatively charged, oxygen-rich phenolic hydroxyl groups and aromatic rings. These components can attract positive molecules due to their negative charges and interact with aromatic compounds through π - π interactions. Furthermore, the plentiful phenolic hydroxyl, sulfonic, and carboxyl groups in lignin offer effective sites for adsorbing cationic dyes (Mondal et al., 2023). The high toxicity and carcinogenicity of heavy metal ions in polluted water underscore the need for new materials that can effectively absorb these contaminants. Lignin, with its polyphenol structure and abundance, is well-suited for this purpose. Several reviews have highlighted the effectiveness of lignin and its derivatives as heavy metal absorbents (Rico-García et al., 2020). Lignin-based hydrogels could be considered as emerging materials with potential applications as flexible supercapacitors and wearable electronics, biomedical applications, stimuli-responsive and smart hydrogels, and wastewater treatment applications. Recent studies within the last five years on these innovative applications of lignin-based hydrogels are presented in Table 1.

CONCLUSIONS AND FUTURE TRENDS

The abundance of lignin, a major by-product of the pulp and paper industries, has sparked growing interest in lignin-based materials. This shift reflects a move toward sustainable, eco-friendly materials. Thanks to its availability and unique properties, lignin can replace harmful,

non-biodegradable substances. Its hydroxyl groups are often used to create hydrogels, which can be applied in coatings, bio-adhesives, cosmetics, and more. This study reviewed lignin biopolymers and their potential as hydrogels, offering insights into their preparation, properties and innovative applications. Lignin is a renewable polymer with biocompatibility, low toxicity, and antioxidant properties, have gained attention for biomedical use. Despite challenges from their complex structure, lignin modification enhances its applications. Incorporating lignin into hydrogels boosts their mechanical strength, stability, water uptake, and controlled release. These improved hydrogels hold promise for drug delivery, wound care, biosensors, and tissue engineering. Several challenges hinder the advancement of lignin-based medical materials, including lignin's complex structure, high polydispersity, and inconsistent molecular weight. Its diverse origins and functional groups complicate large-scale hydrogel production, while current methods for retaining lignin structure during processing are lacking. High-lignin-content hydrogels are particularly difficult to produce, and greener synthesis methods are needed. A better understanding of lignin's properties and modifications is crucial for creating uniform hydrogels for biomedical use. Other obstacles include bridging lab results with real-world applications, ensuring cost-effectiveness, scalability, and meeting regulatory and safety standards. The challenges facing lignin-based hydrogels highlight the need for future research. Efforts should focus on improving lignin consistency, refining isolation and purification methods, and developing cost-effective ways to modify hydrogels. Comprehensive biocompatibility and toxicity testing are essential to ensure safety. Optimizing production to reduce costs is also crucial for scalability. Lignin's combination with other polymers can enhance properties like strength, stability, gelation, and controlled release, making these hydrogels promising for tissue engineering, wound healing, drug delivery, and 3D bioprinting. The promising results suggest lignin could have wide applications in biomaterials, flexible electronics, drug delivery, wearable devices, energy storage, and water treatment. Its strong antioxidant properties and UV resistance also make it a good candidate for sunscreen formulations. Additionally, lignin-based hydrogels, with their excellent water retention, could be beneficial for agricultural soils, including non-saline, saline, and sodic types. With advances in lignin nanotechnology, the field is expected to grow. The review serves as a useful resource for researchers and professionals, promoting sustainable and innovative lignin-based technologies across various industries.

REFERENCES

Bakshi, M. I., Nazir, S., Restu, W. K., Rajamanickam, R., Selvasembian, R., Hua, L. S., Antov, P., Yadav, K. K., Abbas, M., Farobie, O., & Fatriasari, W. (2024). Recent advances in lignin from forest residue for hydrogel application. *Biomass Conversion and Biorefinery*. <https://doi.org/10.1007/s13399-024-05973-9>

- Cao, J., Zhao, Y., Jin, S., Li, J., Wu, P., & Luo, Z. (2022). Flexible Lignin-based hydrogels with Self-healing and adhesive ability driven by noncovalent interactions. *Chemical Engineering Journal*, 429(May 2021), 132252.
- Ciolacu, D., Oprea, A. M., Anghel, N., Cazacu, G., & Cazacu, M. (2012). New cellulose–lignin hydrogels and their application in controlled release of polyphenols. *Materials Science and Engineering: C*, 32(3), 452–463.
- Domínguez-Robles, J., Peresin, M. S., Tamminen, T., Rodríguez, A., Larrañeta, E., & Jääskeläinen, A.-S. (2018). Lignin-based hydrogels with “super-swelling” capacities for dye removal. *International Journal of Biological Macromolecules*, 115, 1249–1259.
- Fazeli, M., Mukherjee, S., Baniasadi, H., Abidnejad, R., Mujtaba, M., Lipponen, J., Seppälä, J., & Rojas, O. J. (2023). Lignin beyond the status quo: recent and emerging composite applications. *Green Chemistry*, 593–630.
- Fei, Y., Jiang, Z., Zhou, D., Meng, F., Wu, Y., Xiong, Y., Ye, Y., Liu, T., Fei, Z., Kuang, T., Zhong, M., Li, Y., & Chen, F. (2023). Preparation a highly sensitive and flexible textile supercapacitor based on lignin hydrogel and polyaniline@carbon cloth composites. *Journal of Energy Storage*, 73(PB), 108978.
- Fu, C., Liu, X., Yi, Y., Fatehi, P., Meng, X., Kong, F., & Wang, S. (2022). Lignin derived hydrogel with highly adhesive for flexible strain sensors. *Polymer Testing*, 107(January), 107486.
- Hachimi Alaoui, C., Réthoré, G., Weiss, P., & Fatimi, A. (2023). Sustainable Biomass Lignin-Based Hydrogels: A Review on Properties, Formulation, and Biomedical Applications. *International Journal of Molecular Sciences*, 24(17), 13493.
- Han, X., Lv, Z., Ran, F., Dai, L., Li, C., & Si, C. (2021). Green and stable piezoresistive pressure sensor based on lignin-silver hybrid nanoparticles/polyvinyl alcohol hydrogel. *International Journal of Biological Macromolecules*, 176, 78–86.
- Haske-Cornelius, O., Bischof, S., Beer, B., Jimenez Bartolome, M., Olatunde Olakanmi, E., Mokoba, M., Guebitz, G. M., & Nyanhongo, G. S. (2019). Enzymatic synthesis of highly flexible lignin cross-linked succinyl-chitosan hydrogels reinforced with reed cellulose fibres. *European Polymer Journal*, 120(June), 109201.
- Huang, S., Shuyi, S., Gan, H., Linjun, W., Lin, C., Danyuan, X., Zhou, H., Lin, X., & Qin, Y. (2019). Facile fabrication and characterization of highly stretchable lignin-based hydroxyethyl cellulose self-healing hydrogel. *Carbohydrate Polymers*, 223(July), 115080.
- Kaur, R., Sharma, R., & Chahal, G. K. (2021). Synthesis of lignin-based hydrogels and their applications in agriculture: A review. *Chemical Papers*, 75(9), 4465–4478.
- Khadem, E., Ghafarzadeh, M., Kharaziha, M., Sun, F., & Zhang, X. (2024). Lignin derivatives-based hydrogels for biomedical applications. *International Journal of Biological Macromolecules*, 261(P2), 129877.

- Li, M., Jiang, X., Wang, D., Xu, Z., & Yang, M. (2019). In situ reduction of silver nanoparticles in the lignin based hydrogel for enhanced antibacterial application. *Colloids and Surfaces B: Biointerfaces*, 177(February), 370–376.
- Ma, C., Kim, T.-H., Liu, K., Ma, M.-G., Choi, S.-E., & Si, C. (2021). Multifunctional Lignin-Based Composite Materials for Emerging Applications. *Frontiers in Bioengineering and Biotechnology*, 9(July), 1–12. <https://doi.org/10.3389/fbioe.2021.708976>
- Mondal, A. K., Uddin, M. T., Sujana, S. M. A., Tang, Z., Alemu, D., Begum, H. A., Li, J., Huang, F., & Ni, Y. (2023). Preparation of lignin-based hydrogels, their properties and applications. *International Journal of Biological Macromolecules*, 245(March), 125580.
- Mondal, A. K., Wu, S., Xu, D., Zou, Q., Chen, L., Huang, L., Huang, F., & Ni, Y. (2021). Preparation of lignosulfonate ionic hydrogels for supercapacitors, sensors and dye adsorbent applications. *International Journal of Biological Macromolecules*, 187(July), 189–199.
- Morales, A., Labidi, J., & Gullón, P. (2022). Influence of lignin modifications on physically crosslinked lignin hydrogels for drug delivery applications. *Sustainable Materials and Technologies*, 33(August), e00474.
- Moreno, A., & Sipponen, M. H. (2020). Lignin-based smart materials: a roadmap to processing and synthesis for current and future applications. *Materials Horizons*, 7(9), 2237–2257.
- Ravishankar, K., Venkatesan, M., Desingh, R. P., Mahalingam, A., Sadhasivam, B., Subramaniam, R., & Dhamodharan, R. (2019). Biocompatible hydrogels of chitosan-alkali lignin for potential wound healing applications. *Materials Science and Engineering: C*, 102(April), 447–457.
- Rico-García, D., Ruiz-Rubio, L., Pérez-Alvarez, L., Hernández-Olmos, S. L., Guerrero-Ramírez, G. L., & Vilas-Vilela, J. L. (2020). Lignin-Based Hydrogels: Synthesis and Applications. *Polymers*, 12(1), 81.
- Ruwoldt, J., Blindheim, F. H., & Chinga-Carrasco, G. (2023). Functional surfaces, films, and coatings with lignin - a critical review. *RSC Advances*, 13(18), 12529–12553.
- Shafiq, A., Ahmad Bhatti, I., Amjed, N., Zeshan, M., Zaheer, A., Kamal, A., Naz, S., & Rasheed, T. (2024). Lignin derived polyurethanes: Current advances and future prospects in synthesis and applications. *European Polymer Journal*, 209(March), 112899.
- Sun, L., Mo, Z., Li, Q., Zheng, D., Qiu, X., & Pan, X. (2021). Facile synthesis and performance of pH/temperature dual-response hydrogel containing lignin-based carbon dots. *International Journal of Biological Macromolecules*, 175, 516–525.
- Vasile, C., & Baican, M. (2023). Lignins as Promising Renewable Biopolymers and Bioactive Compounds for High-Performance Materials. *Polymers*, 15(15), 3177.
- Wang, D., Yang, F., Cong, L., Feng, W., Wang, C., Chu, F., Nan, J., & Chen, R. (2022).

- Lignin-containing hydrogel matrices with enhanced adhesion and toughness for all-hydrogel supercapacitors. *Chemical Engineering Journal*, 450(P1), 138025.
- Wang, Q., Pan, X., Guo, J., Huang, L., Chen, L., Ma, X., Cao, S., & Ni, Y. (2021). Lignin and cellulose derivatives-induced hydrogel with asymmetrical adhesion, strength, and electriferous properties for wearable bioelectrodes and self-powered sensors. *Chemical Engineering Journal*, 414(November 2020), 128903.
- Wang, Q., Pan, X., Lin, C., Lin, D., Ni, Y., Chen, L., Huang, L., Cao, S., & Ma, X. (2019). Biocompatible, self-wrinkled, antifreezing and stretchable hydrogel-based wearable sensor with PEDOT:sulfonated lignin as conductive materials. *Chemical Engineering Journal*, 370(March), 1039–1047.
- Wang, Q., Pan, X., Lin, C., Ma, X., Cao, S., & Ni, Y. (2020). Ultrafast gelling using sulfonated lignin-Fe³⁺ chelates to produce dynamic crosslinked hydrogel/coating with charming stretchable, conductive, self-healing, and ultraviolet-blocking properties. *Chemical Engineering Journal*, 396(April), 125341.
- Wu, L., Huang, S., Zheng, J., Qiu, Z., Lin, X., & Qin, Y. (2019). Synthesis and characterization of biomass lignin-based PVA super-absorbent hydrogel. *International Journal of Biological Macromolecules*, 140, 538–545.
- Xiu, H., Zhao, H., Dai, L., Li, J., Wang, Z., Cui, Y., Bai, Y., Zheng, X., & Li, J. (2022). Robust and adhesive lignin hybrid hydrogel as an ultrasensitive sensor. *International Journal of Biological Macromolecules*, 213(March), 226–233.
- Yu, J., Ran, F., Li, C., Hao, Z., He, H., Dai, L., Wang, J., & Yang, W. (2024). A Lignin Silver Nanoparticles/Polyvinyl Alcohol/Sodium Alginate Hybrid Hydrogel with Potent Mechanical Properties and Antibacterial Activity. *Gels*, 10(4), 240.
- Zhang, L., Lu, H., Yu, J., Fan, Y., Ma, J., & Wang, Z. (2019). Contribution of lignin to the microstructure and physical performance of three-dimensional lignocellulose hydrogels. *Cellulose*, 26(4), 2375–2388.
- Zhang, Y., Mao, J., Jiang, W., Zhang, S., Tong, L., Mao, J., Wei, G., Zuo, M., & Ni, Y. (2021). Lignin sulfonate induced ultrafast polymerization of double network hydrogels with anti-freezing, high strength and conductivity and their sensing applications at extremely cold conditions. *Composites Part B: Engineering*, 217(March), 108879.
- Zhang, Y., Yuan, B., Zhang, Y., Cao, Q., Yang, C., Li, Y., & Zhou, J. (2020). Biomimetic lignin/poly(ionic liquids) composite hydrogel dressing with excellent mechanical strength, self-healing properties, and reusability. *Chemical Engineering Journal*, 400(May), 125984.
- Zhu, J., Luo, Y., Wang, J., Yu, J., Liu, Q., Liu, J., Chen, R., Liu, P., & Wang, J. (2022). Highly efficient uranium extraction by aminated lignin-based thermo-responsive hydrogels. *Journal of Molecular Liquids*, 368, 120744.

Table 1. Applications of lignin-based hydrogels

Matrix	Material	Interaction	Source lignin	Application	Ref
Poly (vinyl alcohol)/Sodium alginate (PVA/SA)	PVA/SA/Lig-Ag NPs hybrid hydrogel	Chemical	Alkali lignin	Healthcare and environmental protection	(Yu et al., 2024)
G-polyacrylic acid (PAA)	Fe-SL-g-polyacrylic acid (PAA) hydrogel	Chemical	Sulfonated lignin	Medicine, interface science, tribology, bionics, and electronics	(Q. Wang et al., 2020)
PVA	Silver nitrate/lignin hydrogel	Chemical (Mannich reaction)	Sodium lignosulfonate	Medical field, in vitro antibacterial applications	(Li et al., 2019)
Chitosan-lignin	Chitosan-alkali lignin hydrogel	Electrostatic	Alkali lignin	Wound healing, scaffolds in tissue engineering	(Ravishankar et al., 2019)
poly (ethylene glycol) diglycidyl ether (PEGDGE)	LS-PEGDGE ionic hydrogels	Chemical	Sodium lignosulfonate (LS)	Sensing, energy storage, dye adsorption	(Mondal et al., 2021)
Triethylenetetramine (TETA)	Lignin-based thermo-responsive hydrogels	Chemical (radical polymerization)	Alkali lignin	Uranium extraction from seawater	(Zhu et al., 2022)
Hydroxyethyl cellulose (HEC) and PVA	HEC-PVA (LCP) conductive hydrogel	Chemical (H-bonding)	Alkali lignin	3D printing and wearable electronic devices	(Huang et al., 2019)
Succinyl chitosan (SucCTS)	Succinyl chitosan (SucCTS) hydrogels	Chemical	Sodium lignosulfonate	Chronic wound dressings and food packaging	(Haske-Cornelius et al., 2019)
PVA	Lignin-based carbon dots (L-CDs)	Chemical	Alkali lignin	Tissue engineering scaffolds and drug carriers	(Sun et al., 2021)
N-Methylmorpholine-N-oxide (NMMO)	Lignocellulose hydrogels (LCGs)	Chemical	Klason lignin	Biosorbent for wastewater treatment.	(L. Zhang et al., 2019)
PVA	Crosslinked lignin hydrogels	Physically crosslinking	Organosolv lignin	Drug delivery systems	(Morales et al., 2022)
PVA	PAA/PVA/LS/LiCl hydrogels	Chemical	Sodium lignosulfonate	Multifunctional electronic materials	(Y. Zhang et al., 2021)
PVA	Polymer hydrogel with Ag NPs	Chemical	Sodium lignosulfonate	Antibacterial medical applications	(Li et al., 2019)
PVA	PVA/Lig-Ag NPs	Chemical	Alkali lignin	Piezoresistive pressure sensors	(Han et al., 2021)

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X
 October 05-07, 2024

	hydrogel				
PEGDGE	Poly- aniline@carbon flexible electrode	Chemical	Kraft lignin	Supercapacitors and flexible sensing fields	(Fei et al., 2023)
Polyacrylamide	Ag-Lignin Polyacrylamide hydrogels	Chemical	Alkali lignin	Flexible supercapacitors	(D. Wang et al., 2022)
PVA	PVA-borax-FT(freezing-thawing process) hydrogel	Chemical	Sodium lignosulfonate	Multiple wearable electronics	(Q. Wang et al., 2021)
Poly- vinylpyrrolidone (PVP)	LS/PVP composite (LPC) hydrogel	Physically crosslinking	Sodium lignosulfonate	Self-healing and adhesive ability biomedical applications	(Cao et al., 2022)
Crosslinking poly(methyl vinyl ether co-maleic acid)	Superabsorbent hydrogels film	Simple thermal process	Kraft lignin	Adsorbents for the removal of organic dyes from waste-water	(Domínguez-Robles et al., 2018)
PVA	lignin-based PVA super-absorbent hydrogel	Chemical	Alkali lignin	Soil water retention and seed cultivation in agriculture, and dye pollutant removal	(Wu et al., 2019)
Polyacrylamide (PAM)/SA	AgNPs@lignin hydrogel	Chemical	Alkali lignin	Flexible wearable electronics	(Xiu et al., 2022)
Crosslinking agent N, N'-methyl bisacrylamide	Lignin-derived hydrogel	Chemical	Lignosulfonate	Sensors	(Fu et al., 2022)
Microcrystalline cellulose	Cellulose–lignin hydrogels (CL)	Chemical	Alkali lignin	Drug delivery systems	(Ciolacu et al., 2012)
Poly (3,4-ethylenedioxythiophene) (PEDOT)	PEDOT:SL-PAA organohydrogel strain sensor	Chemical	Kraft lignin	Strain sensors (healthcare and human-motion guidance)	(Q. Wang et al., 2019)
-	Lignin/poly(ionic liquids) composite hydrogel dressing	Covalent bonds and supramolecular interactions	Alkali lignin	Skin wound care applications	(Y. Zhang et al., 2020)

BULANIK KABA KÜME YAKLAŞIMI ÜZERİNE BİR UYGULAMA
AN APPLICATION ON THE FUZZY ROUGH SET APPROACH

Yasemen UÇAN

Doç. Dr., Yıldız Teknik Üniversitesi, Kimya Metalurji Fakültesi, Matematik Mühendisliği Bölümü
*Assoc. Prof., Yıldız Technical University, Faculty of Chemical and Metallurgical Engineering, Department of
Mathematical Engineering*

ORCID ID: 0000-0001-7634-7869

Nisanur YILDIZ

Yıldız Teknik Üniversitesi, Kimya Metalurji Fakültesi, Matematik Mühendisliği Bölümü
*Yıldız Technical University, Faculty of Chemical and Metallurgical Engineering, Department of Mathematical
Engineering*

ORCID ID: 0009-0008-8321-3904

ÖZET

Günümüzde kesin ve tam olmayan bilgiyi işlemek için bulanık küme, kaba küme ve bunların hibrit küme yaklaşımları matematikte olduğu kadar diğer uygulamalı alanlarda da sıkça kullanılan matematiksel bir araçtır. Örneğin mühendislik, fen ve sosyal bilimlerde de oldukça popülerdir [1]. Bu hibrit küme teorilerinden biri olan bulanık-kaba küme teorisi, belirsizlik içeren veri kümelerinin işlenmesinde önemli bir rol oynar. Bu hibrit yöntem, Zadeh tarafından tanımlanan bulanık küme [2] ile 1982’de Pawlak tarafından tanımlanan [3] kaba küme yaklaşımlarını birleştirerek ilk kez Dubois ve Prade [4] tarafından tanıtılmıştır. İki esasa dayanmaktadır: ilki bulanık bağıntısına dayanan genelleştirilmiş alt ve üst yaklaşımlar, ikincisi ise bulanık-kaba küme özelliklerine dayanan aksiyomatik bir yaklaşımdır.

Son yıllarda sağlık sorunları dünya genelinde ciddi bir endişe kaynağıdır. Özellikle karaciğer hastalıkları gibi ölümcül ve kronik hastalıkların erken teşhisi, hastaların yaşam kalitesini artırma ve yaşam sürelerini uzatma açısından büyük öneme sahiptir. Bu bağlamda, karaciğer hastalıkları ve diğer hastalıkların analizi ve teşhisinde yapay zeka ve makine öğrenmesi algoritmalarının önemi artmıştır.

Bu çalışmada bulanık-kaba küme yaklaşımı kullanılarak primer biliyer sirozlu hastaların sağ kalımını tahminleyen bir karar destek sistemi (KDS) geliştirilmiştir. Bu amaçla Mayo Klinik tarafından başlatılan 312 primer biliyer siroz hastasından elde edilen hastanın yaşı, toplam serum bilirubin ve serum albümin konsantrasyonları, protrombin zamanı ve ödem şiddetini temel alan verilerin bulunduğu Cirrhosis Patient Survival (CPS) veri kümesi kullanılmıştır. Veri kümesi açık kaynaklı olup UCI Machine Learning Repository [5] web sitesinden indirilebilir. CPS veri kümesi kullanılarak siroz hastalarının sağ kalımını tahminleyen ilk model Dickson ve arkadaşları tarafından geliştirilmiştir [6]. Çalışmada Cox regresyon yöntemi kullanarak geliştirdikleri matematiksel modelde, karaciğer biyopsisine gerek olmadan primer biliyer sirozlu hastaların sağ kalımını tahmin ettiklerini göstermişlerdir.

Ayrıca çalışmamızda kullandığımız yöntemden elde edilen sonuçları, önceki model ve bazı makine öğrenmesi yöntemleri ile karşılaştırılarak yöntemimizin etkinliği tartışılmıştır.

Anahtar Kelimeler: Bulanık-Kaba Küme Yaklaşımı, Siroz Hastalığı, Makine Öğrenmesi.

Bu çalışma, Tübitak - 2209-A Üniversite Öğrencileri Araştırma Projeleri Destekleme Programı kapsamında, 2023 yılı 2. dönemi 1919B012313614 numaralı proje ile desteklenmiştir.

ABSTRACT

Fuzzy sets, rough sets, soft sets, and their hybrid set theories are mathematical tools used to process incomplete and uncertain information in information systems. They are particularly popular in disciplines such as engineering, natural sciences, and social sciences [1]. Fuzzy-rough set theory, one of these hybrid set theories, plays an important role in processing data sets containing uncertainty. This hybrid method, combining the fuzzy set approach introduced by Zadeh [2] with the rough set approach introduced by Pawlak in 1982 [3], was first introduced by Dubois and Prade [4]. It is based on two principles: an axiomatic approach based on fuzzy-rough set properties with generalized lower and upper approximations based on fuzzy relations.

Health problems pose a significant global concern in contemporary society. Early diagnosis of fatal and chronic diseases, such as liver diseases, is essential for enhancing patients' quality of life and prolonging their lifespan. Within this framework, the role of artificial intelligence and machine learning algorithms in the analysis and diagnosis of liver and other diseases has become increasingly important.

In this study, the fuzzy-rough set approach was used to create a decision support system (DSS) that predicted patients' survival with primary biliary cirrhosis. The Cirrhosis Patient Survival (CPS) dataset, which includes information on patients' ages, prothrombin times, serum albumin concentrations, total serum bilirubin, and edema severity, was used to accomplish this. The UCI Machine Learning Repository offers this dataset, which was contributed by the Mayo Clinic and comprises 312 individuals with primary biliary cirrhosis, for free download [5]. The first model to predict the survival of cirrhosis patients using the CPS dataset was developed by Dickson et al. [6]. They demonstrated that their mathematical model, developed using the Cox regression method, could predict the survival of patients suffering from primary biliary cirrhosis without requiring a liver biopsy.

We have compared the results obtained from our study with previous models and various machine learning methods. This comparative analysis allowed for a detailed discussion of the effectiveness and relative performance of our method in predicting patient survival.

Keywords: Fuzzy-Rough Set Approach, Primary Biliary Cirrhosis, Machine Learning.

Acknowledgments: This study is supported by the project number 1919B012313614 within the scope of Tübitak - 2209-A University Students Research Projects Support Program, 2nd semester of 2023.

**THE USE OF PHTHALOCYANINE COMPOUND IN ELECTROCHEMICAL
SENSORS**

Rabia TURAN

Marmara University, Engineering Faculty, Department of Chemical Engineering, Istanbul, Turkey
Res. Asst., Beykent University, Faculty of Engineering and Architecture, Department of Chemical Engineering, ,
Istanbul, Turkey

ORCID ID: 0000-0002-8046-685X

Atif KOCA

Prof. Dr., Marmara University, Engineering Faculty, Department of Chemical Engineering, Istanbul, Turkey

ORCID ID: 0000-0003-0141-5817

ABSTRACT

Electrochemical sensors are very important in various analytical applications, and the discovery of phthalocyanine compounds has emerged as a transformative development in this field. In this study, the potential of phthalocyanine compounds as advanced materials for a new generation of electrochemical sensors was investigated. Phthalocyanines, which attract attention with their unique electronic, optical and catalytic properties, offer significant improvements in sensor performance. Their planar structure, exceptional thermal stability and ability to form stable metal complexes highlight their contribution towards improving the sensitivity, selectivity and stability of electrochemical sensors. The integration of phthalocyanines into sensor technologies has received significant attention due to the remarkable properties of these compounds. Advances in manufacturing techniques such as thin film deposition and nanostructuring have further enhanced the capabilities of phthalocyanine-based sensors. These innovations make it possible to develop sensors with superior performance criteria, including improved sensitivity and selectivity. This study highlights specific sensor studies that demonstrate the application of phthalocyanine sensors in various fields.

In general, phthalocyanine compounds represent a promising frontier in electrochemical sensor technology. Their advanced features and the progress in sensor manufacturing techniques show that they have the potential to revolutionize various analytical applications. By offering improved performance and versatility, phthalocyanine-based sensors are poised to make significant contributions to the development of more effective and sensitive analytical tools.

Keywords: Electrochemical sensors, phthalocyanine

ADVANCEMENTS IN METAL-ORGANIC FRAMEWORKS

Deniz SAKARYA

Dr., Institute of Nanotechnology and Biotechnology, Istanbul Univeristy-Cerrahpasa, 34500, Istanbul, Turkey.

ABSTRACT

Metal-Organic Frameworks (MOFs) represent a class of crystalline materials characterized by their highly porous structure, which is constructed from metal ions or clusters interconnected by organic ligands. These frameworks exhibit exceptional surface areas and tunable pore sizes, which render them highly advantageous for a wide array of applications, including gas storage, separation, and catalysis.

The structural versatility of MOFs arises from the diversity of metal centers and organic linkers that can be employed in their synthesis. Metals such as zinc, copper, and iron are commonly utilized, while organic ligands range from simple carboxylates to complex heterocyclic compounds. The coordination between the metal centers and organic ligands forms a three-dimensional lattice, which can be meticulously engineered to achieve desired properties.

One of the most significant attributes of MOFs is their extraordinarily high surface area, often exceeding 5,000 m²/g. This characteristic is a direct consequence of their porous nature, which provides a substantial internal surface for interaction with guest molecules. Consequently, MOFs have shown remarkable potential in gas storage applications, including hydrogen and methane storage, where their high surface area facilitates increased gas adsorption capacities. Additionally, their structural tunability allows for the optimization of pore sizes and surface functionalities, making them effective for selective gas separation and purification processes.

In the realm of catalysis, MOFs offer unique opportunities due to their ability to incorporate active metal sites within their structures. This feature enables MOFs to act as heterogeneous catalysts for a variety of chemical reactions, including oxidation and hydrogenation processes. Moreover, the flexibility in modifying the organic linkers allows for the fine-tuning of catalytic properties and the development of highly specific catalytic systems.

Overall, MOFs represent a dynamic and rapidly advancing field in materials science, with ongoing research focused on enhancing their stability, scalability, and functionality for practical applications.

Keywords: Crystalline materials, Catalyst, Metal-organic frameworks, MOFs

APPLICATION OF MOFS IN BIOMEDICAL SYSTEMS

Deniz SAKARYA

Dr., Institute of Nanotechnology and Biotechnology, Istanbul Univeristy-Cerrahpasa, 34500, Istanbul, Turkey.

ABSTRACT

Metal-organic frameworks (MOFs) represent a class of porous materials characterized by their high surface area, tunable structure, and versatile functionality, making them increasingly significant in the field of biomedical systems. The application of MOFs in biomedicine has garnered substantial attention due to their potential to enhance various therapeutic and diagnostic approaches.

MOFs have been explored for drug delivery systems due to their ability to encapsulate therapeutic agents within their porous structures. This encapsulation can protect sensitive drugs from degradation, control the release rate, and target specific sites within the body. The high surface area and adjustable pore sizes of MOFs allow for the accommodation of a wide range of drugs, from small molecules to larger biomolecules, thus offering a versatile platform for tailored drug delivery.

In addition to drug delivery, MOFs are being investigated for their applications in imaging and diagnostic techniques. The incorporation of luminescent or magnetic properties into MOFs can improve imaging contrast and enable more precise detection of disease states. For example, MOFs can be engineered to contain fluorescent or magnetic tags that enhance imaging modalities such as MRI or fluorescence imaging, facilitating early and accurate diagnosis.

Moreover, MOFs show promise in biosensing applications. Their high surface area and functionalizable framework enable the attachment of biomolecules or sensors that can selectively bind to specific targets, such as pathogens or biomarkers. This property can be utilized in the development of sensitive and selective biosensors for detecting various diseases.

Overall, the integration of MOFs into biomedical systems holds the potential to revolutionize drug delivery, diagnostic imaging, and biosensing. Ongoing research aims to address current challenges and optimize the performance of MOFs in these applications, paving the way for advanced medical technologies and improved patient outcomes.

Keywords: Cancer treatment, Drug delivery, Metal-organic framework, pharmaceuticals

**EMAYELERDE KULLANILAN FRİTLERDE P₂O₅'İN KATKISININ KAPLAMANIN
FİZİKSEL, KİMYASAL VE MEKANİK ÖZELLİKLERİ ÜZERİNDEKİ ROLÜ**
THE ROLE OF P₂O₅ ADDITION IN FRITES USED IN ENAMELS ON THE PHYSICAL,
CHEMICAL AND MECHANICAL PROPERTIES OF THE COATING

Dilay PAR

Algotrio Kimya San. ve Tic. A.Ş, Sakarya, Türkiye.

Algotrio Chem. Inc., Sakarya, Turkey

ORCID ID: 0009-0000-6447-8095

Tuğçe Nazlı KAYA

Ar&Ge Yöneticisi, Algotrio Kimya San. ve Tic. A.Ş, Sakarya, Türkiye.

R&D Manager, Algotrio Chem. Inc., Sakarya, Turkey

ORCID ID: 0000-0003-0460-1949

Orhan ŞAHİN

Ar&Ge Direktörü, Algotrio Kimya San. ve Tic. A.Ş, Sakarya, Türkiye.

R&D Manager, Algotrio Chem. Inc., Sakarya, Turkey

ORCID ID: 0000-0001-6999-2974

Erhan İBRAHİMOĞLU

Sakarya Uygulamalı Bilimler Üniversitesi, Teknoloji Fakültesi, Metalurji ve Malzeme Mühendisliği Bölümü

*Sakarya University of Applied Sciences, Faculty of Technology, Department of Metallurgical and Materials
Engineering*

ORCID ID: 0000-0002-8073-5570

Fatih ÇALIŞKAN

Prof. Dr., Sakarya Uygulamalı Bilimler Üniversitesi, Teknoloji Fakültesi, Metalurji ve Malzeme Mühendisliği
Bölümü

*Prof. Dr., Sakarya University of Applied Sciences, Faculty of Technology, Department of Metallurgical and
Materials Engineering*

ORCID ID: 0000-0002-9568-7049

ÖZET

Emaye; çelik, demir, alüminyum gibi metal yüzeylerinin üzerine camsı yapıda silikat karışımları (frit) ile kaplanarak düşük sıcaklıklarda sinterlenmesi sonucu elde edilen bir kaplama şeklidir. Frit denilen silikat içerikli cam tabakası çamur halde ıslak olarak veya toz halinde kaplanacak malzemenin yüzeyine uygulanabilmektedir. Bu çalışmada, hali hazırda emaye kaplamalarda kullanılan frit kompozisyonuna farklı oranlarda P₂O₅ katkısı yapılmış ve kaplamanın fiziksel, kimyasal ve mekanik özelliklerinde ortaya çıkardığı değişimler test edilmiştir. Bu amaçla frit içerisine ağırlıkça %0, %0,5, %1, %1,5 ve %2 olacak şekilde farklı oranlarda P₂O₅ kullanılarak 5 farklı frit reçetesi oluşturulmuştur. Frit reçeteleri seger

formülasyonunda deęişiklik yapılarak ergitme yapılmıştır. Çalışmada hazırlanan tozlar 12*15 cm'lik temizlenmiş plakalara elektrostatik olarak kaplanmıştır ve daha sonra 840°C'de 4 dk boyunca laboratuvar tipi kutu fırında pişirilmiştir. Hazırlanan emaye kaplı plakalara renk testi, darbe testi, asit testi, ETC ve pirolitik testi uygulanmıştır. Kaplanan emayelerin kimyasal analizi ise X-ışını floresans (XRF) ile belirlenmiştir.

Anahtar Kelimeler: Emaye, P₂O₅, Frit, Elektrostatik Kaplama.

ABSTRACT

Enamel is a coating type obtained by coating metal surfaces such as steel, iron, aluminum with glassy silicate mixtures (frit) and sintering them at low temperatures. The silicate-containing glass layer called frit can be applied to the surface of the material to be coated as wet mud or as powder. In this study, different amounts of P₂O₅ were added to the frit composition currently used in enamel coatings and the changes in the physical, chemical and mechanical properties of the coating were tested. For this purpose, 5 different frit recipes were created by adding different amounts of P₂O₅ to the frit as 0%, 0.5%, 1%, 1.5% and 2% by weight. Frit recipes were determined by making changes in the Seger formulation. The powders prepared in the study were electrostatically coated on 12*15 cm cleaned plates and then baked in a laboratory-type box oven at 840 °C for 4 minutes. Color test, impact test, acid test, ETC and pyrolytic test were applied to the prepared enamel-coated plates. The chemical analysis of the coated enamels was determined by X-ray fluorescence (XRF).

Keywords: Enamel, P₂O₅, Frit, Electrostatic Coatings.

GİRİŞ

Fritler, toz halindeki seramik hammaddelerin belirli bir reçeteye göre tartılarak karışım hale getirildikten sonra karıştırılarak ergitilmesi ve elde edilen bu ergiyik fazın hızlı bir şekilde soğutulması sonucunda oluşturulan cam yapıdaki ürüne verilen addır (Kırkbınar ve ark., 2020; Karaca, 2014). Fritler; fiziksel ve kimyasal özellikleri, kullanım alanları, pişirme sıcaklığı vb. gibi durumlara göre farklılık göstermektedir. Genellikle kaplama sonrası pişirme sıcaklığı kimyasal kompozisyonunda bulunan alkali oksit miktarına göre belirlenmektedir (Şahin, 2019; Pekkan, 2009). Emayeler ise; genellikle Na, K, Li, Ba, Ca, Zn, Mg, Sr gibi elementlerin oksitlerinin sıklıkla tercih edildiği, kaplamadan beklenen özelliğe veya malzemenin nerede kullanılacağına göre de Al, Ti, Zr, P, F gibi elementlerin de oksitlerini içerebilen borosilikat yapısının, toz veya sulu olarak kullanıldığı kaplama malzemesi olarak bilinmektedir (Şahin, 2019; Song ve ark., 2018). Emayeler, mutfak eşyaları, ocak, fırın, soba, beyaz eşya, küvet vb. birçok üründe kullanılmaktadır. Hijyeniklik, neme ve kimyasallara karşı dayanımı, termal mukavemeti, temizleme kolaylığı gibi özellikler emayelerin pratikte kullanımını arttırmaktadır ve avantajları arasında yer almaktadır (Sarp, 2019). Emaye fritleri, inorganik

malzemelerin yüksek sıcaklıklarda ergitilmesiyle elde edilen cam malzemelerdir. Temel olarak metalik bir altlık üzerine camın kaplanmasıyla elde edilen emayeler üretim sırasındaki uygulanan ısı işlem nedeniyle, içeriğinde bulunan bazı bileşimlerin kristalleşmesine neden olabilir ve cam/seramik fazların bir kombinasyonu nedeniyle üstün özellikler geliştirilebilir. Bu nedenle emaye kaplamalar, genellikle yüksek sertlik, yüksek termal ve termal şok dayanımı, kimyasallara karşı inertlik ve korozyon direnci, oksidasyon direnci ve aşınma direnci gibi üstün özellikler göstermektedirler ((Huynh ve ark., 2019). Emayede kullanılan malzemeler; metal yüzeylere, suyla süspansiyon hale getirilerek sulu veya toz/pudra şeklinde kuru yöntem olarak uygulanabilmektedirler (Kara Köksal, 2014; Rossi ve ark., 2015).

Bu çalışmada da kompozisyonları verilen toz şeklindeki emaye fritleri hazırlanmış ve elektrostatik kaplama yöntemi kullanılarak EN10209 (soğuk haddelenmiş çelik) altlıklar üzerine kaplanmıştır. Elde edilen emayelerin fiziksel özellikleri, kimyasal dayanımı ve mekanik özellikleri test edilmiş, P_2O_5 katkısının bu özellikler üzerindeki etkileri değerlendirilmiştir. Bu amaçla, malzemelere renk testi, sitrik asit ve ETC testi, darbe testi ve pirolitik testler yapılmış ve sonuçlar tartışılmıştır.

YÖNTEM

Frit Tozların Üretimi ve Emayenin Kaplanması

Çalışmada farklı oranlarda (ağırlıkça %0, %0,5, %1, %1,5 ve %2) P_2O_5 katkılı 5 farklı frit reçetesi oluşturulmuştur. Oluşturulan fritlerin içinde % ne kadar P_2O_5 olduğu Tablo 1’de gösterilmiştir. Bir frit reçetesi için seger formülasyonları ayarlanarak değirmen formülü oluşturulmuş ve Tablo 2’de paylaşılmıştır. Ergitilen bu fritler Li_2O içermeyen sert bir frit ve pigment ile eşlenerek emayeleri hazırlanmıştır. Her bir karışım aynı silikonla aynı sürede öğütülerek, emayelerin tane boyutu 45 mikron civarlarında olacak şekilde ayarlanmıştır.

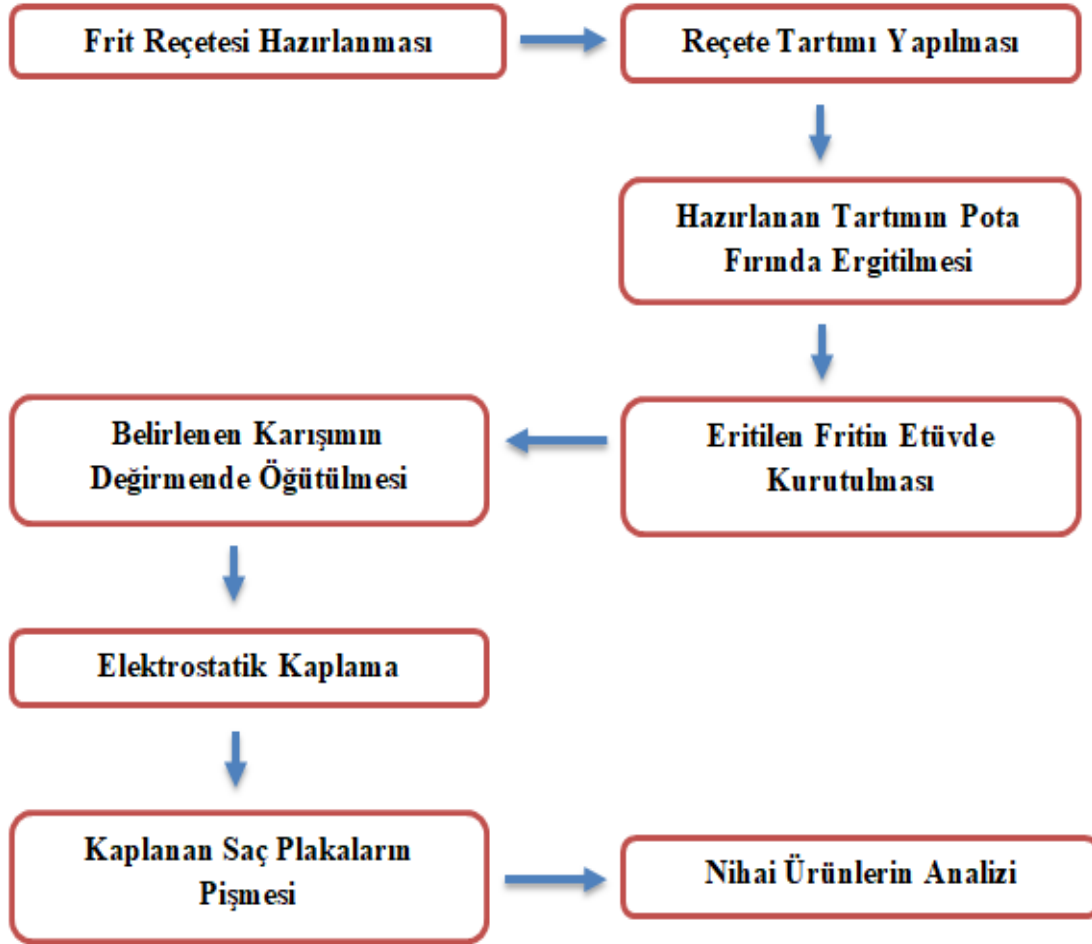
Tablo 1. Oluşturulan Fritlerin % P_2O_5 Değerleri

Fritler	% P_2O_5
A Friti	0
B Friti	0,5
C Friti	1
D Friti	1,5
E Friti	2

Tablo 2. Emaye Üretiminde Kullanılan Karışımların Kimyasal Kompozisyonu

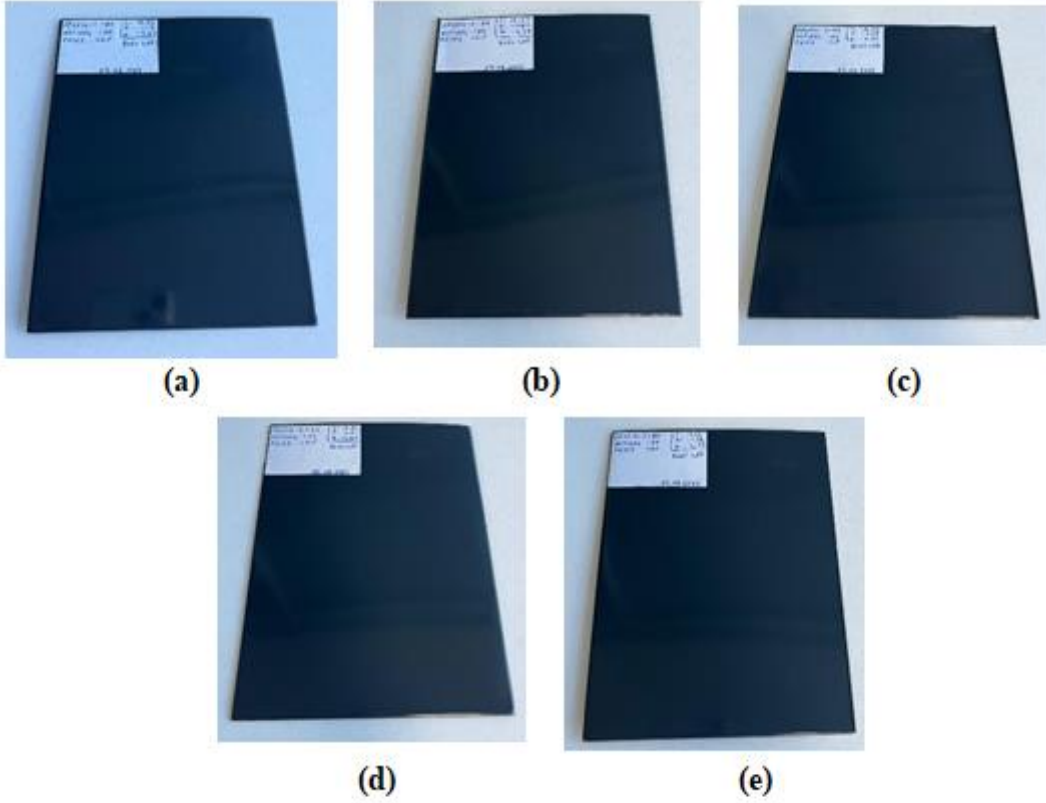
	Karışım 1	Karışım 2	Karışım 3	Karışım 4	Karışım 5
A Friti	80 gr	-	-	-	-
B Friti	-	80 gr	-	-	-
C Friti	-	-	80 gr	-	-
D Friti	-	-	-	80 gr	-
E Friti	-	-	-	-	80 gr
Sert Frit	20 gr	20 gr	20 gr	20 gr	20 gr
Siyah Pigment	0,5 gr	0,5 gr	0,5 gr	0,5 gr	0,5 gr

Üretim prosesinde ilk olarak frit reçeteleri hazırlanıp 1 saat boyunca laboratuvar tipi pota fırında eritilmiştir. Eritilen fritler hızlı bir şekilde soğutulurken cam yapısı elde edilmiştir ve daha sonrasında etüvde kurutulmuştur. Fritler kurutulduktan sonra belirlenen karışım formülü ile bütün karışımlar aynı sürede öğütürken emaye tane boyutları %15 olarak ayarlanmıştır. Hazırlanan emaye tozları 12*15 cm'lik temizlenmiş plakalara elektrostatik toz olarak plakanın arka yüzeyine 3,5 gr ön yüzeyine 5,5 gr uygulanarak 840 °C'de 4 dk boyunca laboratuvar tipi kutu fırında pişirilmiştir ve her bir karışımdan 3'er plaka uygulaması yapılmıştır. Elde edilen emaye kaplamaların üretim prosesine ait akış şeması Şekil 1'de gösterilmiştir.



Şekil 1. Emaye kaplama akış prosesi

Elde edilen emaye kaplamalar P_2O_5 katkı oranına göre sırasıyla Şekil 2’de gösterilmiştir.



Şekil 2. Ağırlıkça farklı oranlarda P_2O_5 katkılı emaye uygulanan plakaların görüntüleri, (a) % 0, (b) % 0,5, (c) % 1, (d) % 1,5 ve (e) % 2

Üretim sonrasında elde edilen emaye kaplamaların fiziksel, kimyasal ve mekanik özelliklerinin belirlenmesi için bir dizi test uygulanmıştır. Emaye fritinin içerisinde yer alan oksitlerin kimyasal kompozisyonu X-ışını floresans (XRF) analizi ile tayin edilmiştir. Sitrik asit ve ETC testleri ile kimyasal dayanımı belirlenmiştir. Termal dayanımı ise pirolitik testi ile analiz edilirken mekanik olarak darbe dayanımına bakılmıştır. Bunlara ek olarak da P_2O_5 katkısına bağlı olarak renk analizi yapılmıştır.

ARAŞTIRMA BULGULARI VE TARTIŞMA

Renk Ölçüm Sonuçları

Numunelerin ev eşyaları gibi uygulamalarda kullanım potansiyeli bulunduğundan P_2O_5 katkısıyla oluşabilecek renk değişimleri Konica Minolta marka renk ölçüm cihazıyla ölçülmüştür. Cihazın görüntüsü Şekil 3'te verilmiştir.



Şekil 3. Renk ölçüm cihazının görüntüsü

Renk ölçümleri sonucu elde edilen L,A,B değerleri renkleri ifade etmektedir. L değeri rengin koyuluk ve açıklığını belirtmektedir. L değeri 0'dan +'ya doğru uzaklaştıkça renk açılır, 0'a doğru yaklaştıkça da renk koyulaşır. A değeri kırmızılık ve yeşilliği temsil eder. A değeri 0'dan +'ya doğru gittikçe kırmızılık değeri artar, 0'dan -'ye doğru gidildikçe yeşilliği artar. B değeri 0'dan -'ye doğru gittikçe maviliği artar, 0'dan +'ya doğru gittikçe de sarılığın artar (Kırkbınar ve ark., 2020). Tablo 3'te renk ölçüm sonuçları verilmiştir.

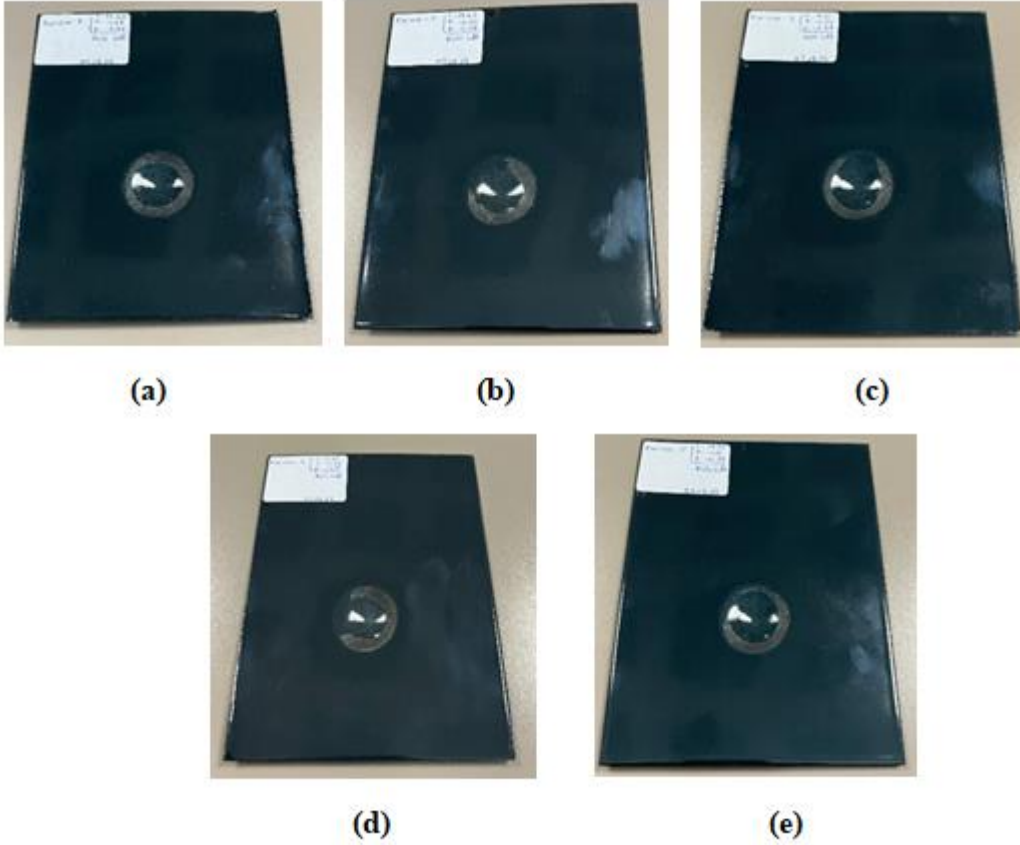
Tablo 3. Numunelere ait renk ölçüm sonuçları

Renk değerleri	Karışım 1	Karışım 2	Karışım 3	Karışım 4	Karışım 5
L	17,6	17,43	19,21	19,6	19,35
A	-1,27	-0,86	-0,75	-0,92	-1,21
B	-3,89	-4,38	-4,68	-4,71	-4,37

Sonuçlar incelendiğinde A değeri için %1'lik P₂O₅ içeren numunede yeşillik değeri en düşük iken, P₂O₅ miktarı %1'in altına düştüğünde ve %1'den daha yüksek katkı oranlarında yeşillik oranı artmaktadır. L değerinde ise benzer durum %1,5 P₂O₅ katkılı Karışım 4 numunesi için geçerlidir. Karışım 4 numunesinde renk açıklığı en fazladır. Bu durumda P₂O₅ miktarının artışıyla renkte açılma söz konusudur ve B değeri de L değerine çok benzer şekilde yine %1,5'lik katkıya kadar mavilik artmakta ve bu değerden sonra hafif bir düşüşe geçmektedir.

Pirolitik Testi Sonuçları

Pirolitik test, hazırlanan emaye kaplamaların ısıl etkiler altında değişime uğrayıp uğramadığını test etmeye yönelik uygulamadır. Test prosedüründe emaye kaplı plakalar 480 °C'de 48 saat boyunca fırında tutulmuştur. 48 saat sonunda fırından çıkan plakaların üzerinde değişim olup olmadığı kontrol edilmiştir. Sonuçlar Şekil 4'te paylaşılmıştır.

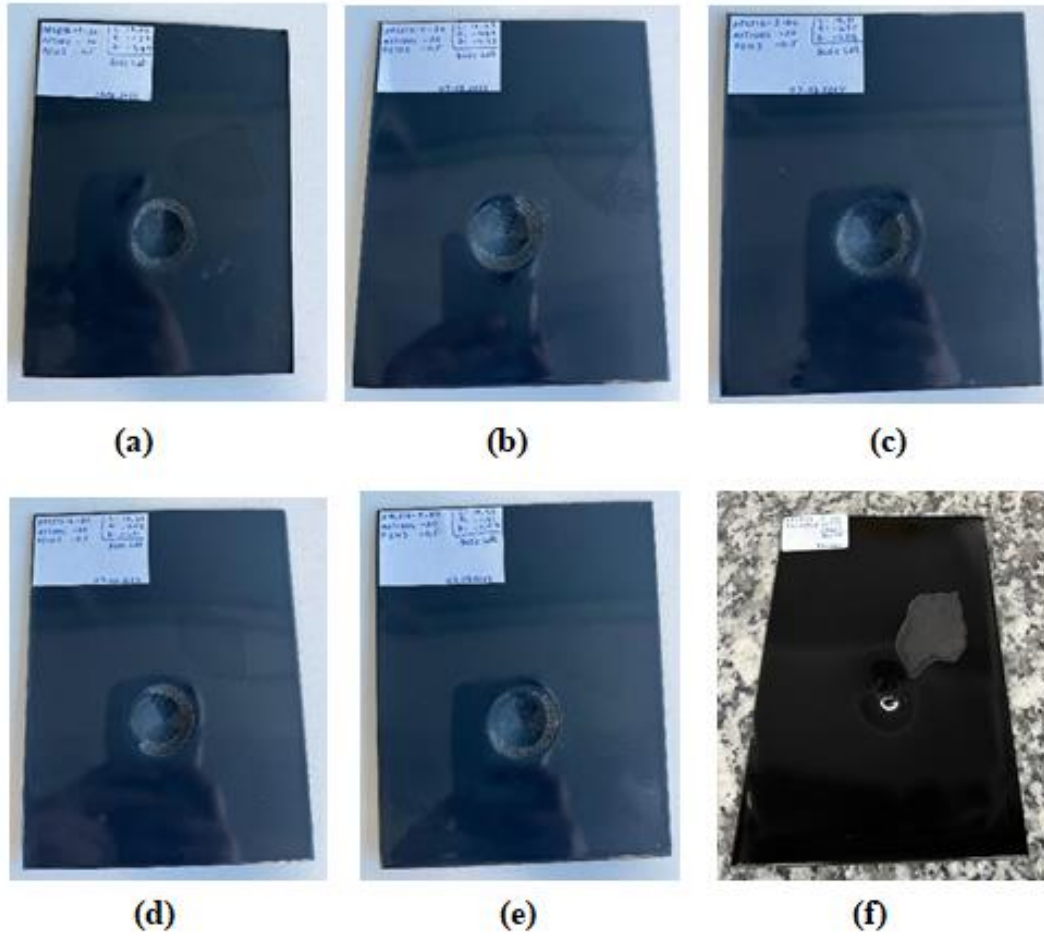


Şekil 4. Pirolitik test uygulanan plakaların yüzey görüntüsü, (a) % 0, (b) % 0,5, (c) % 1, (d) % 1,5 ve (e) % 2

Plakalardan görüldüğü üzere en iyi yüzey görüntüsü %1,5 katkılı numunede elde edilmiştir.

Sitrik Asit Testi Sonuçları

Emaye kaplamalarda kaplamanın sitrik asit ile olan etkileşimi, özellikle gıda ile teması olan araç-gereçlerin yüzeyleri için oldukça önem taşımaktadır. Bu testte emayenin sitrik asit dayanımına bakılmaktadır. Standart prosedürde %10'luk sitrik asit çözeltisi hazırlanmakta ve hazırlanan çözelti, emaye uygulaması yapılmış plakaların üzerine damlatarak 15 dk boyunca bekletilmektedir (ASTM- C 282 Standardı) (ASTM, 1999). Bu çalışmada da standart prosedür takip edilerek yüzey 15 dk boyunca sitrik asit çözeltisine maruz bırakıldıktan sonra yıkanmış ve kurulanmıştır. 15 dk'lık işlemin sonunda yüzeyler yıkanarak kurulanmıştır. 15 dk'lık sitrik asit uygulamasından sonra kaplamalarda deformasyon veya iz vb. oluşması durumunda B, herhangi bir deformasyon veya iz oluşmaması vb. durumunda ise A değeri verilmektedir. Çalışmada sitrik asit testi uygulanan plakaların yüzey görüntüsü Şekil 5'te paylaşılmıştır.



Şekil 5. Sitrik asit testi uygulanan plakaların yüzey görüntüsü, (a) % 0, (b) % 0,5, (c) % 1, (d) % 1,5, (e) % 2 ve (f) Sitrik asit testi değeri B olan plaka örneği.

Test ölçüm sonuçları ise Tablo 4’te verilmiştir. Sonuçlar P_2O_5 ’in emayenin sitrik asit direncine karşı ciddi bir etkisinin bulunmadığını göstermektedir. Tüm emayelerin sitrik asit testinden A değerini aldığı ve emaye yüzeylerinde belirgin bir deformasyon veya iz meydana gelmediği gözlemlenmiştir.

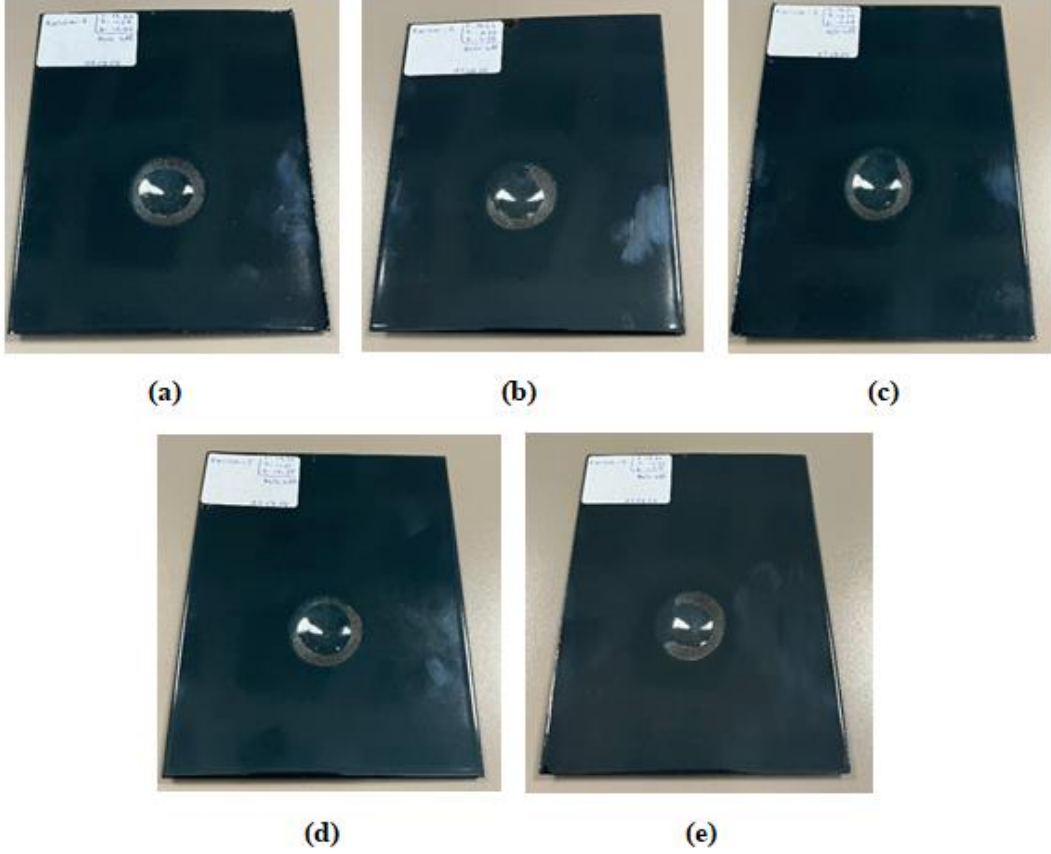
Tablo 4. Numunelere ait sitrik asit test ölçüm sonuçları

	Karışım 1	Karışım 2	Karışım 3	Karışım 4	Karışım 5
Asit testi	A	A	A	A	A

ETC Testi Sonuçları

ETC testi, kolay temizlenebilirlik anlamına gelen “easy-to-clean” kelimesinin kısaltmalarından oluşmaktadır. Bu test kolay temizlenebilirlik istenen emaye kaplamalar için kullanılan bir test olarak bilinmektedir. Test prosedüründe, emaye kaplı yüzey üzerinde sitrik asit testi yapıldıktan sonra aynı bölgeye 0,5 g Lityum nitrat konularak 320 °C deki fırında 15 dk bekletilmektedir. Fırından çıkarılan emaye kaplı plakanın üzerinde eriyen Lityum Nitrat, plakanın soğumasını takiben su ile temizlenerek yüzeyde aşındırma meydana getirip

getirmediği kontrol edilmektedir. Yüzeyde aşınma gözlemlenmediyse emaye kaplama ETC testinden başarı ile geçmiş anlamına gelmektedir. Çalışmada ETC testi uygulanan plakaların yüzey görüntüsü Şekil 6’da paylaşılmıştır.



Şekil 6. ETC test uygulanan plakaların yüzey görüntüsü, (a) % 0, (b) % 0,5, (c) % 1, (d) % 1,5 ve (e) % 2

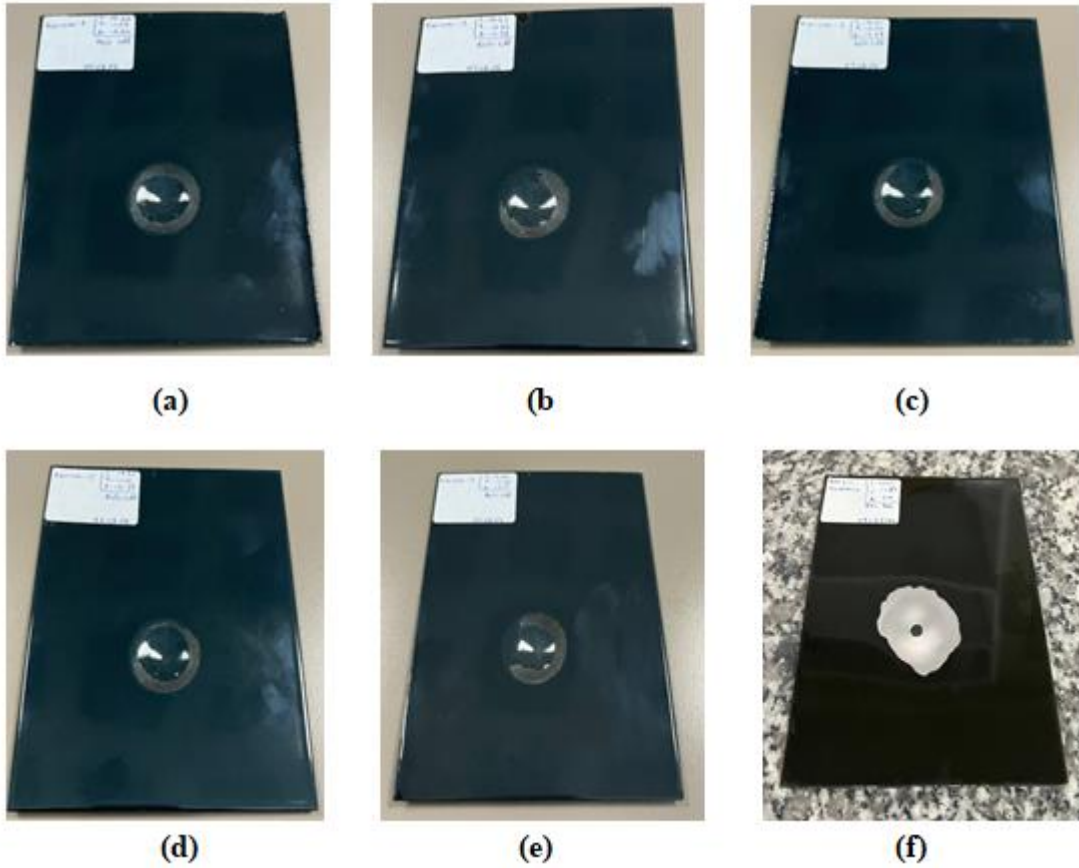
Tablo 5. Numunelere ait ETC test ölçüm sonuçları

	Karışım 1	Karışım 2	Karışım 3	Karışım 4	Karışım 5
ETC testi	iz yok	iz yok	iz yok	iz yok	iz yok

Test ölçüm sonuçları ise Tablo 5’te verilmiştir. Tüm emayelerin ETC testinden olumlu sonuçlar aldığı gözlemlenmiştir.

Darbe Testi Sonuçları

Darbe testi emayenin kaplanmış olduğu metal saca olan yapışmasının kontrolü için yapılmaktadır. Darbe testinde, test cihazına yerleştirilen emaye kaplı plaka üzerine 1,250 kg ağırlığında ve 1,9 cm çapında metal çubuk, 90 cm yükseklikten serbest düşmeye bırakılmakta ve plaka üzerine bir darbe vurulmaktadır. Parçanın üzerindeki darbe etkisi, darbe testi sonucuna göre en iyi de en kötüye doğru 1 – 5 arasında değerlendirilmektedir. Emayede kopma olmazsa 1, emayede kopma olursa 5 değerini almaktadır. Çalışmada darbe testi uygulanan plakaların yüzey görüntüsü Şekil 7’de paylaşılmıştır.



Şekil 7. Darbe testi uygulanan plakaların yüzey görüntüsü, (a) %0, (b) % 0,5, (c) % 1, (d) % 1,5, (e) % 2 ve (f) Darbe testi sonucu 5 değerini almış plaka örneği.

Tablo 6. Numunelere ait darbe testi ölçüm sonuçları

	Karışım 1	Karışım 2	Karışım 3	Karışım 4	Karışım 5
Darbe testi	1	1	1	1	1

Test ölçüm sonuçları ise Tablo 6’te verilmiştir. Tüm emayelerin darbe testinden 1 puan olarak testten geçtiği gözlemlenmiştir.

XRF Sonuçları

X-ışını floresans analizi (XRF), toz veya sıvı formdaki numunelerin içerdiği elementlerin (genellikle oksit formlarının) nitel ve nicel analizlerini yapmak için kullanılan bir yöntemdir. Bir X-ışını kaynağından üretilen ışın analiz edilecek maddenin yüzeyine çarptırılmakta ve içerisinde ihtiva ettiği elementlere özgü karakteristik bir X-ışını yayarak Ge detektör ile analiz edilmekte ve numunenin kimyasal kompozisyonunda yer alan elementlerin ne olduğu ve yüzde miktarları belirlenmiş olmaktadır. Çalışmada emaye kaplama için kullanılan fritlerin kimyasal analizleri Bruker marka XRF analiz cihazıyla gerçekleştirilmiş ve numunelerden elde edilen XRF ölçüm sonuçları ise Tablo 7’de verilmiştir.

Tablo 7. Emaye fritlerine ait XRF sonuçları (ağırlıkça %)

Bileşik Adı	Karışım 1	Karışım 2	Karışım 3	Karışım 4	Karışım 5
	Ağırlıkça % Miktarları				
Na ₂ O	6,858	6,817	6,745	6,716	6,705
K ₂ O	2,638	2,67	2,65	2,68	2,665
CaO	2,818	2,851	2,857	2,841	2,841
BaO	0,153	0,154	0,15	0,156	0,156
MgO	0,042	0,045	0,049	0,05	0,058
SrO	0,001	0,002	0,002	0,001	0,002
SiO ₂	54,36	54,288	54,491	53,767	53,764
Al ₂ O ₃	2,006	1,536	1,626	1,69	1,755
B ₂ O ₃	19,74	19,68	19,245	19,282	18,699
F	1,592	1,684	1,546	1,701	1,671
ZrO ₂	4,32	4,47	4,445	4,364	4,452
TiO ₂	1,779	1,79	1,792	1,741	1,755
P ₂ O ₅	0	0,386	0,746	1,4	1,852
NiO	1,339	1,354	1,356	1,35	1,33
MnO	0,195	0,194	0,193	0,192	0,205
CoO	0,899	0,917	0,92	0,909	0,909
CuO	0,042	0,042	0,043	0,042	0,05
Fe ₂ O ₃	0,441	0,428	0,453	0,435	0,453
Cr ₂ O ₃	0,17	0,178	0,18	0,179	0,185
MoO ₃	0,387	0,392	0,391	0,385	0,38
Sb ₂ O ₃	0,12	0,121	0,119	0,118	0,112
Toplam	99,999	99,999	99,999	99,999	99,999

Sonuçlar incelendiğinde, yapı içerisinde başlangıç reçetesinden gelen yoğun kuvars ve sodyum feldispat bileşiklerinin girdisinden kaynaklı yüksek SiO₂, Na₂O, Al₂O₃ varlığı gözlemlenmektedir. Tablodan görüleceği üzere %50'nin üzerindeki SiO₂ miktarının frit oluşumunu olumlu etkileyeceği görülmektedir. Yapı içerisinde P₂O₅ yüzdesinin Karışım 1'den 5'e kadar beklenildiği şekilde yükseldiği görülmektedir. Ancak yapı içerisine katılan P₂O₅'in yapıdaki diğer oksitlerle başka fazlara yol açtığı Tablo 7'da verilen oranlardan çıkarılabilecek bir sonuç olduğudur.

SONUÇ

Bu çalışmada, yüksek SiO₂, Na₂O, Al₂O₃ içeren fritler üretilmiş ve soğuk haddelenmiş çelik altlıklar üzerine emaye olarak elektrostatik yöntemle kaplanmıştır. Bu emaye kaplamalarda kullanılan ve reçetesi belirlenen frit kompozisyonlarına farklı oranlarda (ağırlıkça %0, %0,5,

%1, %1,5 ve %2 olacak şekilde) P₂O₅ katkısı yapılmış ve kaplamanın fiziksel, kimyasal ve mekanik özellikleri incelenmiştir.

Nihai ürünlerin kimyasal içeriği XRF ile belirlenmiş ve yüksek miktarda SiO₂, Na₂O, Al₂O₃ tespit edilmiştir. Bu oksitlerin varlığının hammaddeden gelen kompozisyonundan kaynaklandığı belirlenmiştir. Renk testinde, P₂O₅ miktarı %1 civarlarına geldiğinde yeşillik oranı düşmekte, %1,5 civarına geldiğinde renk açıklığı ve mavilik oranı artmaktadır. Termal ölçümlerde ise en iyi yüzey görüntüsü %1,5 katkılı numunede elde edilmiştir. Daha sonra numunelere uygulanan darbe, asit, ETC testlerinde tüm numuneler başarılı sonuçlar elde etmiştir. Sonuçlar tüm numunelerin emaye uygulamalarında kullanılabilceğini gösterse de özellikle %1,5 katkılı numunenin umut verici olduğu söylenebilir.

KAYNAKLAR

- ASTM – C 282, Standard Test Method for Acid Resistance of Porcelain Enamels (Citric Acid Spot Test). American Society for Testing and Materials, July 1999.
- Huynh, H. N., Shanhong, W., Tieu Kiet, A., Pham Sang, T., Hongtao, Z., 2019, Tribological behaviour of enamel coatings. *Wear Volumes 426–427, Part A*, 319-329.
- Kara Köksel, M., 2014, Sürekli Tavlama Yöntemi Yeni Kalite Bir Emaye Çeliği Üretimi, (Yüksek Lisans Tezi), İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Metalurji ve Malzeme Mühendisliği Bölümü, İstanbul.
- Karaca, H., 2014, Kalsiyum ve Magnezyum Oksit Bileşimli Bir Frit Kompozisyonu Geliştirmek ve Kristalizasyon Davranışını İncelemek, (Doktora Tezi). Dokuz Eylül Üniversitesi Fen Bilimleri Enstitüsü.
- Kırkbınar, M., İbrahimoglu, E., Çalışkan, F., 2020, Sinterleme Yöntemiyle Apatit – Wollastonit Cam Seramik Üretimi, *Academic Platform - Journal of Engineering and Science*, Volume: 8 Issue: 2, 217 – 221, <https://doi.org/10.21541/apjes.656253>
- Pekkan, K., 2009, Zirkonsuz Opak Frit Üretimi ve Hızlı Pişirim Duvar Karosu Sırlarının Geliştirilmesi, (Doktora Tezi), Anadolu Üniversitesi, Fen Bilimleri Enstitüsü, Seramik Mühendisliği Bölümü, Eskişehir.
- Rossi, S., Quaranta, A., Tavella, L., Deflorian, F., Compagnoni, A. M., 2015, Innovative Luminescent Vitreous Enamelled Coatings, *Intelligent Coatings for Corrosion Control*, 251-282.
- Sarp, F., 2019, Emaye Fritleri Üretim Teknikleri El Kitabı, Sakarya.
- Song, D., Tang, R., Yang, F., Qiao, Y., Sun, J., Jiang, J., Ma, A., 2018, Development of High Performance Enamel Coating on Grey Iron by Low Temperature Sintering, *Materials*, 11, 2183, doi:10.3390/ma11112183.
- Şahin, O., 2019, Dökme Demirlere Uygulanabilen Renkli Majolik Emaye Fritlerinin Geliştirilmesi, (Yüksek Lisans Tezi), Sakarya Uygulamalı Bilimler Üniversitesi, Lisansüstü Eğitim Enstitüsü, İmalat Mühendisliği, Sakarya.

**HARDENED PROPERTIES PREDICTION OF ROLLER COMPACTED
CONCRETE VIA GENE EXPRESSION PROGRAMMING**

Şevin EK MEN

Assistant Professor Dr., Harran University, Engineering Faculty, Department of Civil Engineering, TÜRKİYE

ABSTRACT

Roller-compacted concrete (RCC) is a type with zero slumps that can be used in different areas such as roads, pavements, and hydraulic structures. While roller-compacted concrete consists of aggregate, cement, and water with appropriate gradation like traditional concrete, it also differs from conventional concrete in compacting. In order to achieve high strength in these special concrete application areas, it must be intensively compacted with vibrating rollers. Roller-compacted concrete pavement technology, mainly used in road applications, provides advantages such as low cost, early opening to traffic, and low shrinkage. In order to ensure that the concrete applications have a sufficient service life, it is crucial to create the appropriate design. While it is possible to obtain a lot of data on this subject thanks to laboratory studies, time, cost, and energy loss also occur. In order to minimize these losses, novel regression models may be used. Thanks to this study, data predictions were performed by gene expression programming (GEP) using experimental data obtained as a result of RCC studies in the literature. Aggregate amount, cement amount, and water amount, which constitute the RCC mixture parameters to be used in GEP, are the independent variables, while the compressive strength, flexural tensile strength, and splitting tensile strength values of concrete are determined as dependent variables. As a result of the study, high correlation values were reached between the experimental study results and the values estimated by GEP. The function achieved by GEP allows for the elaboration of future studies and the closure of gaps.

Keywords: Roller Compacted Concrete, Gene Expression Programming, Hardened Properties.

ÖZET

Silindirle sıkıştırılmış beton (SSB), yollar, kaldırımlar ve hidrolik yapılar gibi farklı alanlarda kullanılabilen sıfır çökmeli bir beton türüdür. Silindirle sıkıştırılmış beton, geleneksel beton gibi uygun gradasyona sahip agrega, çimento ve sudan oluşurken, sıkıştırma konusunda da geleneksel betondan farklılık gösterir. Bu özel beton uygulama alanlarında yüksek dayanım elde edebilmek için titreşimli silindirler ile yoğun bir şekilde sıkıştırılması gerekmektedir. Ağırlıklı olarak yol uygulamalarında kullanılan silindirle sıkıştırılmış beton kaplama teknolojisi, düşük maliyet, trafiğe erken açılma ve düşük rötre gibi avantajlar sağlamaktadır. Beton uygulamalarının yeterli hizmet ömrüne sahip olmasını sağlamak için uygun tasarımın

oluřturulması çok önemlidir. Laboratuvar alıřmaları sayesinde bu konuda birok veri elde etmek mmkn olsa da zaman, maliyet ve enerji kaybı da yařanmaktadır. Bu kayıpları en aza indirmek iin yeni regresyon modelleri kullanılabilir. Bu alıřma sayesinde literatrdeki RCC alıřmaları sonucunda elde edilen deneysel veriler kullanılarak gen ekspresyon programlama (GEP) ile veri tahminleri gerekleřtirilmiřtir. GEP'te kullanılacak SSB karıřım parametrelerini oluřturan agrega miktarı, imento miktarı ve su miktarı bağımsız deęiřkenler, betonun basın dayanımı, eęilmede ekme dayanımı ve yarmada ekme dayanımı deęerleri ise bağımlı deęiřkenler olarak belirlenmiřtir. alıřma sonucunda, deneysel alıřma sonuları ile GEP tarafından tahmin edilen deęerler arasında yksek korelasyon deęerlerine ulařılmıřtır. GEP ile elde edilen iřlev, gelecekteki alıřmaların detaylandırılmasına ve bořlukların kapatılmasına olanak saęlamaktadır.

Anahtar Kelimeler: Silindirle Sıkıřtırılmıř Beton, Gen Ekspresyon Programlama, Sertleřmiř zellikler.

**A REVIEW OF POLYMERIC DISPERSANTS IN THE STABILIZATION OF
HYDROPHOBIC DYES AND PIGMENTS**

M.A. Sarli

Ege University, Department of Textile Engineering, Izmir, Turkey

A.T. Özgüney

Ege University, Department of Textile Engineering, Izmir, Turkey

E.S Dalbaşı

Ege University, Department of Textile Engineering, Izmir, Turkey

ABSTRACT

Dispersing agents are a group of chemical additives that immigrate to a liquid-solid interface and prevent particle aggregation or agglomeration by changing interfacial tension, electrostatic repulsion, or steric hindrance effect. The dispersing mechanism is highly dependent on the class and chemical structure of the dispersant. In terms of dispersant chemical structure, they are widely divided into two categories: surfactants and soluble polymers. Recent studies show the greater efficiency of polymeric dispersants to prepare stable colloids. While polymer functional groups are responsible for dispersant adsorption on dye surfaces, the long polymeric chains can provide an effective steric hindrance effect. Sodium polynaphthalene sulphonic formaldehyde, polyacrylates, lignin-based polymers, styrene-maleic anhydride copolymer have been recently suggested as effective dye dispersants. However, very limited investigations on the performance of polycarboxylates (PC) as dye dispersants have been published. This is while PCs have proven outstanding performance in dispersing many inorganic particles such as cement, kaolin, titanium dioxide, etc. in water. Molecular weight, molecular weight distribution, side-chain length, side-chain density, and molecular composition have been shown to be strongly effective in dispersing cement particles. Comb-like PCs are generally synthesized by either grafting poly(ethoxy) to the PC homopolymer or radical copolymerization of (meth)acrylic acid with a macromonomer containing poly(ethoxy) chains. Regarding copolymerization, the macromonomer plays a significant role in synthesizing more efficient dispersants. It has been reported that macromonomers like tresylated polyethylene glycol (TPEG) react more facile with acrylic acid compared to other ethoxylated acrylic macromonomers. Despite numerous studies on the synthesis and application of PC dispersants with various architectures, we were unable to find a comprehensive study on the efficiency and design of PC molecules for dispersing organic molecules such as disperse dyes.

Keywords: Dispersing agent; Polycarboxylate; Polymeric dispersants; Dispersion stability.

1. Introduction

A considerable quantity of dispersant is required for dyeing with dispersion dyes to create a tiny particle size and a stable suspension of the dye. Thus the dispersing solution acts as a dye diluent [1]. Dispersants are surfactants consisting of a hydrophobic non-polar part and a polar or hydrophilic part [2]. During the dyeing operation, only the dye is diluted in the fibers, while the dispersant and other compounds remain in the effluent solution [1]. Therefore, dispersants must have high thermal stability and, at the same time, create the lowest foam and also reduce or keep the viscosity of the dye dispersant. Common LSS dispersants include concentrated naphthalene sulfonate, concentrated phenol formaldehyde, and various lignin dispersants [1,3].

Modifying the physical surface of non-covalent bonds is a prevalent method for dispersing and stabilizing solid particles in a liquid medium. This is done by the surfactants or macromolecules that are absorbed by the surface of the particles. High surface energy and physical absorption forces between particles are minimized for this purpose, and particle aggregation is prevented. These include the small surfactants of the molecule. Polymeric dispersants have received more attention in recent developments and are synthesized by CLRP radical polymerization techniques, such as ATRP atomic radical transfer polymerization, reversible polymerization, and RAFT transfer chain enhancement [4]. Polymeric dispersants have been developed with promising results in particle suspension in recent CLRP applications. On the other hand, recent research has concentrated on relatively basic structures such as simple dual-mass copolymers AB, but has not generally examined the link between structure effect or structure performance between various Polymeric dispersants [4].

2. Coloring agents

2.1. Disperse Dyes

Nowadays, very few natural dyes are used for the dyeing of fibers, and there are hundreds of types of industrial dyes in various classes and groups. One type of these dyes is disperse dyes [5]. Disperse dyes are dyes designed for polyester, acetate, and other hydrophobic fibers. It is believed that azo or anthraquinone dyes account for 85 percent of dispersion dyes [6]. Disperse dyes are water-insoluble dyes. The dispersed colloidal form of these dyes can be used in dyeing and printing of hydrophobic fibers and fabrics [1,2,7]. These fibers include polyester, acetate, and sometimes nylon and orlon [2,5]. Polyester fiber has been developed rapidly because of its various excellent properties and various purposes, and its dyeing with disperse dyes has leaped to the forefront of all kinds of dyes in both variety and yield [8].

It is well known that polyester fibers are dyed using disperse dyes at higher temperatures, generally at 130 °C [9]. The first dispersion dyes were ionamine dyes from the English dyes group. These dyes, N-methane sulfonic acids, are amino azo or amino anthraquinone dyes that release the acidic group N-methane sulfonic acid during dyeing. This operation led to the

rapid dyeing of dispersion dyes on acetate fibers [7]. With the introduction of this mechanism in early 1923, major dispersion dyes spread, such as the English group Dyestuff and Celanese. Since 1950, the production of dispersion dyes has increased rapidly, followed by the production of synthetic fibers, especially polyester fibers [7]. Disperse dyes should be dispersed in the dye bath, so particle size and stability during dyeing are essential [2]. Most commonly, the disperse dyes used today are azo and anthraquinone based. On a majority basis, they are monoazo and anthraquinone based disperse dyes [10].

2.2. Pigments

A pigment is a colored substance that is entirely or almost entirely insoluble in water. On the other hand, dye is generally soluble, at least at some point during its application. Pigments are usually inorganic chemicals, whereas dyes are usually organic substances. Ocher, charcoal, and lapis lazuli are prehistoric and historical pigments [11]. Pigments are insoluble in water and solvents and are not considered textile dyes, so they do not tend to fibers [5,7]. The physical form and crystal structure of the pigment particles are essential for their applications. After synthesis, physical finishing methods such as milling and solvent finishing for the raw pigment are required to obtain functional products [7]. Most graftings are made on the surface of the fibers with resin [5]. Pigments are widely used in printing and sometimes for dyeing light shades and are also used to produce colored fibers in doping spinning [5].

3. Low molecular weight dispersants

Low molecular weight dispersants are a well-established family of surfactant-type compounds that are classified as anionic, cationic, electro-neutral, or non-ionic based on their chemical structure. These products have a low molecular weight, generally between 300 and 2,000 g/mol. Non-ionic and ionic polymeric dispersants are distinguished by the weight properties of the interconnected functional groups. Depending on the pH and ionic stability, ionic functional groups can act as an efficient dispersant in the stabilization of particles in aqueous solutions. Non-ionic dispersants are usually insensitive to pH and ion stability variations. The molecular weight of Polymeric dispersants is important in the preparation of polymer chains. If the chains are too short, they do not affect the accumulation of pigments and, therefore very low molecular weight, creating unstable dispersions. When chains are excessively long, they have a significant risk of particle-to-particle bonding, as well as a tendency to twist and accumulate mass. Hence, too high a molecular weight reduces the dispersing function. Polymeric dispersants should have a molecular weight of less than 20,000 g/mol [12,13]. Functional groups in high-molecular-weight dispersants generate significant polymer adsorption on particles. In addition, their lengthy molecule chains cause the steric hindrance effect of these dispersants [14].

Surfactants are chemical structures that attach to various interface surfaces in low quantities and lower surface tension in the liquid they dissolve (e.g., water). This reduction in surface tension may be between two or more phases (water and oil). Surfactants are amphiphilic;

hence they do not have all the characteristics of an active amphiphilic surface. An amphiphilic molecule offers a tendency for different phases. An organic amphiphilic molecule is made up of hydrophilic and hydrophobic components, which describe how the molecule interacts with different phases and solvents. If water is present in the system, the hydrophobic and hydrophilic components are employed. Amphiphiles have a strong tendency to migrate to interface surfaces. The polar or hydrophilic moieties of amphiphiles often contain atoms such as oxygen, sulfur, nitrogen, or phosphorus in the form of functional groups such as alcohol, thiol, sulfate, sulfonate, ether, ester, carboxylic acid, and phosphate. Polar liquids, particularly water, have a significant attraction towards the polar regions. In other words, the non-polar or hydrophobic part is generally an alkyl or benzene alkyl with non-ionized oxygen atoms or halogens [1].

4. Polymeric dispersants

A dispersant, also known as a dispersing agent, is a surfactant added to a suspension of solid or liquid particles in a liquid (such as a colloid or emulsion) to increase particle separation and avoid settling or clumping [15]. Dispersants are chemical structures that migrate to the solid-liquid phase, stabilizing solid particles in a liquid medium. A significant mechanism for low molecular weight dispersants is the change in the surface free energy of solid particles [16]. Dispersants are used in various industries, including textiles, printing, electronics, and pharmaceutical applications, to enhance particle stability in a liquid media by dispersing particles. Dispersants have hydrophilic and hydrophobic components in their molecular structure. The hydrophobic section of the dispersant absorbs the surface of the hydrophobic particles in an aqueous media, while the hydrophilic component dissolves in water [16]. Polar or smooth chemical structures are often employed as hydrophobic components in Polymeric dispersants for dye dispersion because these groups considerably increase the physical interactions of dispersants with dye molecules with comparable chemical structures. For instance, anthraquinones, black carbon, phthalocyanines, and diazo dyes are chemical structures [17].

Polymeric dispersants are themselves derivatives of low molecular weight inorganic or organic dispersants. A polymeric dispersant derives structural properties that bind to several adsorption sites simultaneously, and durable adsorption layers are formed in the pigment particles. Polymeric dispersants consist of a solid functional group or groups or a soluble polymer chain [1]. Polymeric dispersants in dispersed particles are characterized by their average molecular weight, molecular weight distribution, solubility, functional groups, and polymer arrangement. [14].

4.1. Polynaphthalene sulfonates

Homopolymers such as polypropylene and polyethylene exhibit low surface activity, particularly at the liquid/liquid interface, since they are comprised of a monomer that lacks a hydrophilic and hydrophobic component. These materials are composed of two or more

monomers that combine to generate hydrophilic and hydrophobic elements. Polymeric surfactants are typically produced from synthetic polymers. Prominent polyethylene oxide polymeric surfactants examples are b-polypropylene oxide copolymers, PCEs, concentrated ethoxylates, or sulfonates, for example, naphthalene sulfonate [1].

4.2. Polycarboxylates

Polycarboxylates are carboxylate-rich linear polymers with a high molecular weight ($M_r \leq 100000$). This type of surfactant is sodium salt of acrylic acid homopolymers or its copolymers with maleic acid [17]. They are a type of carboxylate-based polymeric dispersants, in which the high density of the side chains makes the dispersant more hydrophilic. Because carboxylate groups react with dye molecules, polymeric dispersants with higher side chain density contain fewer carboxylate groups in the polymer structure, lowering the number of carboxylates to minimize adsorption. Carboxylate groups play a vital part in the reactions of dye molecules' functional groups between hydrogen bonds. Similarly, poorer adsorption of polycarboxylates with increased side chain densities has been reported for cement particles [14]. These dispersants are water soluble and have characteristics such as low consumption, high absorption, electrostatic repulsion, and spatial ester resistance. [18,19] Polycarboxylates are frequently used as polymeric dispersants in concrete, paint, and ceramics [14]. As mentioned earlier, polycarboxylates are homopolymers or copolymers of carboxylic acid-containing monomers, such as methacrylic acid or its maleic hydride [14]. Water-soluble comb-like polycarboxylates include polyethylene or polypropylene oxide side chains that are adsorbed to the main structure. They can be adsorbed on solid particles via electrostatic, covalent, or van der Waals interactions. Chemical structure such as side chain length, side chain density, and molecular weight are critical factors in the design of polycarboxylate dispersants [14].

Polymethacrylic acid (PMAA) and polyacrylic acid (PAA) have shown different ionization degrees at different pH values. It is suggested that methyl groups be replaced in the polymer structure, impacting the structure hardness and hydrophobicity of polycarboxylate ether (PCE). PCE is a weak polyelectrolyte, and pH conditions can change its structure. As the pH increases, the degree of ionization of carboxylic groups increases [20]. Modified poly(styrene-comaleic anhydride) copolymer (SMA) is a kind of polycarboxylate dispersant [10].

Methoxypolyethylene glycols (MPEG) is a commonly used hydrophilic chain modified by esterification, and the modified products have a comb-like structure, can reduce surface tension, known as comb-like polycarboxylate copolymers [20].

Aqueous disperse dye dispersion was made using a ball-milling technique when using poly(styrene-co-maleic anhydride)-grafted 2-methoxypolyoxyethylene glycol (12) aminobenzoate (P(SMA-MPEGAB)) copolymer as a dispersant. Three kinds of polycarboxylate polymers synthesized by grafting the side chain to SMA of different percentages of maleic anhydride. The structure of P(SMA-MPEGAB) was characterized by FTIR and $^1\text{H-NMR}$. The results

showed the copolymer P(SMA1000- MPEGAB) synthesized by the SMA with the highest content of anhydride has the highest grafting rate (Figure 1) [10].

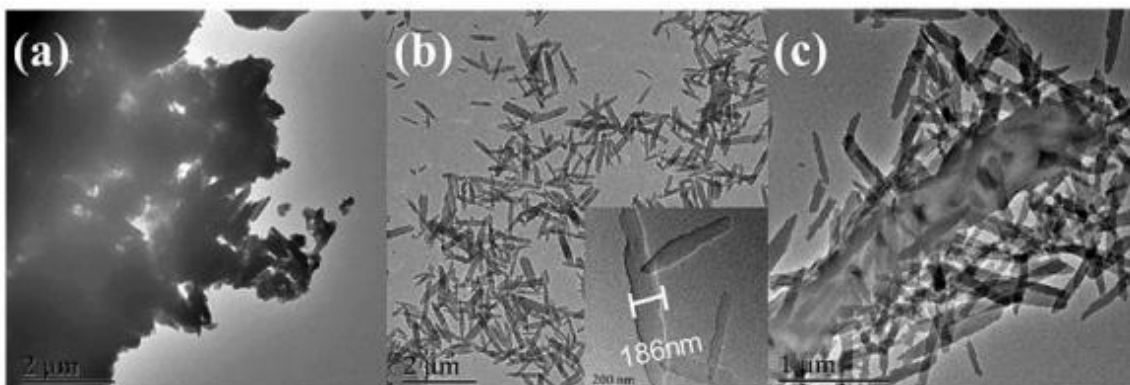


Figure 1. Copolymers of P(SMA-MPEGAB)

4.3. Ethoxylates

Ethoxylation is a chemical process that involves the addition of ethylene oxide to a substrate. It is the most widely practiced alkoxylation, which consists of the acquisition of epoxides to substrates. Alcohols and phenols are often transformed into $R(OC_2H_4)_nOH$, with n ranging from 1 to 10. Alcohol ethoxylates are the name for such compounds. Alcohol ethoxylates are often transformed into ethoxysulfates, a similar species. Surfactants such as alcohol ethoxylates and ethoxysulfates are commonly utilized in cosmetics and other commercial items [21]. In 1994, more than 2,000,000 metric tons of different ethoxylates were produced globally, making this process extremely important for industry [22]. Ethoxylate or sorbitan is produced by the reaction of sorbitol with a fatty acid at a temperature above 200 degrees. First, sorbitol is dehydrated and converted to 1,4-sorbitan. Then the esterification process is performed. Free OH functional groups in the molecule can be converted to esters to produce di and triester, and depending on the type of alkyl acid used, different products can be produced, including mono, di, and triester. The reaction of ethylene oxide with the remaining hydroxyl groups in the sorbitan ester group produces the ethoxylated derivatives of these substances. Polyoxyethylene sorbitan monolaurate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monooleate are examples of these materials [2].

4.4. Polyacrylates

Acrylate polymers are a kind of polymer that is made from acrylate monomers. These polymers are known for their clarity, strength, and elasticity. They are also referred to as acrylics or polyacrylates. As an adhesive, acrylate polymer is extensively used in cosmetics such as nail polish [23]. Polymeric dispersants are synthesized by the CLRP radical polymerization method. In this method, Polymeric dispersants with controlled molecular weight, limited molecular weight distribution, and suitable defined structure are produced, which include bulk copolymers, (AB double copolymers (poly (2-meth) amino) ethyl methacrylate) 30 - b - poly (ethyl methacrylate) 40) and three-mass copolymer ABA (poly (2 -

methyl amino) ethyl methacrylate) 30 - b - poly (ethyl methacrylate) 60 - b - poly (2 - meth amino) ethyl methacrylate) 30) and BAB) and bond copolymers (comb, dendrimer) and other copolymers are more effective in dispersing particles than homopolymers or copolymers synthesized by other conventional methods. Strong bonds can adsorb the structure of these copolymers on the particle surface with multi-point covalent interactions such as hydrogen bonding, bipolar bonding, amphoteric ions, and acid-base interactions. These strong bonds can build a strong ester fence around the particles in the solvent medium, causing dispersion and homogenous stability as well as inhibiting particle accumulation. Using the ATRP approach, a dual-mass copolymer dispersant AB with poly (2- (dimethylamino) ethyl acrylate) (PDMAEA) as the operating chain and poly (butyl acrylate) (PBA) as the stable chain that can inhibit pigment particle buildup in solvents is created [4].

4.5. Natural polymers

A polymer is a massive molecule (macromolecule) made up of repeating structural units that are usually connected via covalent chemical bonding. Although synthetic and natural polymers are available, natural polymers are preferred for pharmaceutical applications because they are cost-effective, readily available, and non-toxic. They can be chemically modified, are biodegradable, and mostly biocompatible [24]. Plant-derived substances face several obstacles, including the need to synthesize small quantities of intricate mixtures that vary depending on the location of the plants and other factors such as the season. This might lead to prolonged and costly isolation and purification process. Intellectual property rights are another issue that has become increasingly important [25,26]. Natural polymeric dispersants are extracted from non-petroleum sources. These dispersants are described as bonded Polymeric dispersants with more complex structures than synthesized polymeric dispersants. Commercial examples used include lignosulfonates, polysaccharides such as starch, carboxymethyl, carboxyethyl cellulose, and pectin. In particular, polysaccharide derivatives are also known as natural polymeric dispersants. They have monosaccharides linked to the main polymer chain via glycosidic bonds and different quasi-bond displacements adsorbed in the main polymer chain. As complex lignin polymers have three monomers that are repeated throughout the polymer [1].

5. Adsorption process

The adsorption of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface is known as adsorption [27]. This procedure forms an adsorbate layer on the adsorbent's surface. This contrasts with absorption, which occurs when a liquid or solid (the absorbent) dissolves or permeates a fluid (the absorbate) [28]. Adsorption is a surface process, whereas absorption affects the entire volume of the substance; therefore, adsorption frequently occurs before absorption [29]. Both processes are referred to as sorption, whereas desorption is the reverse. The adsorption of polymeric dispersants on the pigment surface is different from the adsorption of small molecules. Adsorption of various polymers on the surface of particles

from solution allows double bonds with the surface by lowering the free energy of the bond types and functional groups in the polymer [7].

5.1. Adsorption kinetics

Adsorption kinetics is the measurement of adsorption uptake over time at constant pressure or concentration, and it is used to determine adsorbate diffusion in pores [30]. Several factors that participate in the polymer adsorption kinetics are:

- 1) Heat transfer and diffusion processes regulate the mass that can be transferred from the polymer to the substrate surface;
- 2) The polymer velocity at the substrate surface, on which the amount of activation is dependent.
- 3) the structure of the adsorbed molecules with the least energy released.
- 4) in multi-dispersion systems, shorter polymer chains are replaced by longer chains.

Each of the parameters mentioned above is affected by several factors, namely the polymer molecular weight, the initial polymer concentration, solution conditions, and the surface composition. Polymers having a molecular weight of less than 20,000, for example, benefit from fast adsorption kinetics [12].

5.2. Absorption mechanisms

Polymer adsorption mechanisms to the solid surfaces are classified into physical and chemical according to the forces involved. The interactions are weak in the former mechanism, while polymers bind to the solid surface through covalent bonding in the chemical adsorption mechanism, which is stronger than the physically absorbed polymer molecules. Electrostatic interactions, chemical interactions, hydrogen bonding, and hydrophobic interactions are some commonly observed mechanisms. In electrostatic interactions, the electrostatic forces of the adsorbent engage the charged surface of the adsorption, and the charged ions repel the accumulation, while the repulsive electrostatic forces are present between the anionic molecules. Chemical bonding may happen between functional groups of the dispersing polymer and the surface. Chemical linkages can generate insoluble compounds by creating covalent or ionic bonds on the solid surface through the interaction of polymer groups with positive ion moieties. Hydrogen bonds are a type of acid-base interaction commonly seen in polymeric dispersants that can bond hydrogen to the material's surface. In organic compounds, the hydrogen atom forms a strong bond with an electronegative atom (O, S, or N). Hydrophobic interactions may be more prominent in the adsorption of organic compounds with non-polar groups. For example, in an aqueous medium, a hydrocarbon structure -CH₂-CH₂- joins the surface because hydrophobic molecules are repelled by water [12].

5.3. Adsorption isotherms

The adsorption isotherm shows the quantity of polymer adsorbed on the solid surface versus the balance of polymer concentration in solution under constant temperature. Polymeric dispersant adsorption density on oxidized surfaces usually rises as the molecular weight of the polymeric dispersant increases. The shape of the adsorption isotherm is determined by the system's nature and understanding of the main adsorption mechanisms. There are four types of classes for adsorption isotherms: 1) S-like, 2) Langmuir (L), 3) High inclination (H), 4) Stable separation (C). The diagram of adsorption isotherms is shown in Figure 2 [12].

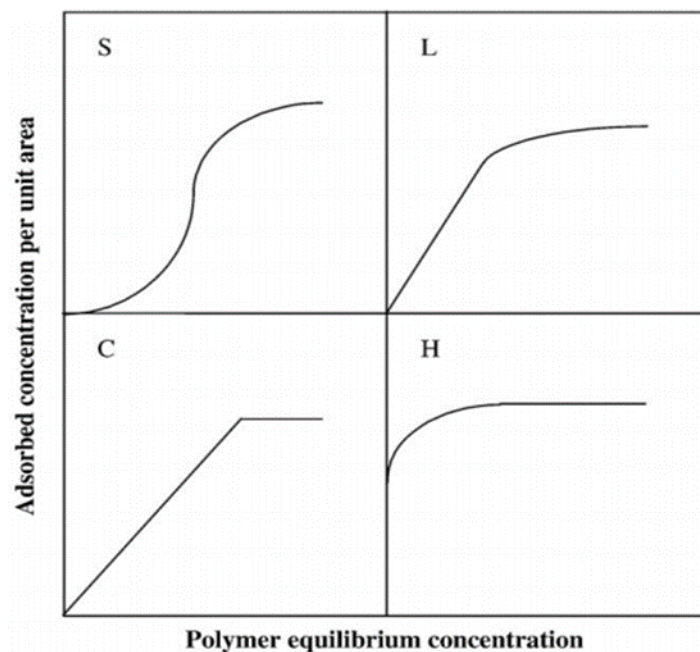


Figure 2. Solid adsorption isotherms

In S, L, and H adsorption isotherms, single layer adsorption may be converted to multilayer adsorption. Type S isotherms occur less frequently in polymer adsorption. The L adsorption isotherm shows that more surface locations are obtained. Systems with H adsorption isotherm are classified as high-affinity systems in which polymer molecules typically stick to the surface via monolayer adsorption. H-curves are formed when the solubility of the sample's solute is high, even at extremely low polymer concentrations. Most polymers have an H-type adsorption isotherm [12,31].

5.3. Adsorption layer structure

In general, the structure of the adsorbed polymer plays an essential role in mineral suspension stability and dispersion. Adsorbed polymers are composed of three components: 1) internal parts or chains. 2) bonded parts by chains at the end or rings. 3) bonded parts by chains at the end or tail.

The difference in the length of the chains, loops, and tail of the chain regulates the adsorbed structure and the adsorbed layer's thickness. Adsorption of anionic polymers is significantly dependent on the degree of functional group decomposition, which is influenced by solution pH and ionic strength values. The polymer acts as a non-ionic adsorbed polymer with a tiny ring and a long hanging tail at pH levels that decomposition does not occur. Ion strength directly affects the polymer solution's properties, with a slight increase in ion strength often resulting in thick adsorbed polyelectrolyte layers. Ionic polymers with low ionic stability have a long structure and are adsorbed on thin layers in flat structures [7].

6. The application of polymeric dispersants

6.1. Dyeing

It is essential to employ dispersants when dyeing synthetic fibers with disperse dyes. Recently, Polymeric dispersants have been used to improve dyeing properties. The use of polyoxyethylene sorbitan monooleate dispersant (Tween 80 and Tween 20) has been investigated in the dyeing process of synthetic fibers with 79 blue dye. Parameters of time, temperature, and concentration of dispersant have been concisely studies in this research. The dissolution rate of the dye was investigated. It was observed that the dissolution kinetics of the dye in the presence of both dispersants follow the exponential function, and its velocity decreases with increasing time. Concerning the impacts of temperature and time, it was reported that no apparent changes in dye dissolution happened between 50 and 70 minutes, indicating that the dye solution had reached saturation at this time. Also, the dye dissolution rate has increased more than three times in the temperature range of 25 to 65 °C. The washing, optical, and abrasion stabilities were studied, and it was discovered that the type of dispersant did not affect these stabilities, although the washing stability values were good for all dispersants. [2,14].

6.2. Printing inks

In recent years, the use of new technologies for printing textiles has received much attention. Printing on polyester textiles with various dispersants has been investigated, and also some light stabilization, washing, and body sweat have been investigated, and good results have been observed in the presence of dispersants. Comparing surface tension, viscosity, particle size in different concentrations and times, it has been observed that changing dispersants with different concentrations and times did not have a significant effect on the characteristics of static viscosity and surface tension but has had a significant effect on dynamic surface tension and distribution of particle size [32].

6.3. Inorganic materials (Clay, Calcium carbonates, and Cement)

An inorganic material typically a chemical compound that lacks carbon-hydrogen bonds. The difference, however, is not well defined or agreed upon, and authorities have various perspectives on the subject [33,34,35]. The study of the above mentioned materials is called

inorganic chemistry. Although the compositions of the deep mantle are still being studied, the majority of the Earth's crust is made up of inorganic materials [36]. Polyelectrolytes are utilized as a dispersant in the ceramic and cement industries. As a weak polyelectrolyte, polycarboxylate ether can improve the performance of cementitious materials. As a result, this polymer dispersant is often used to disperse cement at pH levels greater than 11 [37,38]. The comb-like structure of PCE polycarboxylate ether is made up of two radical units. The first property of these materials is the presence of anionic groups such as carboxylic or sulfonic functional groups that can absorb cement particles via surface electrostatic interactions. Their second characteristic is long bonded chains (polyethylene glycol) that prevent the accumulation of cement particles. Improved adsorption improves PCE dispersing performance, and carboxylic group complexation with Ca^{2+} ions is critical when controlling PCE efficiency in cementitious systems and is regulated by weight density. That should also be noted that PCE with a lower proportion of carboxylic groups will provide higher adsorption efficiency than PCE with more carboxylic groups [37,38].

7. Summary

Dispersants are chemicals that migrate to the solid-liquid phase and stabilize solid particles in the liquid environment. Dispersants are also surfactants used to dye polyester fibers with dispersion dyes. Polymeric dispersants are themselves derivatives of low molecular weight inorganic or organic dispersants that come in a variety of forms. Ethoxylates, polynaphthalene sulfonates, polyacrylates, polycarboxylates, and natural base dispersants are some of them. Polymeric dispersants are used in dyeing, printing, and minerals, including cement.

References

- [1]. Patrik borenus, Lignin and Hemicellulose in Dispersions – As surfactants and functional materials, 2019.
- [2]. Kamaldin Qaranjig, Alireza Khosravi, Volga Niknam, Anahita Ahmadi, Mojgan Hosseinejad, Investigation of dissolution and dyeing properties of a dispersion dye in the presence of biocompatible dispersants Twain, 2012, 253-261, Journal of Color Technology.
- [3]. j. Benko and G Daneaul, Lignin dispersing agents and method of making same, Patent US, 1975.
- [4]. Tommy fong, Meng Huo, zhengyi Wan, Hongge Chen, Liao Peng, Study of structure – performance relationships of polymeric dispersants on particle dispersion and stabilization, 2017, p.2513-2519, Royal Society of chemistry.
- [5]. Herman P Baumann, J M Fletcher, Textile Dyeing,
- [6]. Hamprecht, Rainer; Westerkamp, Aloys (2000). "Disperse Dyes". Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH. doi:10.1002/14356007.a08_565.

- [7]. K. Hunger, Industrial Dyes, Wiley-VCH.
- [8]. J Yang and Y liu, Dyestuff industry , 2002, p 24-25.
- [9]. S J, Colorants and auxiliaries organic chemistry and application properties, 2002.
- [10]. Yuanyuan Liu, Linping Zhang, Xiaofeng Sui, A novel Anionic Polymeric Dispersant for Preparation of Aqueous Disperse Dye Dispersion , 2020, 2-15
- [11]. Völz, Hans G.; Kischkewitz, Jürgen; Woditsch, Peter; Westerhaus, Axel; Griebler, Wolf-Dieter; De Liedekerke, Marcel; Buxbaum, Gunter; Printzen, Helmut; Mansmann. "Pigments, Inorganic". Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH.
- [12]. Saeed Farrokhpay, A review polymeric dispersant stabilisation of titania pigment, 2009, p 24-32, Advances in Colloid and Interface Science.
- [13]. Clayton J .Surf Coat int, 1997, 414.
- [14]. Hamid Gharanjig, Kamaladin Gharanjig, Alireza khosravi, Effect of the side chain density of Polycarboxylate dispersants on dye dispersion properties, 2019, p 1-9, Coloration Technology.
- [15]. Pirrung, Frank O.H.; Quednau, Peter H.; Auschra, Clemens (2002). "Wetting and Dispersing Agents". CHIMIA International Journal for Chemistry. 56: 170–176.
- [16]. Gi Young Kim, Suguna Perumal, Soon Cheon Kim, Design and Prediction of dye dispersibility stabilized by polymeric dispersant using a Dye-Monomer interaction force measurement, 2020, P 1-8, Dye and Pigments.
- [17]. Entry on Polycarboxylate. at: Römpf Online. Georg Thieme Verlag, retrieved 17. August 2016.
- [18]. A Zamanian, M Yasaei, M Mozafari, Ceramics international, 2013, 9525-9532.
- [19]. T Qian, Y Zhong, ZP Mao, J Appl Polym Sci, 2019, 136.
- [20]. B Yang, Z Du, W Zhang and P Li, fine chemicals, 2009, 450-454.
- [21]. Smulders, E.; von Rybinski, W.; Sung, E.; Rähse, W.; Steber, J.; Wiebel, F.; Nordskog, A. (2011). "Laundry Detergents, 1. Introduction". In Elvers, Barbara; et al. (eds.). Ullmann's Encyclopedia of Industrial Chemistry. Weinheim, GER: Wiley-VCH.
- [22]. Arno Cahn (30 January 1994). Proceedings of the 3rd World Conference on Detergents: Global Perspectives. The American Oil Chemists Society. p. 141.
- [23]. Erich Penzel (2000). "Polyacrylates". Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH.
- [24]. Satturwar P.M., Fulzele S.V., Dorle A.K., Biodegradation and in vivo biocompatibility of rosin: A natural film-forming polymer, AAPS Pharm. Sci. Tech. 2003; 4 : 1-6.
- [25]. Lam K.S., New aspects of natural products in drug discovery, Trends Microbiol. 2007; 15 : 279-89.
- [26]. McChesney J.D., Venkataraman S.K., Henri J.T., Plant natural products: Back to the future or into extinction? Phytochemistry. 2007; 68 : 2015-2022.
- [27]. "Glossary". The Brownfields and Land Revitalization Technology Support Center. Archived from the original on 2008-02-18. Retrieved 2009-12-21.

- [28]. "absorption (chemistry)". Memidex (WordNet) Dictionary/Thesaurus. Archived from the original on 2018-10-05. Retrieved 2010-11-02.
- [29]. Atkins, P. W.; De Paula, Julio; Keeler, James (2018). *Atkins' Physical chemistry* (Eleventh ed.). Oxford, United Kingdom.
- [30]. Calligaris, M.B., and Tien, C., Species grouping in multicomponent adsorption calculations. *Can. J. Chem. Eng.*, 60, 772-780 (1982).
- [31]. Theng BKJ, Formation and properties of clay – polymer complexes, Elsevier Scientific Publishing co, 1979.
- [32]. Abd El- Wahab H, Abd elBary HM, Abd Elrahman, Hasanein M, Influence of Chemistry of Dispersing Agent on the properties of Textile Inkjet Inks for Polyester printing, 2019, p 1-7, *Advance Research in Textile Engineering*.
- [33]. Some major textbooks on inorganic chemistry decline to define inorganic compounds: Holleman, A. F.; Wiberg, E. *Inorganic Chemistry* Academic Press: San Francisco, 2001. ISBN 0-12-352651-5; Greenwood, Norman N.; Earnshaw, Alan (1997). *Chemistry of the Elements* (2nd ed.).
- [34]. J. J. Berzelius "Lehrbuch der Chemie," 1st ed., Arnoldischen Buchhandlung, Dresden and Leipzig, 1827. ISBN 1-148-99953-1. Brief English commentary in English can be found in Bent Soren Jorgensen "More on Berzelius and the vital force" *J. Chem. Educ.*, 1965, vol. 42, p 394.
- [35]. Dan Berger, Bluffton College, analysis of varying inappropriate definitions of the inorganic-organic distinction: Otherwise consistent linked material differing from current article in downplaying the carbon present vs carbon absent distinctive.
- [36]. Newman, D. K.; Banfield, J. F. (2002). "Geomicrobiology: How Molecular-Scale Interactions Underpin Biogeochemical Systems". *Science*. 296 (5570): 1071–1077.
- [37]. Qian Zhang, Qianping Ran, Hongxia Zhao, PH- induced conformational changes of comb like polycarboxylate investigated by experiment and simulation, 2016, *Colloid polym Sci*.
- [38]. Qian Zhang, Bin Yang, Qianping Ran, Effect of side on conformational properties of comb like polycarboxylate in salt solution, 2019, p 3-12, *Journal of Dispersion Science and Technology*.

**SUPER-CONGRUENCES WITH BINOMIAL COEFFICIENTS AND GENERALATE
HARMONIC NUMBERS**

Laid Elkhiri

Tiaret University Faculty of Material Sciences, RECITS Laboratory USTHB,

Miloud Mihoubi

USTHB, Faculty of Mathematics, RECITS Laboratory, Algiers, Algeria.

ABSTRACT

In this presentation, we study some congruences modulo a power of a prime number (supercongruences) in the ring of \mathbb{Z} -integers concerning sums involving inverse binomial and generalized harmonic numbers, we given some extension of congruences obtained by Meštrović and Andjić, we establish various congruences involving harmonic numbers and binomial coefficient modulo prime number p .

INTRODUCTION

In 2017, Meštrović and Andjić investigated arithmetic properties to obtain various basic congruences modulo a prime for several sums involving harmonic numbers and binomial coefficients. Motivated by the above work, we mainly determine in this paper the congruences modulo p^2 or p^3 for the expressions

$$\sum_{k=1}^{(p-1)/2} (-1)^{k-1} \binom{k+m}{m}^{-1} \binom{(p-1)/2}{k} H_{k,n},$$
$$\sum_{k=1}^{(p-1)/2} (-1)^{k-1} \binom{(p-1)/2}{k} \binom{k}{m} H_{2k}.$$

The harmonic number and the congruence in the ring of p integer \mathbb{Z}_p ply important role in mathematics. Recall that harmonic numbers are to be

$$H_0 = 0, \quad H_n = \sum_{k=1}^n \frac{1}{k}, \quad n \geq 1,$$

\mathbb{Z}_p is the set of rational numbers having denominators not divisible by p and the unit group $U(\mathbb{Z}_p)$ is the set of rational numbers having denominators and numerators not divisible by p .

We define, for all prime number p and for all numbers $x, y \in \mathbb{Z}_p$

$$x \equiv y \pmod{p} \Leftrightarrow \text{numerator}(x - y) \equiv 0 \pmod{p}.$$

This shows when $x, y \in U(\mathbb{Z}_p)$ that

$$x \equiv y \pmod{p} \Leftrightarrow \frac{1}{x} \equiv \frac{1}{y} \pmod{p}.$$

Main results

We have the following theorems and corollaries.

Theorem 1. Let $p > 3$ be a prime number and $m \in \{1, 2, \dots, (p-1)/2\}$. We have

$$\sum_{k=1}^{(p-1)/2} (-1)^{k-1} \binom{k+m}{k}^{-1} \binom{(p-1)/2}{k} H_k \equiv \frac{m}{2m-1} (T(m) + S(m)p) \pmod{p^2}, \quad (8)$$

where

$$T(m) = -4q_2 + H_{2m-2} - 4H_{m-1} \text{ and}$$

$$S(m) = 2q_2^2 + H_{m-1,2} - 4H_{2m-2,2} + 4 \frac{q_2 + H_{m-1} - H_{2m-2}}{2m-1}.$$

Reducing the modulus in this congruence to get

$$\sum_{k=1}^{(p-1)/2} \binom{k+m}{k}^{-1} \binom{2k}{k} \frac{H_k}{4^k} \equiv \frac{4m}{2m-1} (q_2 - H_{2m-2} + H_{m-1}) \pmod{p}. \quad (9)$$

By the congruence (16), the congruence (9) for $m \in \{1, 2\}$ and by the fact that

$$\binom{k+2}{k}^{-1} = \frac{2}{k+1} - \frac{2}{k+2},$$

we may state:

Corollary 2. For each prime number $p > 3$ we have

$$\sum_{k=1}^{(p-1)/2} \frac{C_k H_k}{4^k} \equiv 4q_2 \pmod{p}, \quad (10)$$

$$\sum_{k=1}^{(p-1)/2} \binom{2k}{k} \frac{H_k}{4^k (k+2)} \equiv \frac{2}{3} + \frac{8}{3} q_2 \pmod{p}. \quad (11)$$

Theorem 3. Let $p > 3$ be a prime number and $m \in \{1, 2, \dots, (p-3)/2\}$. We have

$$\sum_{k=1}^{(p-1)/2} (-1)^{k-1} \binom{(p-1)/2}{k} \binom{k}{m} H_{2k} \equiv \frac{(-1)^m}{p-1-2m} \left(1 + \frac{(-1)^{(p-1)/2}}{2^{2m+p-1}} \binom{2m}{m} \right) \pmod{p^3}. \quad (12)$$

Reducing this modulus to obtain

$$\sum_{k=1}^{(p-1)/2} \binom{2k}{k} \binom{k}{m} \frac{H_{2k}}{4^k} \equiv \frac{(-1)^m}{2m+1} \left(1 + \frac{(-1)^{(p-1)/2}}{2^{2m}} \binom{2m}{m} \right)$$

REFERENCES

- [1] E.Elkhiri, Sibel Koparal and N Ömür "Congruences with -harmonic numbers and q-binomial coefficients" *Indian Journal of Pure and Applied Mathematics* (2023).
- [2] S Koparal,N Ömü, L Elkhiri. "Some congruences with q-binomial coefficients and q-harmonic numbers. *Hacettepe Journal of Mathematics and Statistics* (2023)
- [3] S. Koparal and N. Ömür, "Congruences related to central binomial coefficients, harmonic and Lucas numbers", *Turk. J. Math.*, **40**, 973-985 (2016).
- [4]S. Koparal and N. Ömür, "On congruences involving special numbers", *J. Ramanujan Math.*, **34**, 151-167 (2019).
- [5] R. Meštrović and M. Andjić, "Certain congruence for harmonic numbers", *Mathematica Montisnigri*, **38** (2017).

**EFFECT OF HIGH PRESSURE ON THE DEBYE TEMPERATURE OF CaO
MATERIAL**

Nadjet BENCHIHEUB

Laboratory of Materials Physics, Radiation and Nanostructures (LPMRN), University Mohamed El Bachir EL
IBRAHIMI of Bordj Bou Arreridj, 34000 Bordj Bou Arreridj, Algeria.

Nadhira BIOUD

Faculty of Sciences and Technology, University Mohamed El Bachir EL IBRAHIMI of Bordj Bou Arreridj,
34000, Bordj Bou Arreridj, Algeria

Laboratoire d'Optoélectronique et Composants, Faculté des sciences, Université Ferhat Abbas de Sétif1, 19000,
Sétif, Algérie

ABSTRACT

The present contribution aims to study the high-pressure effect up to on the Vashchenko-Zubarev Grüneisen parameter γ_{v-z} and the Debye temperature θ_D for calcium oxide (CaO) binary compound using a semi-empirical approach. The details of the calculation method adopted here are presented in reference (Bioud and Benchiheub, 2023). The following expression as a function of pressure given by $\theta_D = \theta_D(0)(\rho/\rho_0)^\gamma$ has been used to determine the Debye temperature θ_D of the compound of interest. Where ρ is the mass density, γ is the Grüneisen parameter, $\theta_D(0)$ and ρ_0 are respectively the normal conditions of Debye temperature and the mass density. The mass density ρ can be calculated easily from the mass ratio to the unit cell's volume.

Whereas, the Grüneisen parameter of materials is calculated by using the Vashchenko-Zubarev approach, through the formula : $\gamma_{v-z} = \left(\frac{1}{2} B' + \frac{2p}{9B} - \frac{5}{6} \right) / \left(1 - \frac{4p}{3B} \right)$. Where B is the isothermal bulk modulus, p is the pressure, and B' denotes the pressure derivative of B defined previously using the Vinet equation, and evaluated at different values of pressure.

Our data show that the Debye temperature of CaO material increases gradually with increasing pressure, while the Vashchenko-Zubarev Grüneisen parameter decreases with enhanced pressure up to

Keywords: CaO material, High pressure, Grüneisen parameter, Debye temperature.

INTRODUCTION

Metal oxides are a class of materials with applications in microelectronic domains. Particularly, calcium oxide (CaO) ionic compound is considered as a prototype oxide having a wide band gap and could play an important role in the modern field of spintronics (Ghebouli

et al, 2010). In their study, (Ghebouli *et al*, 2010) have investigated some physical parameters of CaO, SrO, and BaO metal oxides. They have studied the structural parameters, the elastic constants, and the electronic and optical properties using the (PP- PW) method within the generalized gradient approximation (GGA), while (Tsuchiya and Kawamura, 2001) have investigated the elastic properties of some alkaline earth oxides materials (such as MgO, CaO, SrO, and BaO) using an ab initio FP-LMTO approach.

Employing a semi-empirical approach, (Bioud and Benchiheub, 2023) have investigated the effect of high pressure up to on the bulk modulus, Vickers hardness, mass density, Grüneisen parameter, Debye temperature, and average acoustic velocity for calcium oxide compound.

(Speziale *et al*. 2006) have studied the high-pressure elasticity of CaO material using both the Brillouin scattering measurements and the radial X-ray diffraction method.

In the present work, we investigated the effect of high pressure up on the Grüneisen parameter and the Debye temperature of CaO material using some data measured at normal conditions.

THEORY, RESULTS AND DISCUSSION

Before proceeding to the high-pressure Debye temperature θ_D calculations of calcium oxide, we first predicted the high-pressure Grüneisen parameter γ , which is a good factor of anharmonicity (Bioud and Benchiheub, 2023). In this study, we used the Vashchenko-Zubarev Grüneisen parameter γ_{v-z} (V. Y. Vashchenko *et al*. 1963; N. Bioud, 2023). In the Vashchenko-Zubarev approach, the Grüneisen parameter γ_{v-z} can be calculated from the formula (V. Y. Vashchenko *et al*. 1963; N. Bioud, 2023):

$$\gamma_{v-z} = \left(\frac{1}{2} B' + \frac{2p}{9B} - \frac{5}{6} \right) / \left(1 - \frac{4p}{3B} \right) \quad (1)$$

where B is the bulk modulus, p is the pressure, and B' denotes the pressure derivative of B evaluated at different values of pressure.

Using the data reported in Ref. (Bioud and Benchiheub, 2023) on the bulk modulus B and its pressure derivative B' for calcium oxide material, the dependence with the pressure of the Vashchenko-Zubarev Grüneisen parameter γ_{v-z} for CaO material is classified in (Table 1).

Table 1. Vashchenko-Zubarev Grüneisen parameter γ_{v-z} for CaO versus pressure p up to 65.2 GPa.

p (GPa)	0	10	20	30	40	50	60	65.2
γ_{v-z}	1.37	1.28	1.22	1.18	1.14	1.11	1.09	1.08

The variation of the Grüneisen parameter γ_{v-z} with the pressure for calcium oxide (CaO) material was also plotted in (Figure 1), along with the result on the Dugdale and MacDonald Grüneisen parameter γ_{D-M} of Bioud and Benchiheub (Bioud and Benchiheub, 2023). As we can

see, the Grüneisen parameter of calcium oxide material decreases gradually with increasing pressure up to . Our achieved results for the CaO compound concord well with the behavior reported for CaX (X = S, Se, Te) materials (F. Okba and R. Mezouar, 2022) and these of CdSe, Cd_{0.75}Cr_{0.25}Se, ZnS, and Zn_{0.75}Cr_{0.25}S materials (S. Amari et al. 2023). The 3rd order polynomial fit of our data γ_{v-z} on versus pressure p for calcium oxide material is given as follows: $\gamma_{v-z} = 1.37 - 0.94 \times 10^{-2}p + 1.28 \times 10^{-4}p^2 - 7.88 \times 10^{-7}p^3$, where γ_{D-M} is dimensionless, while p is expressed in.

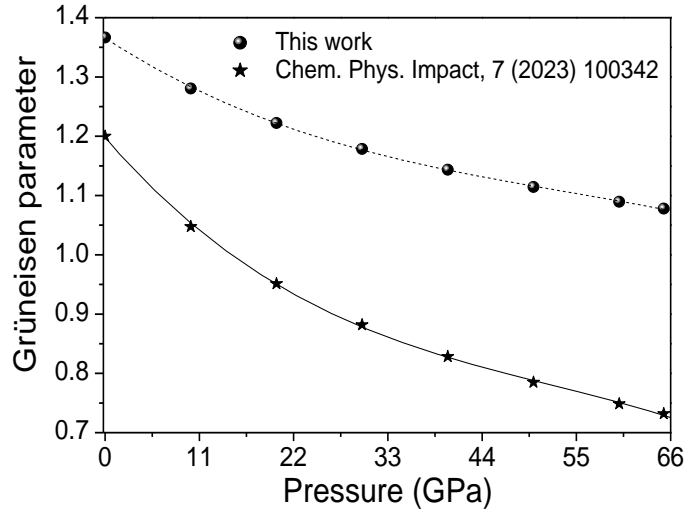


Figure 1. Pressure dependence of γ_{v-z} for CaO compound up to , along with the result γ_{D-M} of (Bioud and Benchiheub, 2023).

The Debye temperature θ_D is a critical thermodynamic quantity, which is employed for delineating high-temperature regions from low-temperature regions in solids (Bioud and Benchiheub, 2023). The Debye temperature θ_D can provide sufficient information on several thermal and mechanical properties of materials (Bioud and Benchiheub, 2023). One of the formulas has been used to determine the Debye temperature θ_D of crystals is a function of pressure; and it is given as follows (Bioud and Benchiheub, 2023):

$$\theta_D = \theta_D(0)(\rho/\rho_0)^\gamma \quad (2)$$

where ρ is the mass density, γ is the Grüneisen parameter, and $\theta_D(0)$ and ρ_0 are the normal conditions of Debye temperature and the mass density, respectively.

Using the θ_{D0} reported by Gmelin (E. Gmelin, 1969), our obtained values of θ_D for calcium oxide material are reported in (Table 2), and illustrated in (Figure 2), along with the result of (Bioud and Benchiheub, 2023). The Debye temperature of CaO increases monotonously and non-linearly with increasing pressure up to 65.2 GPa.

Table 2. Debye temperature θ_D versus pressure p for CaO material.

p (GPa)	0	10	20	30	40	50	60	65.2
θ_D (K)	562.0*	619.8	662.8	697.2	726.0	750.7	772.4	782.7

* Reference: S., Amari et al. (2013)

We note also that a similar behavior of θ_D against pressure was found for cadmium oxide (CdO) semiconducting material (N. Bioud, 2024), BeX (X = Co, Ni, Cu, and Pd) intermetallic compounds (S. Daoud and A. Latreche, 2016), cubic zincblende boron nitride (BN) semiconducting compound (S. Daoud and N. Bioud, 2014) and for tetragonal lead dioxide (β -PbO₂) compound (F. Bounab et al. 2019).

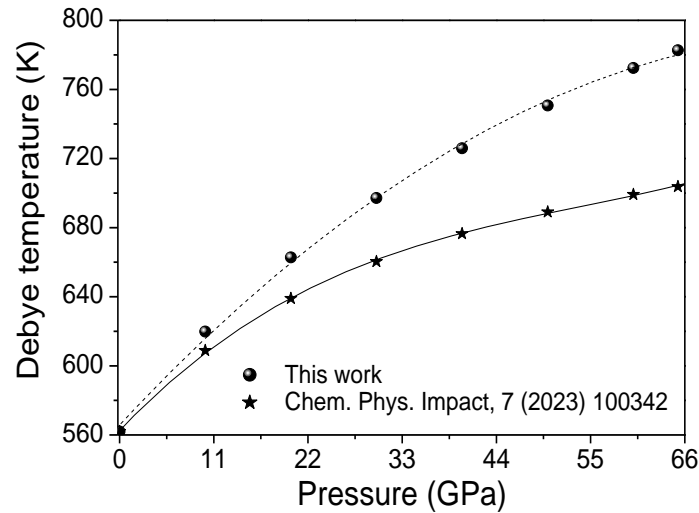


Figure 2. Debye temperature θ_D of CaO compound versus pressure up to 65.2 GPa, along with the result of (Bioud and Benchiheub, 2023).

The Debye temperature θ_D for calcium oxide material was established to follow a second-order polynomial relationship with pressure p . The obtained analytical expression is given as follows: $\theta_D = 565.83 + 5.31 p - 3.11 \times 10^{-2} p^2$, where θ_D is expressed in K and p is expressed in GPa.

CONCLUSION

The effects of high pressure on the Grüneisen parameter and the Debye temperature of CaO compound have been evaluated using a semi-empirical approach. The approach used here has been previously applied successfully for other materials. We found that the Grüneisen parameter of calcium oxide compound decreases gradually with increasing pressure up to 65.2 GPa, while the Debye temperature of CaO increases gradually and non-linearly with increased pressure up to 65.2 GPa. Similar behavior was observed for several other materials in the literature.

REFERENCES

- B., Ghebouli, M. A., Ghebouli, M., Fatmi, M., Benkerri, (2010). First-principles calculations of structural, elastic, electronic, and optical properties of XO (X=Ca, Sr and Ba) compounds under pressure effect, *Mater. Sci. Semicond. Process.*, 13 (2), 92-101.
- T., Tsuchiya, K., Kawamura, (2001). Systematics of elasticity : *Ab initio* study in -type alkaline earth oxides, *J. Chem. Phys.*, 114 (22), 10086–10093.
- N., Bioud, N., Benchiheub, (2023). Pressure effect on some physical properties of calcium oxide material, *Chem. Phys. Impact*, 7, 100342.
- S., Speziale, S., R., Shieh, T., S., Duffy, (2006). High-pressure elasticity of calcium oxide : A comparison between Brillouin spectroscopy and radial X-ray diffraction, *J. Geophys. Res.*, 111(B2) B02203
- V., Y., Vashchenko, V., N., Zubarev, (1963). *Sov. Phys. Solid State*, 5, 653
- N., Bioud, N., Benchiheub, (2024). Mechanical and Thermal Behavior of Semiconducting Cadmium Oxide at High-Pressure, *Annals of West University of Timisoara-Physics*, 66 142.
- F., Okba, R., Mezouar, (2022). Some Physical Parameters of Calcium Chalcogenides at High Pressures: Semi-Empirical Approach, *J. Nano-Electron. Phys.* 14 (4), 04004.
- S., Amari, S., Daoud, H., Rekab-Djabri, (2023). Structural, Thermodynamic and Magneto-Electronic Properties of Cd_{0.75}Cr_{0.25}Se and Zn_{0.75}Cr_{0.25}S : An Ab-Initio Study, *Acta Phys. Pol. A*, 143(1), 36-46.
- E., Gmelin, (1969). Thermal Properties of Alkaline-Earth-Oxides I. Specific heat measurements 1-3 Centre National de Recherches sur les Tres Basses Temperatures, *Z. Naturforsch.* 24A, 1794-1800.
- S., Daoud, A., Latreche, (2016). Density functional investigation on electronic structure and elastic properties of BeX at high pressure, *Indian J. Phys.*, 90, 1243–1244.
- S., Daoud, N., Bioud, (2014). Anisotropy and Pressure Effect on the Elastic and Mechanical Properties of (B3) BN, *Ukr. J. Phys.*, 59(4), 418.
- F., Bounab, N., Bouarissa, A., Merrouche, A., Benmakhlouf, S., Daoud, N., Chelali, (2019). Theoretical investigation of elastic constants and related properties of compressed PbO₂, *J. Comput. Electron.*, 18, 1111- 1118.

**DESIGN AND SIMULATION STUDIES OF A GRID CONNECTED 1MW WIND
ENERGY POWER PLANT USING MATLAB**

Kumkum Malakar

Department of Renewable Energy, Rajasthan Technical University Kota India-324010

Shiv Lal

Department of Renewable Energy, Rajasthan Technical University Kota India-324010

ABSTRACT

This study presents the design and simulation of a 1 MW grid-connected phasor-type wind turbine system using MATLAB/Simulink. The turbine is modelled with a line-to-line voltage of 400 V and operates at a frequency of 50 Hz, aligning with standards in India. Advanced features include high-temperature superconducting generators to reduce size and weight while maintaining efficiency with minimal losses. The aerodynamic design is optimized using blade element momentum (BEM) theory to enhance performance across various wind speeds. The simulation incorporates a step device for wind speed control and a rate limiter to regulate speed variations. Power flow is measured from the wind turbine to the grid, with a capacitor bank providing necessary reactive power. The results demonstrate that the system successfully delivers 1 MVA of power to the grid, confirming the effectiveness of the design and simulation parameters.

The analysis indicates that as wind speed drops below nominal levels, the pitch angle increases, and reactive power becomes negative, around -0.22. Real power decreases with wind speed, from 1 PU at 12 m/s to 0.495 PU at 10 m/s. At 14 m/s, real power exceeds 1 PU. With a 400 kVAR capacitor bank, some reactive power is supplied by the grid, whereas at 1 VAR, the grid provides all required reactive power. For a wind speed of 12 m/s, the turbine's power measurement is about 163.2 kVA, while the grid measures 179.5 kVA, reflecting minor reactive power losses. Ultimately, the wind turbine delivers approximately 0.96 MW of real power to the grid.

Keyword: wind turbine, reactive power loss, MATLAB, Blade element moment, real power etc.

1. Introduction:

Now a days the electricity call for is increasing swiftly in India. The power call for is increasing every day and the conventional resources of power are getting exhausted. traditional power sources also are inflicting many fitness troubles. Given our urgent strength desires, we have to attention on opportunity assets of electricity which are renewable and whose use reasons minimal or no harm to the environment. Renewable power is supply that

reduces emissions of greenhouse gases and other hazardous gases such as sulfur dioxide and nitrogen oxides. persisted consciousness and elevated use of renewable energy can limit the dependence of the us of a's improvement on imported fossil fuels and lead India toward self-reliance and electricity independence. therefore, it's far necessary to fully enlarge and make use of renewable sources of energy like sun, wind, hydropower, biomass strength from waste and so forth [1].

The need of energy has a massive contribution inside the economy of united states. As in early a while energy production takes region by means of burning of fossil fuels that are not extended as the call for of strength rising day by day and the traditional resources of electricity production are coming to cease, so to be able to attain net 0 emission by using 2050 and to reach toward smooth and green power production we need to transport towards non-conventional electricity sources that are lasting for years. As wind and solar are playing a essential role in the era of energy. amongst of these, wind is a traditional source of electricity, used to offer high potential electricity at low energy rates. To obtain our smooth and green energy purpose the power technology from wind energy resources are very low-budget [2]. Indian government has taken initiatives with several key aspects for promoting the non-conventional energy resources that includes wind energy also.

In 2023 the worldwide wind power enterprise made tremendous steps with the addition of 88.15 GW of latest potential bringing the full installed wind power capability to an excellent 988 GW this marked a strong nine percent growth over the previous yrs underscoring the sectors consistent enlargement most of the people of this growth became driven through key markets which includes China, US, Brazil, Germany and India those 5 international locations on my own have been liable for 73 percent of the newly mounted capacity worldwide displaying a mild growth of their collective share in comparison to 2022 but this growth comes with nuanced challenges considerably china and the usa regardless of being leaders in the wind energy quarter faced hurdles that caused a four percent decline of their blended marketplace share this decline marks the 33 consecutive yr of market proportion discount for those two giants highlighting the evolving dynamics inside the international wind energy panorama as those international locations navigate coverage monetary and infrastructural demanding situations their enjoy could function a bellwether for the future trajectory of wind energy worldwide [3].

With 45 GW to be installed by the beginning of 2024, India ranks fourth in the world in terms of renewable wind energy and is the second largest wind market in the Asia Pacific region. The country plans to expand its capacity to 140 GW by 2030. In 2023, India achieved its highest annual addition of onshore wind capacity since 2017, reaching 2.8 GW. There is a significant pipeline of over 13 GW of wind projects in the country. Additionally, a new offshore wind strategy includes a 4 GW lease in Tamil Nadu, supported by updated guidelines and funding. Public Sector Undertakings (PSUs) are spearheading new auctions and forming partnerships to advance the sector [4].

The landscape of wind strength in India provides a compelling juxtaposition of extremely good ability coupled with continual obstacles that obstruct development. As of the data recorded in March 2020, the country boasted an established wind electricity potential amounting to 37.69 gigawatts (GW), a determine that unluckily represents a trifling 12.47% of the comprehensive expected capability, which stands at a magnificent 302 GW, thereby illuminating a big disparity within the effective utilization of this renewable electricity resource. This discrepancy highlights the urgent need for strategic projects and progressive regulations aimed toward harnessing the abundant wind strength ability that stays untapped in the u . s . a . , thereby facilitating a transition toward a extra sustainable electricity framework [5]. The governmental authorities have hooked up a strategic objective to enhance the existing capacity of strength production to a full-size range of a hundred and forty to 150 gigawatts by the yr 2030; but, this ambitious increase trajectory has encountered substantial deceleration as a result of a myriad of challenges, which encompass, however are not restrained to, complications associated with the procurement of land for development functions, the necessity for sturdy monetary incentives to stimulate investment, and the pervasive presence of antiquated infrastructure this is sick-equipped to guide such expansive energy technology projects [8]. in spite of the truth that India holds the commendable role of being ranked fourth inside the international in phrases of the entire capability of wind energy installations, it's far vital to note that the real usage of this ability is alarmingly inadequate, thereby underscoring an urgent need for the method and implementation of better policies and the development of strong infrastructure that could correctly facilitate and expedite the advancement of this important quarter [6,8]. In summary, even though it is obvious that India has made massive progress and advancements within the realm of wind energy improvement, the belief of its fantastically ambitious objectives and dreams will necessitate the surmounting of vast limitations in addition to the augmentation and enhancement of funding on this crucial sector of renewable electricity [7].

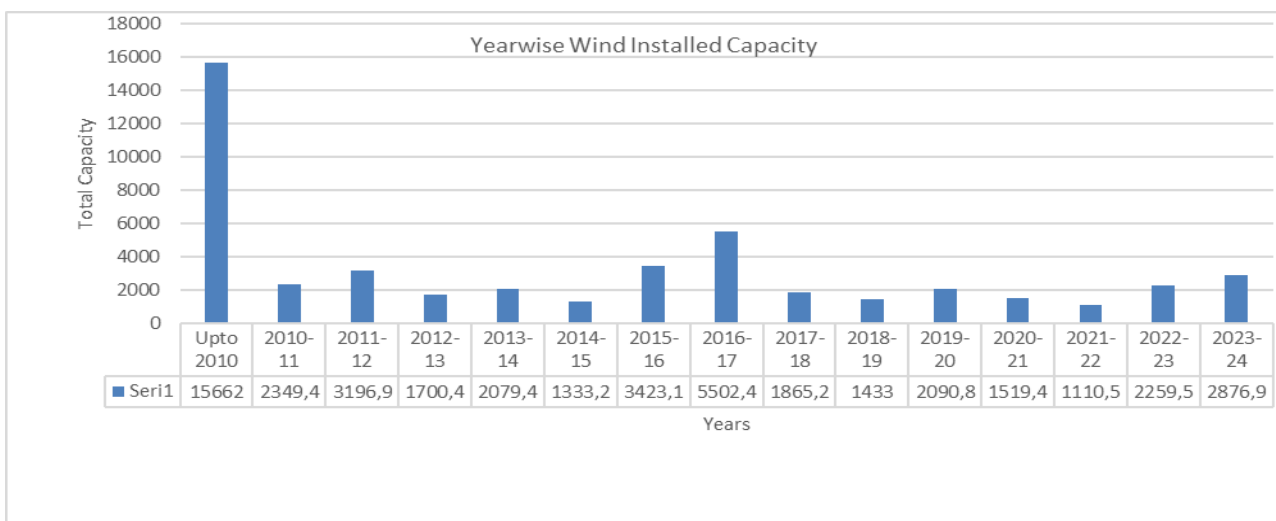


Figure 1: Year-wise wind installed capacity [9][10]

India has taken revolution for production of green hydrogen as per the MNRE (Ministry of New and Renewable Energy)

Significant progress has been made in wind energy research, with a strong emphasis on refining energy extraction techniques and addressing the issues caused by inconsistent wind patterns. Recent breakthroughs in turbine technology, including innovative designs and advanced computational simulations, have been instrumental in these efforts. These advancements are crucial for improving the efficiency and reliability of wind turbines, enabling them to generate more power even under variable wind conditions. As a result, wind energy is becoming an increasingly dependable and effective component of the global renewable energy portfolio [9].

The comprehensive analysis of systems designed for the harvesting of wind energy underscores the critical necessity of a profound comprehension of the intricate dynamics associated with wind speed, alongside the strategic application of hybrid forecasting methodologies, which collectively serve to enhance the predictability of wind resources and foster a greater appreciation for their potential contributions to energy generation. In addition to these technological considerations, it is paramount to acknowledge that the successful execution and deployment of wind energy systems are heavily contingent upon the harmonious integration of various non-technological elements, which notably include the establishment of regulatory standards and the effective incorporation of these systems into existing power grids. Thus, it is clear that a multifaceted approach, which intertwines both technological innovations and regulatory frameworks, is indispensable for the advancement and optimization of wind energy harvesting initiatives in the contemporary energy landscape [10]. The ongoing and dynamic evolution from what were once fairly simple and unassuming wind turbines to the increasingly advanced and intricately designed multi-megawatt systems that are capable of generating substantial amounts of energy undeniably acts as a significant and persuasive testament to the burgeoning confidence and reliance placed upon wind energy as a credible and sustainable source of power, which in turn underscores its extraordinary ability to contribute meaningfully towards addressing the incessantly rising global energy requirements, especially when considered against the backdrop of the daunting and formidable obstacles that are presented by the pressing issue of climate change [9].

Table 1: Review of research

Author	Year	Country	Model	Output
Gulshan Bankar [11]	2022	India	Hybrid power system	The hybrid power system blends wind, diesel, and solar energy with battery storage, providing a reliable and efficient power source, especially for remote locations. This sustainable energy solution is key to advancing both industrial and agricultural growth.
Dong-Cheol Shin and	2020	Korea	wind power generation	The study presents a wind power generation model using MATLAB/Simulink for operating modular multilevel

INTERNATIONAL AEGEAN CONFERENCES
ON INNOVATION TECHNOLOGIES & ENGINEERING-X

October 05-07, 2024

Dong-Myung Lee [12]			system model	converters (MMC) in a hardware-in-the-loop simulation (HILS). It connects wind power to the grid via HVDC and validates the model's real-time performance.
Anthony McFarlane [13]	2022	South Africa		The grid code specifies that voltage must stay within +/- 1 pu, frequency within +/-5%, and harmonic distortions should not exceed 0.1% for voltage (THDv) and 5% for current (THDi). The power factor must range between 0.9 and 0.95. Furthermore, renewable distributed generators (RDGs) are required to remain operational during faults and help restore voltage levels.
J. Hussain et al. [14]	2019	Pakistan		This paper explores a method to improve power quality in grid-connected wind power plants by integrating a DSTATCOM with a battery energy storage system (BESS). The technique primarily addresses the reactive power demands of the load and the induction generator.
Guruswamy Revana et al. [15]	2020	India	mathematical model	This paper models and verifies a wind turbine system for clean energy generation, utilizing a DFIG with a wound rotor and an IGBT-based PWM converter. The simulation results confirm the model's effectiveness, aiding in improved system design.
S. D. M, S.Saranya [16]	2023	China	model analysis techniques	This paper examines oscillations in PMSG wind farms by modeling and simulating in MATLAB/Simulink. The study identifies two main oscillation modes: subsynchronous, driven by DC voltage control, and low-frequency, affected by grid strength and PLL dynamics.
G. Revana et al. [17]	2022	China	system transient stability	This paper examines the stability of grid-connected constant speed wind turbines (CSWT) and doubly-fed induction generators (DFIG) using dynamic models and the IEEE 3-machine 9-bus system, focusing on their impact on transient stability at different wind power penetration levels.
L. Zhu et al. [18]	2021	China	MATLAB	This article reviews the development and challenges of wind power grid integration. It models grid-connected variable speed wind turbines in MATLAB to analyze their output under normal and faulty conditions.
P. Li, Z. Lin et al. [19]	2024	Indonesia	Matlab Simulink	This study uses Matlab Simulink to model a wind power plant for coastal regions, focusing on a case study in Cilacap, Indonesia. It involves problem identification and data collection on local wind conditions and turbine components.
Y. Mao, X. Wang et al. [20]	2023	South Africa	RSCAD	This paper examines how standardized codes can enhance the design and integration of wind power plants. It reviews existing literature on wind turbine generators and simulates a large-scale wind power facility.
F. R. Saputri and N.	2016	Barcelona	EMT and Phasor model	This paper offers simulation guidelines for Voltage-Source Converters (VSCs) in AC grids. It compares

Pranata [21]				EMT and Phasor models for converter-integrated generation, assessing their effectiveness in both small and benchmark systems and addressing challenges with phasor models in transient analysis
V. A. Lacerda, E. P. Araujo et al. [22]	2018	India	Fuzzy Controllers	This paper examines using fuzzy controllers to enhance power quality in grid-connected wind turbines, improving harmonic current management and extending the life of power electronics compared to traditional PI controllers.

The main objective is to present the systematic approach to designing a wind turbine system that is both efficient and adaptable to varying wind conditions. It emphasizes the importance of advanced generator technology, like high-temperature superconducting generators, and aerodynamic optimization techniques, like the Blade Element Momentum (BEM) theory, in achieving high efficiency and effective power conversion. Additionally, the passage explains the simulation setup, including the use of a capacitor bank for reactive power compensation, and the method to measure power flow between the wind turbine and the grid.

Ultimately, this discussion aims to demonstrate the effective design and simulation of a wind turbine system capable of delivering 1 MW of power while maintaining stability and efficiency in a grid-connected environment.

2. Material and Methods:

2.1 Wind mill construction detail

The complex process of building a wind turbine involves many important stages and many important factors that together contribute to the overall performance of the system. To begin this multifaceted endeavor, the foundation must be carefully designed, taking into account the specific soil and various environmental factors that will in turn affect the integrity of the structure; this includes the use of the concept of precast concrete elements, which help to create a solid and stable foundation that can withstand the powerful forces generated by strong winds [24]. Once a secure foundation is established, the towers, usually made of steel or concrete, are assembled in different sizes and then equipped with cranes for different heights, usually ranging from 80 to 160 meters [24, 25].

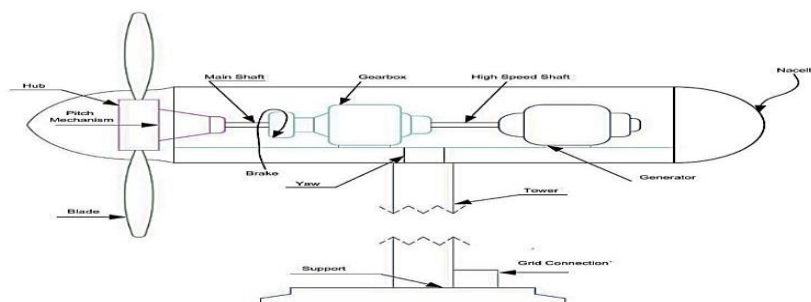


Figure 2: Construction of HAWT [27]

Once the tower is complete, the nacelle, the main component containing the main machinery such as gearboxes and generators, is carefully assembled at the top of the tower [24]. In addition, the rotor blades, carefully designed from the finest composite materials, are fixed to the central hub before being lifted into place, marking a unique, delicate and important stage in the entire construction process [26]. At the same time, the integration of the electrical system, which includes the cables running from the cabin to the ground and connecting it to the grid, has been carried out [24]. Inspection process is to ensure that the operation of the wind turbine is carried out through regular inspection and maintenance necessary to ensure the good operation of the turbine people [25].

2.2 Classification of Wind Turbine:

Basically, wind turbines are of two types:

- I. Horizontal Axis
- II. Vertical Axis

Numerous sizes of wind turbines exist, of which the blade length is an important variable that affects electricity production from the turbine. Small wind turbines, rated at around 10 kW are capable of providing power to a single residence, and the largest wind turbines that are in operation currently, have added capacity of about 15000 kW and are still being manufactured in larger sizes. Turbines are often arranged in arrays to create wind power production plants, or wind farms, and supply electricity to the larger electric power grid. [28].

2.2.1 Horizontal Axis:

Blades of horizontal-axis turbines are much like airplane propellers and are established on a tower [eia]. A horizontal axis wind turbine is a kind of wind turbine wherein the primary rotor shaft is ready horizontally and the blades rotate round a vertical axis.

they are the most common sort of wind turbine and usually have three blades. as the wind blows, the blades spin around a horizontal axis, similar to the motion of a conventional windmill.

the largest horizontal-axis mills can reach heights equal to six hundred metres homes and function blades extending over 33 metres in period. increased height and longer blades make contributions to higher power era. Horizontal-axis generators dominate the cutting-edge wind turbine market, with almost all operational mills following this layout [29].

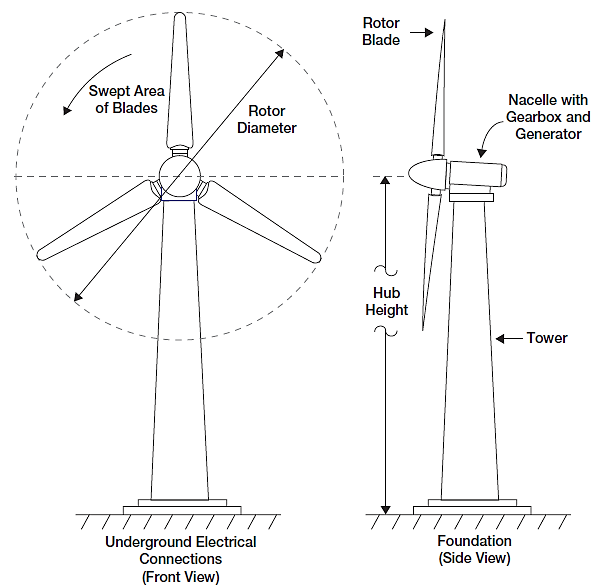


Figure 3: Horizontal axis wind turbine [30]

2.2.1.1 Forms of Horizontal Axis Wind turbine:

➤ **Pitched Controlled Wind Turbines:**

Pitch controlled wind mills exchange the orientation of the rotor blades alongside its longitudinal axis to manipulate the output power. Those mills have controllers to check the output electricity numerous instances according to 2^{nd} , and whilst the output electricity reaches a maximum threshold, an order is sent the blade hydraulic pitch mechanism of the turbine to pitch the rotor barely out of wind to sluggish down the turbine. Conversely, while the wind slows down, then the blades are grew to become (or additionally known as pitched) decrease again into the wind. In some unspecified time in the future of operation, the blades are pitched some stages with every exchange in wind to maintain the rotor blades on the top-rated attitude to most power seize.

➤ **Stalled Controlled Wind Turbines**

The rotor blades of a stall controlled wind turbine are bolted onto the hub at a set attitude. The blades are aerodynamically designed to sluggish down the blades when winds are too strong. The stall phenomenon resulting from turbulence on rotor blade prevents the lifting pressure to behave at the rotor. The rotor blades are twisted slightly along the longitudinal axis so that the rotor blade stalls progressively instead of suddenly when the wind reaches the generators' important fee.

➤ **Active Stall Controlled Wind Turbines**

Energetic stall turbine are very similar to the pitch managed turbine due to the fact they carry out the equal way at low wind speeds. However, as soon as tool has reached it's rate energy, energetic stall mills will flip its blades inside the opposite path from what a pitch controlled machine might by way of doing this, the blades induces stall on its rotor blades and therefore waste the greater energy within the wind to save you the generator from being overloaded.

This mechanism is generally both found out through hydraulic structures or electric powered stepper cars [31].

2.2.2 Vertical Axis:

Vertical axis turbines have blades that rotate around a vertical axis, blades of which are attached to the upper and lower of a vertical rotor, resembling an eggbeater is a type of very common vertical axis wind turbine. Vertical axis wind turbines have their heights equivalent to 33 metres and width of 16 metres. They can capture wind from any direction without needing to face into the wind like horizontal-axis turbines. This design makes them suitable for areas with variable or turbulent wind patterns [32].

2.3 Wind power design and development

According to Deepika Chauhan et al the size of wind turbine in 2004 was 0.77 Mega Watt which further increased in 2009 having the size of 1 Mega Watt [31]. Designing and development involves several critical components and methodologies of 1 Mega Watt wind power system. A significant advancement is the use of high-temperature superconducting generators, which can reduce the generator's size and weight while maintaining efficiency, with losses not exceeding 1.6 percent of nominal output power [33]. The rotor speed of 600 rev/min is showing the potential for compact and efficient energy conversion. Additionally, the aerodynamic design of horizontal axis wind turbines (HAWT) is crucial. Utilizing blade element momentum (BEM) theory, researchers have optimized turbine performance, achieving effective power coefficients under specific operational conditions [34]. The integration of innovative designs, such as those tailored for low wind speeds, further enhances the viability of wind power in diverse environments [35]. Overall, the combination of advanced generator technology and aerodynamic optimization is essential for the successful implementation of 1MW wind power systems.

To design a grid connected wind turbine (phasor type) an induction generator is used which is about 1MVA (1 MW). We are to design the generator's parameters as line to line voltage of 400 V and make its frequency of about 50 Hz because the frequency in India is about 50 Hz and the same is 60 Hz for the other countries. The nominal power of the turbine will be 1e6 VA. We will input the desired wind speed according to our requirement. Based on the above parameters the wind when we see the characteristics diagram at different wind speed at pitch angle beta equal to 0 degree then it varies in between 1 PU to 0.1 for the wind speed of about 12 m/s to 6 m/s. When wind speed is about 12 m/s then the wind turbine output power and turbine speed is 1 PU.

In case of wind speed is less than 12 m/s i.e. 10.8 m/s then the turbine speed is 1 PU and the turbine power output is less than 1 PU that is approximately 0.75 PU. If the wind speed further reduces the turbine power is also reduced accordingly.

If the rotational speed and maximum power at base wind speed changes the turbine power characteristics also changes with it.

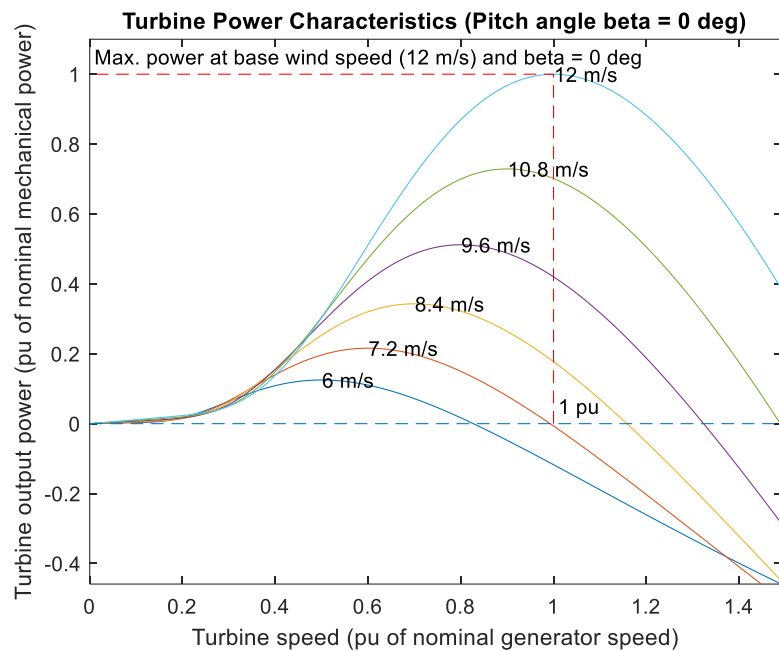


Figure 4: Wind turbine power characteristics

Further we use a step device which control the quality of wind being supplied to the wind turbine with initial value 8 and final value as 12. Now for controlling the wind speed a rate limiter is used which is connected with step with slew range from +1 to -1. Make it's sample time modes continuous. The other end of this rate limiter is connected with the input port of wind turbine generator. Trip signal is maintained to 1 with a constant. Take output from a wind turbine go for bus selector. Select then inputs for it as real power P (pu), reactive power Q(pu), rotor speed w_r (pu), electrical torque T_e (pu), pitch angle in degree. Further we connect this bus selector with a scope for each and every signal which provide the output result of the turbine. In this real power port is connected with rate limiter. To take output we connect A, B and C port of wind turbine with three phase programmable Voltage source with changing it's parameters by taking it's amplitude $25e3$, phase zero and frequency is about 50 Hz. This three phase programmable voltage source is connected with neutral to ground. For measuring the power flow in grid side we take three phase V-I measurement source in which parameters of voltage measurement is phase to ground. Insert signal label as V_{abc} , and in the current measurement similarly we use signal lable as I_{abc} , and output signals as in terms of complex.

Take a three phase two windings transformer of 4MVA of nominal power, phase to phase winding 1 and winding 2 parameters changing with 25 kV and 400 V. Configuration of these windings are Y_g , Y_n having type of three single- phase transformer. Set the magnetic resistance as infinite. Use ground to connect transformer's neutral to ground. Now we take a WT side three-phase V-I measurement and connect it with transformer's output. Now this is a wind turbine induction generator based system it will take some amount of reactive power so

it is necessary to connect a capacitor bank of 400 kVAR, with the help of which a required amount of reactive power can be injected to this wind turbine. This capacitor bank and V-I measurement block is connected with wind generator.

Finally we have to conclude power flow from wind turbine generator to grid side. For which take power measurement block (Power- phasor) named as grid side power measurement. Similarly, we take wind turbine power measurement to give input from voltage and current measurement of grid side for which we use from block with parameters of it's are V_{abc} . Similarly, for current we use I_{abc} . We can connect display to Grid side power measurement and WT power measurement to measure the power. For wind turbine measurement block take signal label as WTV_{abc} for voltage and WTI_{abc} for current at WT side three phase V-I measurement. Put powergui and make it as phasor type frequency having 50Hz. Do setting for model configuration parameters start time of which is 0 sec. and end time is 10 sec. See solver details select solver type. After making these all configuration we run the simulation the total of the output value is 1 MVA; negative value indicating that power is measuring at WT side. So, real power flow from WT to grid that's why it is having the value negative.

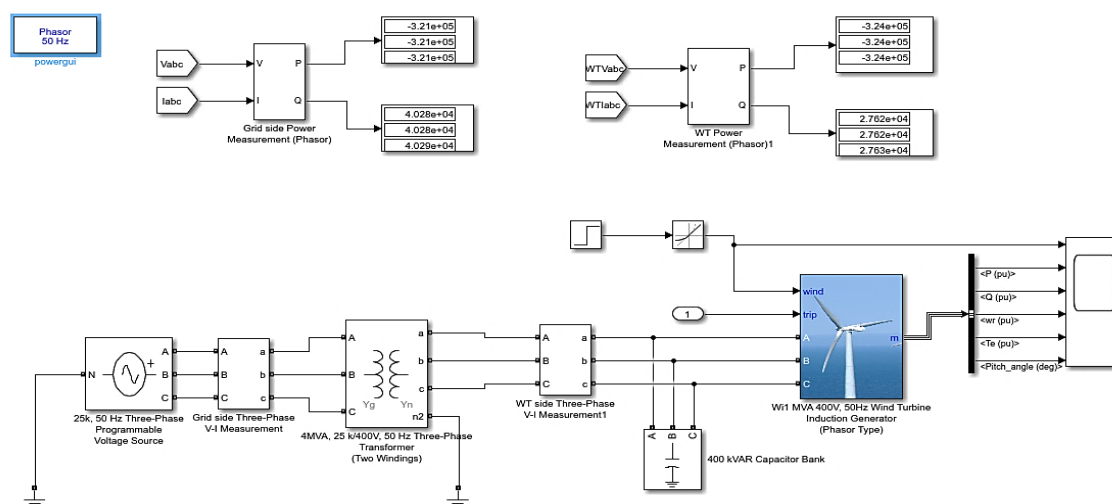


Figure 5: Grid connected wind turbine

2.4 Mathematical calculation:

The calculations show that the total active power generated by the wind turbine is approximately 1 MW. The active power is calculated as follows:

Total Active Power :-

$$P = (3.24e + 05) + (3.24e + 05) + (3.24e + 05) = 9.72e + 05 \text{ W} \approx 1.00e + 06 \text{ W (or 1 MW)}$$

The slight discrepancy is due to minor losses, confirming the output as 1 MW. The negative sign indicates the direction of power flow from the wind turbine to the grid.

For reactive power:

Total Reactive Power :-

$$Q = (2.76e + 04) + (2.76e + 04) + (2.76e + 04) = 8.29e + 04 \text{ VAR}$$

This reactive power is the amount drawn from the grid by the wind turbine. Additionally, the system supplies 400 kVAR via a capacitor bank, resulting in:

$$\text{Total Reactive Power (Q) absorbed by the WT} = 8.29e + 04 + 4.00e + 05 = 4.83e + 05 \text{ VAR} \\ \approx 0.483 \text{ MVAR}$$

Thus, while generating 1 MW of active power, the wind turbine also absorbs approximately 0.483 MVAR of reactive power.

3. Result and Discussions:

3.1 Validation

This report provides validation of the design and simulation of a 1 MVA phasor-type wind turbine system using MATLAB/Simulink. The validation process involved constructing an elaborate model of the phasor-type wind turbine system with a specified turbine design including a 400 V (line-to-line) voltage and a frequency of 50 Hz. The system also incorporated additional features including a high temperature superconducting generators, and incorporated a 400 kVAR capacitor bank for managing reactive power. The simulations evaluated the performance of the turbine using various wind speeds, finding that the turbine model behaved as intended, producing 1 PU of power at 12 m/s wind speed and limited variation of the generated power at lower wind speeds. Further, estimates of the capacity to compensate for reactive power were achieved, where the models experienced accurate accounting for the flow of power from turbine to the grid and met expectations with regard to the produced power from the turbine and load conditions. Overall, the simulated, expected and validated results achieved are supportive of the accuracy of the model and performance of the phasor-type wind turbine system. The accuracy and validation of the simulation, confirms that the wind turbine model provides a reasonable representation of operational conditions of the real wind turbine model, are considered satisfactory results in the design specifications.

3.2 Simulation studies

Graph 1 represents the relationship between wind speed and time, showcasing the performance of wind power generation. The graph indicates that the wind speed remains constant at 8 m/sec for the first 5 seconds, resulting in a steady output. After 5 seconds, the wind speed begins to increase. When the wind speed reaches 12 m/sec, the real power output of the wind turbine rises to 1 per unit (PU), equivalent to 1 MW. This illustrates that as wind speed increases, the power generated by the wind turbine also increases, with 1 MW achieved at 12 m/sec.

The reactive power (Q) initially starts high but stabilizes at approximately 0.48 MVAR when the wind speed reaches 12 m/sec. This indicates that the wind turbine is consuming less reactive power as the wind speed increases. Additionally, the rotor speed is slightly greater

than 1 PU, specifically around 1.004 PU. This is expected since the system operates as an induction generator, where the rotor speed slightly exceeds the synchronous speed during power generation.

The torque produced by the wind turbine is 1 PU, but it is negative, indicating that the turbine is generating power. The pitch angle remains at 0 degrees since the power output does not exceed 1 PU when the wind speed is below 12 m/sec. In scenarios where the wind speed exceeds 12 m/sec, the pitch angle would need to adjust to control the output power, but in this case, with no change in nominal power, the pitch angle stays at 0 degrees. As the wind speed increases, the pitch angle will increase accordingly to prevent the turbine from exceeding its rated power output. Conversely, as the wind speed decreases, the pitch angle will decrease to maintain optimal power generation. This dynamic adjustment of the pitch angle ensures efficient operation across varying wind speeds while protecting the turbine from potential overloading.

Practically if we see the variation in the graph as per below figure we can say that if wind speed is changed with 14 m/sec the wind power change with 8 to 14 PU not with 8 to 12 PU. The real power is slightly greater than 1 PU it is not as changed by the wind speed that is 12 m/sec. When wind speed is 14 m/sec however the pitch angle increases from 0 to 5 degree to maintain or to reduce power within 1 PU and it is also controlling the reactive power. So, pitch angle is zero as long as there is no power violation takes place but soon after greater than nominal power pitch angle in force to control the power or to control the blade such that nominal power is maintained here.

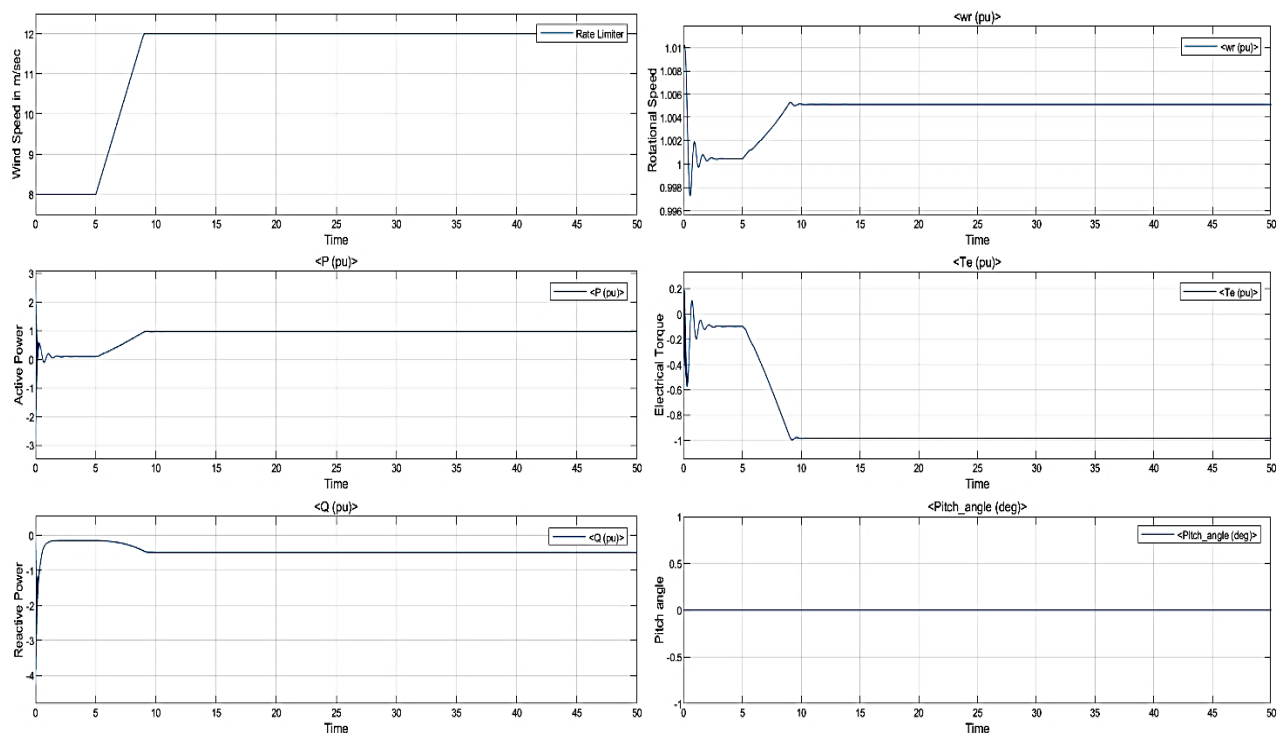


Figure 6: Graphs at wind speed of 12 m/sec.

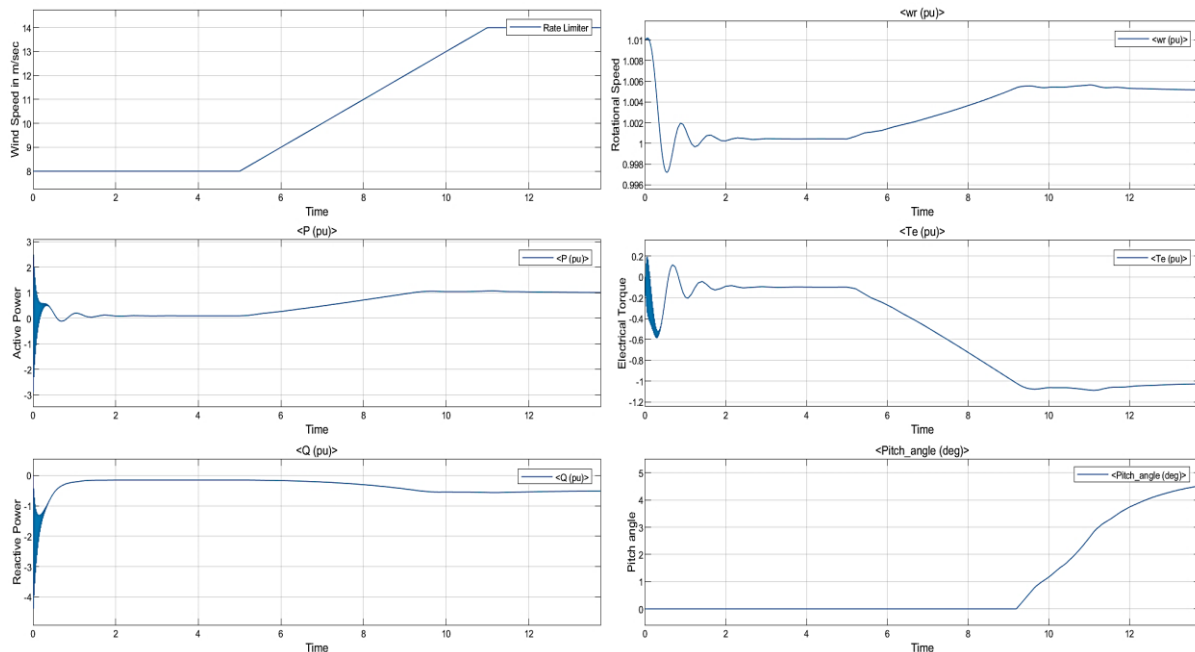


Figure 7: Graphs at wind speed of 14 m/sec.

One more example that when we take wind speed as 10 m/sec here the analysis showing that wind power changing from 8 to 10 PU look at pitch angle it is making zero value because for 10 m/sec our power output is less then nominal power. So, for 10 m/sec it is maintaining approximately 0.495.

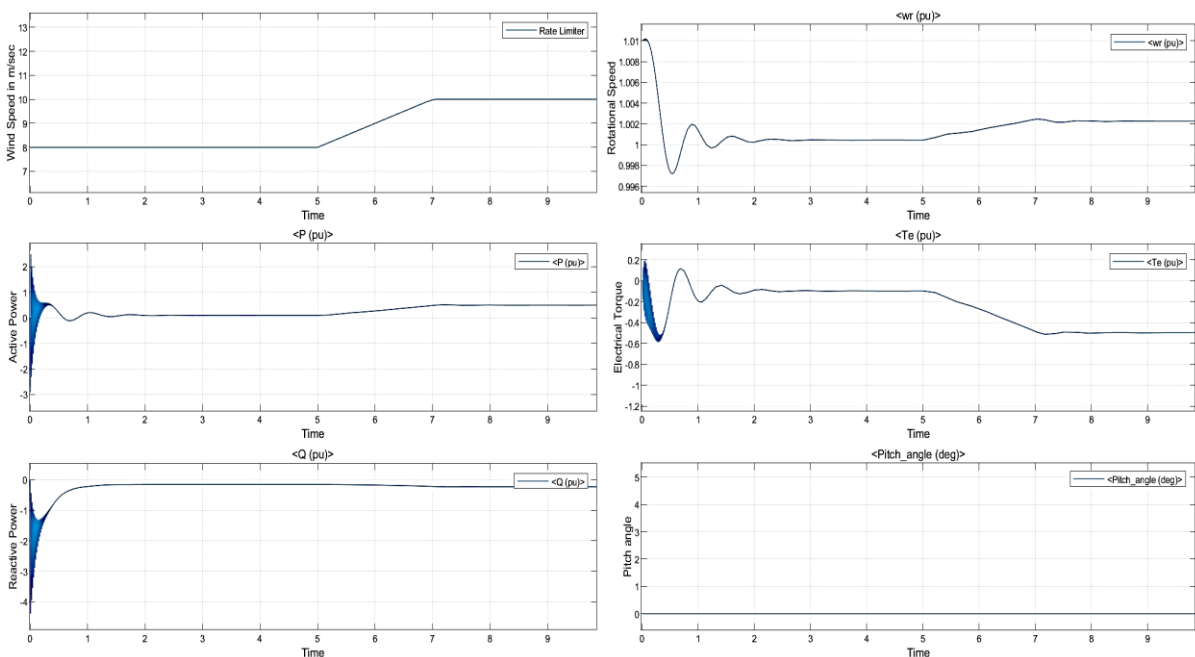


Figure 8: Graphs at wind speed of 10 m/sec.

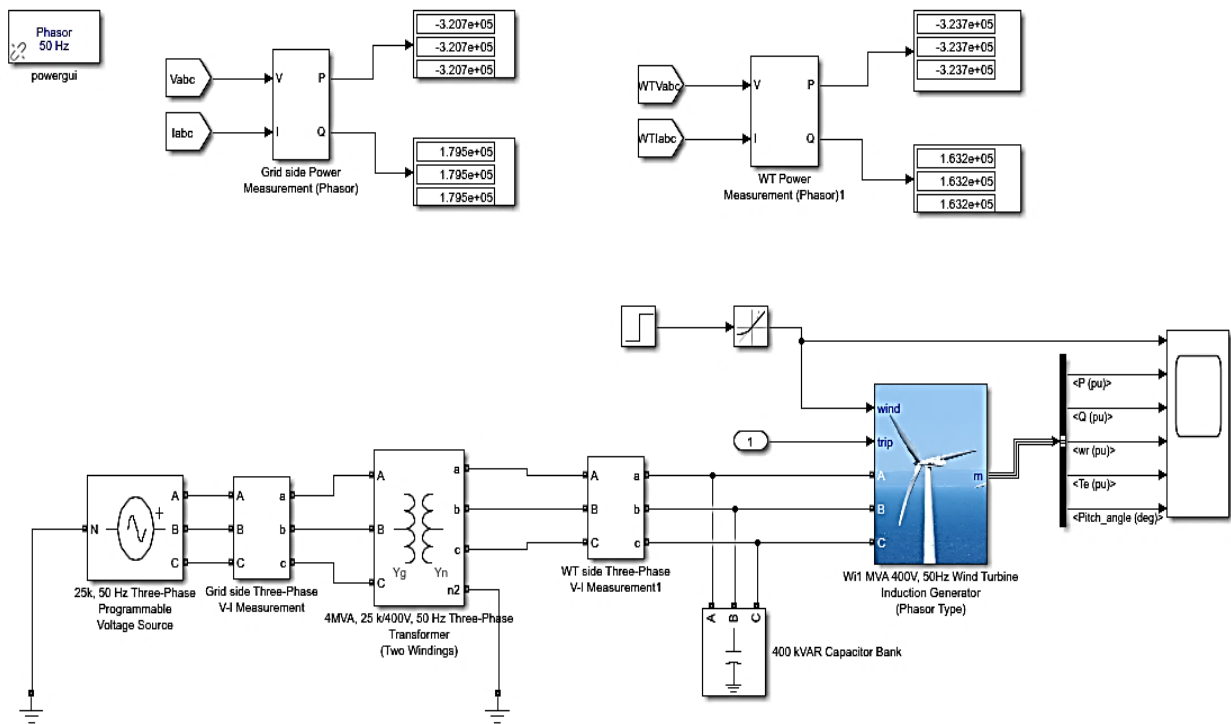


Figure 9: Real power at 12 m/sec.

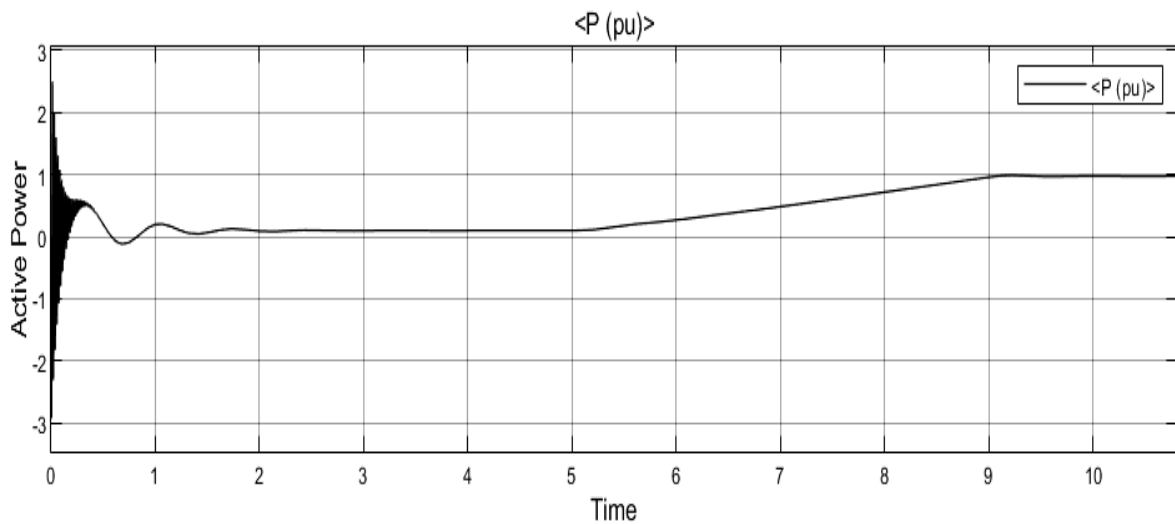


Figure 10: Simulation of Grid connected wind turbine for 1 VAR reactive power of capacitor bank

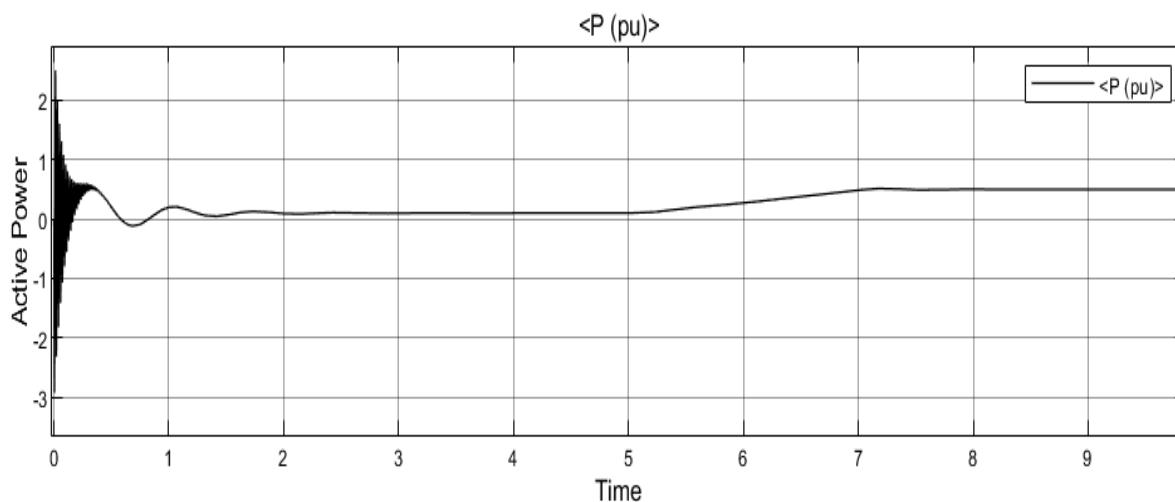


Figure 11: Real power at 10 m/sec.

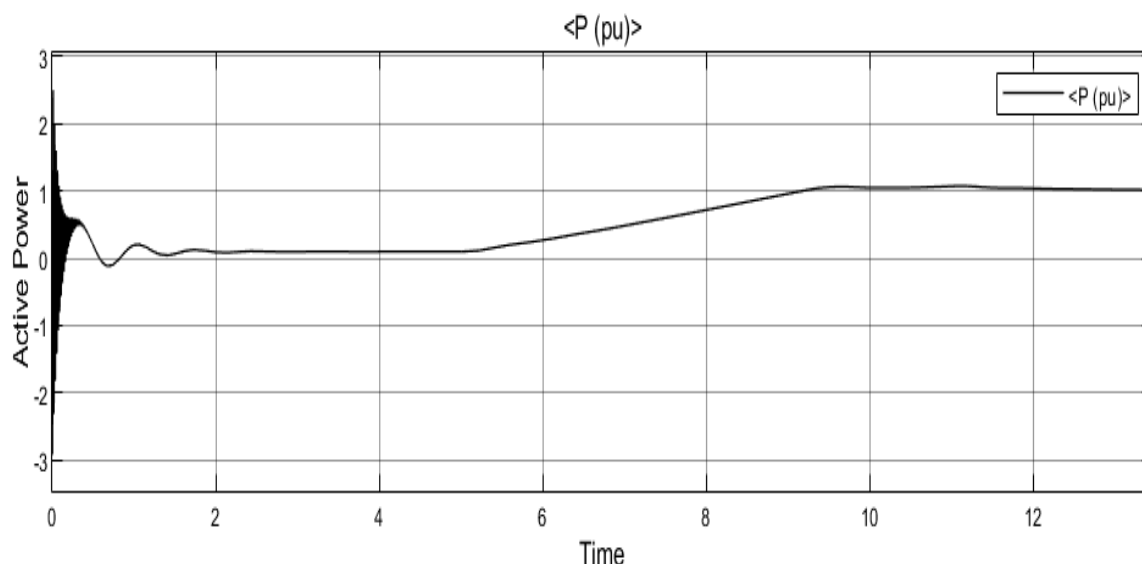


Figure 12: Real power at 14 m/sec.

4. Conclusions:

The conclusion from the previous chapter results is that when the wind turbine operates below nominal power, the pitch angle increases. Additionally, the reactive power becomes negative, indicating a value of approximately -0.22, which suggests that the turbine is absorbing reactive power from the grid rather than supplying it.

When the wind speed is lower than the base speed, the real power generated by the wind turbine decreases proportionally. For instance, at a wind speed of 12 meters per second (m/s), the real power output should be maintained at a nominal value of 1 per unit (PU). However, if the wind speed drops to 10 m/s, the real power output falls to approximately 0.495 PU, indicating a significant reduction in power generation. On the other hand, if the wind speed

increases to 14 m/s, the real power output slightly surpasses the nominal value of 1 PU, reflecting the turbine's ability to generate more power when the wind speed exceeds the base level. This relationship between wind speed and real power output highlights the importance of operating wind turbines within their optimal wind speed range to maintain efficient power generation.

The capacitor bank in the system is rated at 400 kVAR. When the reactive power of the capacitor bank is reduced from 400 kVAR to just 1 VAR, the wind turbine becomes dependent on the grid to supply all the reactive power it requires. This is because the capacitor bank no longer provides sufficient reactive power, forcing the grid to compensate for the deficit. Conversely, when the capacitor bank is supplying 400 kVAR, it meets a significant portion of the wind turbine's reactive power needs, reducing the amount of reactive power that must be drawn from the grid. Essentially, the higher the reactive power supplied by the capacitor bank, the less the grid needs to contribute, optimizing the system's efficiency and reducing strain on the grid.

Based on the calculations for a wind speed of around 12 m/sec, the wind turbine (WT) power measurement is approximately 163,200 watts (1.632e+05 W). Meanwhile, the power measured on the grid side is about 179,500 watts (1.795e+05 W). The close proximity of these values suggests that the difference, which is mainly around 16,300 watts, can be attributed to reactive power losses occurring within the transformer.

Furthermore, the real power output from the wind turbine is close to 1 MW. Of this, about 960,000 watts (0.96 MW) is successfully transferred to the grid, indicating that the wind turbine is effectively supplying most of its generated power to the grid, with minimal losses.

REFERENCES

- [1] R. Sitharthan, J.N. Swaminathan, T. Parthasarathy, "Exploration of Wind Energy in India: A Short Review" 2018 NPEC, 978-1-5386-3803-3/18/\$31.00 ©2018 IEEE, pp. 1-5.
- [2] Global wind report 2023 <https://gwec.net/globalwindreport2023/>. Assessed on 12.08.2024.
- [3]Renewable watch <https://renewablewatch.in/2024/05/19/need-to-ramp-up-key-insights-from-gwecs-global-wind-report-2024/#:~:text=Wind%20energy%20installations%20need%20to,least%20320%20GW%20by%202030>. Assessed on 12.08.2024
- [4] S. S. L. Patel and P. Patel, "Wind energy for sustainable development in India: current status and future prospects," *Bharatiya Vaigyanik evam Audyogik Anusandhan Patrika*, vol. 31, no. 1, 2023, <http://doi.org/10.56042/bvaap.v31i1.2722>.
- [5] U. Singh, M. Rizwan, and H. Malik, "Wind Energy Scenario , Success and Initiatives towards," *Energies*, vol. 15, p. 2291, 2022.

6. [6] N. Rodrigues, R. Pachouri, S. Thakare, G. Renjith, and T. Spencer, *Integrating Wind and Solar in the Indian Power System*. Springer Fachmedien Wiesbaden, 2023. http://doi.org/10.1007/978-3-658-38215-5_7.
7. [7] A. Kumar, D. Pal, S. K. Kar, S. K. Mishra, and R. Bansal, “An overview of wind energy development and policy initiatives in India,” *Clean Technol. Environ. Policy*, vol. 24, no. 5, pp. 1337–1358, 2022, <http://doi.org/10.1007/s10098-021-02248-z>.
8. [8] G. Bangga, “Progress and Outlook in Wind Energy Research,” *Energies*, vol. 15, no. 18, 2022, <http://doi.org/10.3390/en15186527>.
9. [9] Indian wind energy association; Wind power installation <http://www.inwea.org/wind-energy-in-india/wind-power-installation/> Assessed on 15.08.2024.
10. [10] Ministry of New and Renewable Energy; [Year wise Achievements | Ministry of New and Renewable Energy | India \(mnre.gov.in\)](http://mnre.gov.in) Assessed on 15.08.2024.
11. [11] S. M. H. D. Perera, G. Putrus, M. Conlon, M. Narayana, and K. Sunderland, “Wind Energy Harvesting and Conversion Systems: A Technical Review,” *Energies*, vol. 15, no. 24, 2022, <http://doi.org/10.3390/en15249299>.
12. [12] Samarskaya, N. & Paramonova, O. & Lysova, E. & Chistyakova, V.. (2023). Development of a life cycle model for a wind turbine. *Modern Trends in Construction, Urban and Territorial Planning*. 1. 25-31. <http://doi.org/10.23947/2949-1835-2022-1-4-25-31.12>.
13. [13] A. Wasnik, N. Malwar, and P. Ghutke, “Improvement in Power Quality of Grid Connected PV & Wind Power Generation Systems,” *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 11, no. 8, pp. 2282–2287, 2023, <http://doi.org/10.22214/ijraset.2023.55401>.
14. [14] D. C. Shin and D. M. Lee, “Development of real-time implementation of a wind power generation system with modular multilevel converters for hardware in the loop simulation using matlab/simulink,” *Electron.*, vol. 9, no. 4, 2020, <http://doi.org/10.3390/electronics9040606>.
15. [15] W. K. Ntuli, “Performance Evaluation of Control Strategies for Grid Connected Wind Power,” no. July, 2022.
16. [16] S. D. M, S.Saranya, “Power Quality Improvement of Grid Connected Wind Energy System by STATCOM-Control Scheme,” *Int. J. Adv. Res. Electr. Electron. Instrum. Eng.*, vol. 04, no. 05, pp. 3881–3886, 2015, <http://doi.org/10.15662/ijareeie.2015.0405013>.
17. [17] G. Revana, A. D.E, S. D, and A. D, “Simulation Based Designing of Control Systems for Wind Power Generation,” *Int. J. Eng. Technol. Manag. Sci.*, vol. 4, no. 5, pp. 104–109, 2020, <http://doi.org/10.46647/ijetms.2020.v04i05.019>.
18. [18] L. Zhu, L. Chen, P. Hu, Y. Wu, M. Liao, and M. Xu, “Performance analysis of modeling scale on multiband oscillations in grid-connected wind farm,” *Front. Energy Res.*, vol. 11, no. May, pp. 1–13, 2023, <http://doi.org/10.3389/fenrg.2023.1184119>.
19. [19] P. Li, Z. Lin, Z. Zhou, and Y. Li, “Analysis of Grid-Connected Wind Turbine Generators on Power System Stability,” *Adv. Transdiscipl. Eng.*, vol. 23, pp. 49–56, 2022, <http://doi.org/10.3233/ATDE220265>.

20. [20] Y. Mao, X. Wang, and Z. Wang, "Analysis of Wind Power Grid Connection Based on MATLAB," *E3S Web Conf.*, vol. 267, pp. 1–4, 2021, <http://doi.org/10.1051/e3sconf/202126701050>.
21. [21] F. R. Saputri and N. Pranata, "Modeling and Simulation for Wind Power Plant Based on Wind Potency in Coastal Area Using Matlab Simulink: Case Study in Cilacap, Indonesia," *Adv. Transdiscipl. Eng.*, vol. 54, pp. 522–528, 2024, <http://doi.org/10.3233/ATDE240351>.
22. [22] V. A. Lacerda, E. P. Araujo, S. Member, and M. Cheah-mañe, "Phasor Modelling Approaches and Simulation Guidelines of Voltage-Source Converters in Grid-Integration Studies," vol. 1, no. 1, pp. 1–10, 2021.
23. [23] S. Nomandela, M. E. S. Mnguni, and A. K. Raji, "Modeling and Simulation of a Large-Scale Wind Power Plant Considering Grid Code Requirements," *Energies*, vol. 16, no. 6, 2023, <http://doi.org/10.3390/en16062897>.
24. [24] V. A. Lacerda, E. P. Araujo, M. Cheah-Mane, and O. Gomis-Bellmunt, "Phasor Modeling Approaches and Simulation Guidelines of Voltage-Source Converters in Grid-Integration Studies," *IEEE Access*, vol. 10, pp. 51826–51838, 2022, <http://doi.org/10.1109/ACCESS.2022.3174958>.
25. [25] S. Kavitha, R. Mahalakshmi, and B. Chinthamani, "Improvement of power quality in grid connected photovoltaic and wind energy system," *J. Green Eng.*, vol. 10, no. 8, pp. 4405–4414, 2020.
26. [26] M. Bošnjaković, M. Katinić, R. Santa, and D. Marić, "Wind Turbine Technology Trends," *Appl. Sci.*, vol. 12, no. 17, 2022, <http://doi.org/10.3390/app12178653>.
27. [27] M. Mahran Kasem, 'On the Design and Manufacture of Wind Turbine Blades', Wind Turbines - Advances and Challenges in Design, Manufacture and Operation. IntechOpen, Oct. 26, 2022. <http://doi.org/10.5772/intechopen.104490>.
28. [28] U. S. Energy Information Administration, <https://www.eia.gov/energyexplained/wind/types-of-wind-turbines.php> assessed on August 16, 2024.
29. [29] <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.elprocus.com%2Fhorizontal-axis-wind-turbine%2F&psig=AOvVaw0VSSmmvtZw1n2Sbyk4wgik&ust=1723963041672000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCPjHmPa0-4cDFQAAAAAdAAAAABAE>
30. [30] Vigneswaran, K., & Suresh Kumar, P. (2007). Maximum Power Point Tracking (MPPT) Method in Wind Power System. *International Journal of Innovative Research in Science, Engineering and Technology* (An ISO, 3297(1), 680–687. <https://doi.org/10.15680/IJIRSET.2015.0501118>
31. [31] D. Chauhan, S. Agarwal, and M. K. Suman, "Wind Power Scenario in India : A Review," *Int. J. Sci. Res. Publ.*, vol. 3, no. 9, pp. 1–5, 2013.

32. [32]<https://www.researchgate.net/profile/Hazem-Elzarka/publication/321679367/figure/fig1/AS:569295656296449@1512742069735/Components-of-a-wind-turbine-NCHRP-2013.png>
33. [33] K. Kovalev et al., “Synchronous generator with HTS-2G field coils for Windmills with output power 1 MW,” J. Phys. Conf. Ser., vol. 507, no. PART 3, 2014, <http://doi.org/10.1088/1742-6596/507/3/032023>.
34. [34] M. T. Velázquez, M. V. Del Carmen, J. A. Francis, L. A. M. Pacheco, and G. T. Eslava, “Design and Experimentation of a 1 MW Horizontal Axis Wind Turbine,” J. Power Energy Eng., vol. 02, no. 01, pp. 9–16, 2014, <http://doi.org/10.4236/jpee.2014.21002>.
35. [35] M. Marhatang, H. Nawir, M. R. Djalal, M. Maudini, and M. A. Syarifuddin, “Design of Wind Power Generator for Tambak Houses,” J. Electr. Technol. UMY, vol. 7, no. 1, pp. 20–28, 2023, <http://doi.org/10.18196/jet.v7i1.17457>.

**DESIGN AND DEVELOPMENT OF GRID- CONNECTED 1 KW WIND ENERGY
POWER PLANT FOR DRE BUILDING IN RTU INDIA USING MATLAB**

Himanshi Kumari

Shiv Lal

Shibna Hussain

Santosh Kumar Sharma

ABSTRACT

The renewable energy sources like wind energy takes an important role to achieve sustainable goal. The wind energy is freely available pollution free sources by which electricity can be produced by the help of wind turbine. As per Ministry of New and Renewable Energy the India have 695.5GW at 120m agl and 1163GW at 150m agl. Rajasthan is one of the key states of wind energy which have the potential of 127.75GW and 284.2GW respective to agl's. Small wind is available in Kota of speed 3m/s to 5 m/s for whole year. So small wind mill which can be operate on the small and medium wind can be installed in Kota alongwith the Chambal River in plane areas and nearby hills.

This study focuses on the design and simulation of a 1 kW grid-connected wind energy power plant for a Department of Renewable Energy building in Kota, India. The project aims to harness wind energy as a sustainable source of power to meet the energy demands of the building. By integrating a small-scale wind turbine with the existing grid infrastructure, this system ensures both renewable energy generation and reliability through grid support. The wind energy potential of the Kota region is analyzed, and the system is designed based on local wind speed patterns. The design includes key components such as the wind turbine, power electronics for grid interfacing, and battery storage for energy stability. Simulations are conducted using MATLAB/Simulink to evaluate the system's performance in terms of energy output, efficiency, and grid compatibility. The study demonstrates the feasibility of implementing small-scale wind energy systems in urban residential buildings and highlights the potential of renewable energy integration in India's energy mix.

Keywords: Wind energy, Matlab, grid connected system design etc.

NEURAL NETWORK MODELING FOR SCOUR PREDLCTION AT BRIDGE FOUNDATION

Yasser, A.M. Moussa

Professor, Civil engineering Department, College of Engineering. Jazan University

ABSTRACT

Accurate estimation of local scour depth is essential for the design of bridge foundations, particularly when scour countermeasures like collars are employed. This study proposes a novel approach using artificial neural networks (ANNs) to forecast maximum scour depth at bridge abutments with various collar designs. Leveraging a comprehensive dataset of experimental findings, a multilayer back-propagation network was trained using the Levenberg-Marquardt algorithm. The resulting ANN model outperformed both multiple linear regression (MLR) and numerical simulation methods. With an R^2 value of 98.3% and a standard error of 0.03, the ANN model demonstrated superior accuracy and generalization capabilities. These findings contribute to the development of safer and more reliable bridge foundations in challenging environments such as valleys and streams.

Keywords: Neural network model, Bridge supports, Soil erosion, Linear regression model.

INTRODUCTION

Scour, the erosion of soil around bridge foundations, poses a significant threat to bridge stability. Studies indicate that scour is a contributing factor in approximately 60% of bridge failures (Richardson and Davis, 2001). Piers and abutments are particularly vulnerable, accounting for 25% and 72% of failure cases, respectively (Richardson and Abed, 1993). Numerous studies have emphasized the critical role of scour in bridge failures (Johnson and Dock, 1998; Melville, 1999). Various scour countermeasures, such as collars, have been investigated to mitigate local scour at bridge abutments (Lagasse et al., 2007; Barkdoll et al., 2007). Experimental and numerical studies have explored the impact of collar design and placement on scour depth (Richardson and Davis, 2001; Sturm, 2006; Kose and Yanmaz, 2010; Pu and Lim, 2013; Teruzzi and Ballio, 2016; Abdel-Aal et al., 2010; Mohamed et al., 2016a, b; Nasr-Allah et al., 2016). Artificial neural networks (ANNs) have emerged as a promising tool for predicting scour depth in engineering applications (Li et al., 2005; Xie et al., 2006). Previous studies have successfully employed ANNs to estimate scour around spillways (Azmathullah, 2006), bridge piers (Sung-Uk and Sanghwa, 2006), and abutments (Muzzammil, 2008; Şarlak and Tiğrek, 2011). Mohammaddpour et al. (2013) demonstrated the effectiveness of ANNs in predicting time-dependent local scour depth around bridge abutments. Inspired by the human brain, ANNs are computational models capable of recognizing complex patterns in data. They consist of interconnected processing elements, or

neurons, arranged in layers. By adjusting the weights of these connections through a training process, ANNs can learn to map input data to desired outputs. Numerous studies have shown that feedforward multilayer neural networks with at least one hidden layer can approximate any continuous function (Hornik et al., 1989; Cybenko, 1989). Supervised learning, a common training method, involves presenting a neural network with labeled data to learn a mapping between inputs and outputs. The Levenberg-Marquardt algorithm is a popular choice for training ANNs due to its efficiency and stability compared to traditional backpropagation methods. This study utilized an artificial neural network (ANN) to model local scour around bridge abutments of various shapes and collar configurations. The Levenberg-Marquardt backpropagation algorithm was employed to train a multilayer neural network to predict scour depth based on key parameters: tail Froude number, expansion ratio, entrance angle, abutment shape, and collar dimensions (as illustrated in Figure 1 and Table 1). The model was trained on a dataset of measured values to establish the relationship between these parameters and scour depth.

Table 1. Experimental Parameters and Conditions (Based on Mohamed et al., 2016a, 2016b; Nasr-Allah et al., 2016)

Discharge (l/s)	3.5
Median sand size (mm)	1.77
Flow depth (cm)	3 to 7
Froude Number	0.2 to 0.6
Abutment width (b) cm	3.75, 5.0, and 7.5
Entrance angle of abutment (θ) (Degree)	10 to 90
Collar width (L1) cm	4.5, 6 and 7.5
Radii arrangement of abutment (cm)	0 to 100
Collar Length (Lc) cm	12 to 50

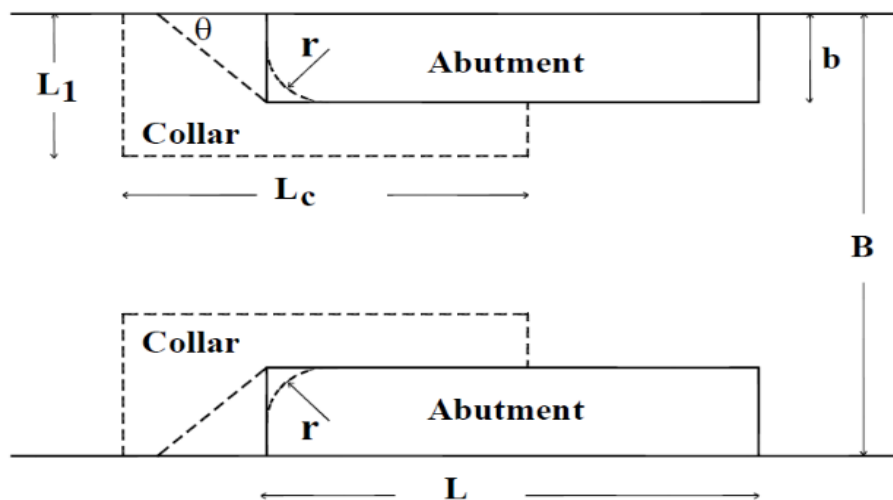


Figure1. experimental model

NEURAL NETWORK-BASED PREDICTION MODELS

This study employed artificial neural networks to analyze experimental data (Mohamed et al., 2016a, 2016b; Nasr-Allah et al., 2016) to identify the relationship between local scour depth and various independent parameters. Table 1 and Figure 1 provide details on the experimental conditions, bridge abutment configurations, and collar arrangements. For a comprehensive understanding of the experimental procedures, please refer to the original studies (Mohamed et al., 2016a, 2016b; Nasr-Allah et al., 2016). The collected dataset (Mohamed et al., 2016a, 2016b; Nasr-Allah et al., 2016) was organized into a matrix format, with each row representing a sample input and its corresponding output. To train the neural network, the data was randomly divided into three subsets: training (40%), validation (20%), and testing (20%) (Ivan, 2017). The training set was used to adjust the network's weights and biases, while the validation set was employed for early stopping to prevent overfitting. The testing set was reserved for final evaluation of the network's generalization performance. Several factors, including network structure and initial weights, can influence the training process and final performance. The neural network architecture used in this study (Figure 2) consisted of an input layer with seven excitatory inputs, a single output node, and a hidden layer with a variable number of nodes. To optimize performance, different hidden layer sizes and random weight initialization were explored. Following the preparation of the training, validation, and testing sets, the neural network training process was conducted for each network structure and set of weights according to the following steps:

- **Initialize the network weights and biases:** Randomly generate initial values for the weights and biases within the range of -1 to 1 (Kasabov and Nikola, 1998).
- **Forward propagation:** Calculate the network's output using the current weights and biases and the input data.
- **Error calculation:** Compute the sum of squared errors (SSE) between the predicted outputs and the actual target values, as defined by Equation 1.

$$E(x, w) = \frac{1}{2} \sum_{p=1}^P \sum_{m=1}^M e_{p,m}^2 \quad \text{Eq. 1}$$

Where: E: Error vector, x: Input vector, w: Weight and bias vector, p: Pattern number, m: Output number, and $e_{p,m}$: Difference between the desired output and the actual output at node m when applying pattern p.

- **Weight update:** Modify the network weights using the backpropagation algorithm and the calculated error, as defined by Equation 2.

$$w_{k+1} = w_k - (J_k^T J_k + \mu I)^{-1} J_k e_k \quad \text{Eq.2}$$

Where: **k**: Iteration index, **J**: Jacobian matrix, **I**: Identity matrix, and **μ** : Combination coefficient, a positive scalar value

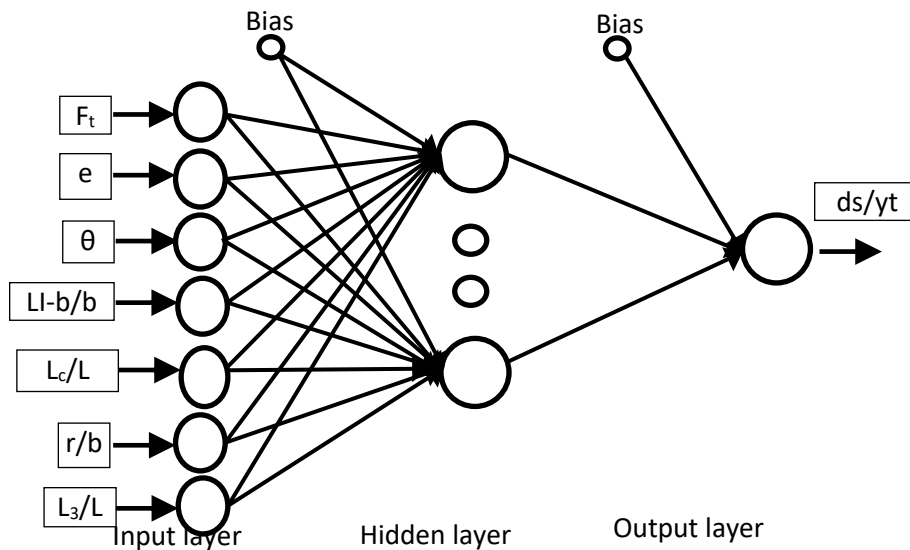


Figure 2. The Multi-layer neural networks structure.

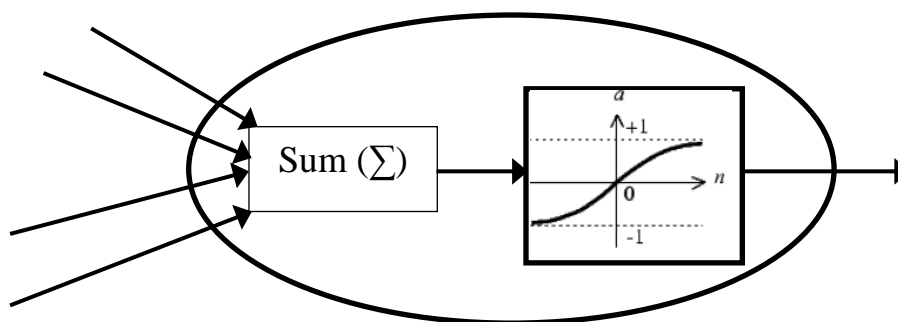


Figure 3. The process elements structure.

- **Evaluate the new SSE:** Calculate the sum of squared errors (SSE) using the updated weights.
- **Compare SSE values:** Compare the SSE obtained in step 2 with the SSE from step 4.
 - If $SSE_{step2} < SSE_{step4}$:
 - Revert the weight vector to its previous values.
 - Increase the combination coefficient μ by a factor of [specify factor].
 - Return to step 3.
 - If $SSE_{step2} > SSE_{step4}$:
 - Keep the new weight vector.
 - Decrease the combination coefficient μ by a factor of [specify factor].
 - Return to step 3.

The training process outlined above was applied to various ANN architectures, each with a different number of nodes in the hidden layer: 7, 10, and 25. To ensure robust performance,

each ANN structure was trained multiple times (approximately 15 iterations) with different sets of initial weights.

Multiple linear regression analysis was conducted on the experimental data (Mohamed et al., 2016a, b; Nasr-Allah et al., 2016) to develop a predictive model for local scour around bridge abutments with collars. The model correlated relative local scour depth with various independent parameters. Through extensive experimentation, the following equation was determined to provide the best fit:

$$\frac{d_s}{y_t} = -0.35 + 1.38 F_t - 0.026e + 0.0034\theta + 0.03 \frac{L_c}{L} + 0.003 \frac{r}{b} + 0.33 \frac{L_s}{L} \quad \text{Eq.3}$$

The correlation coefficient and standard error for Equation 3 are 79% and 0.11, respectively.

RESULTS AND DISCUSSION

Building upon the exploration of various network structures in the previous section, this study employed the Levenberg-Marquardt backpropagation algorithm to train multiple multilayer networks with one hidden layer. The goal was to identify the most accurate and generalizable network for predicting local scour depth around bridge abutments equipped with collars. The networks were trained to map the relationship between scour depth and key parameters, including tail Froude number, expansion ratio, entrance angle, collar width and length ratios, abutment curvature ratio, and collar length beyond the abutment. We generated different ANN models with varying structures and initial weights. The four most successful ANN models had the following architectures: two networks with a 7-7-1 structure (i.e., 7 input neurons, 7 hidden neurons, and 1 output neuron) and two with a 7-10-1 structure. Each pair of networks had distinct initial weight sets. Remarkably, the coefficients of determination for all four models were exceptional, exceeding 98.8% for both training and validation sets. This demonstrates the effectiveness of ANNs in capturing the complex relationships governing local scour depth around bridge abutments with collars. Among the tested models, the 7-10-1 architecture achieved the best overall performance. These results highlight the potential of ANNs to accurately predict scour depth under various collar configurations.

The developed neural network demonstrates exceptional performance in predicting local scour depth around bridge abutments equipped with collars. Table 2 summarizes the coefficients of determination and standard errors for the simulated models based on various datasets: overall (145 patterns), training (87 patterns), validation (29 patterns), and testing (29 patterns). Table 3 presents a comparison of the average absolute errors between the numerical model and the ANN models. The ANN consistently outperforms the numerical model in predicting relative scour depth across all datasets. In fact, the average absolute error of the numerical simulation is at least twice that of the ANN models.

Table 2. Standard error and R² value for the 7-10-1 ANN.

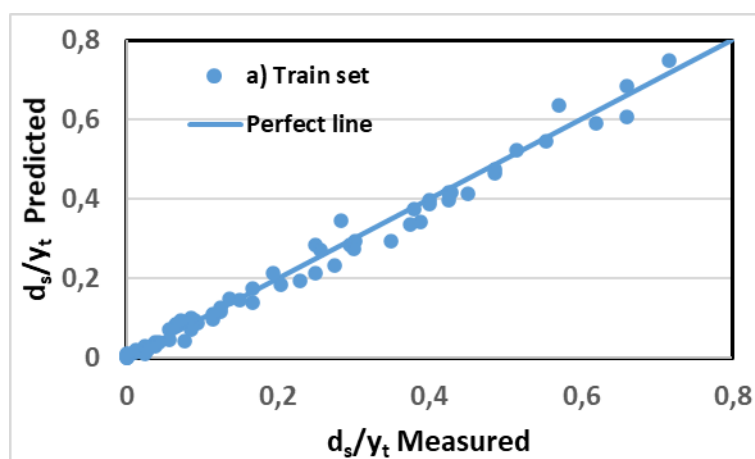
Type of pattern	Standard error	Coefficient of determination
-----------------	----------------	------------------------------

		R^2
Over all pattern	0.032	0.98255
Training set	0.021	0.993255
Evaluation set	0.036	0.978292
Test set	0.050	0.944133

Table 3. Comparative error analysis of numerical and ANN models

Type of pattern	Overall pattern	Training set	Evaluation set	Test set
Average (Abs (Numerical error/ ANN error)) %	329.6	424.6	221.1	153.0

Figures 4a, 4b, and 4c illustrate the comparison between actual and simulated scour depth (d_s/y_t) for the training, validation, and testing datasets, respectively. The numerical models were generated using the SSIIM (Sediment Simulation in Water Intakes with Multiblock Option) program. This 3D computational fluid dynamics (CFD) model is based on the finite volume method for solving the Navier-Stokes equations. The overall correlation coefficient (R^2) and standard error for the numerical results are 97.4% and 0.04, respectively. Figure 5 compares the results of the neural network and numerical model, demonstrating the superior performance of the neural network in predicting scour depth around bridge abutments with collars. Figure 6 further highlights the advantage of the neural network model over the multiple linear regression (MLR) model (Equation 3) in terms of accurately predicting relative scour depth.



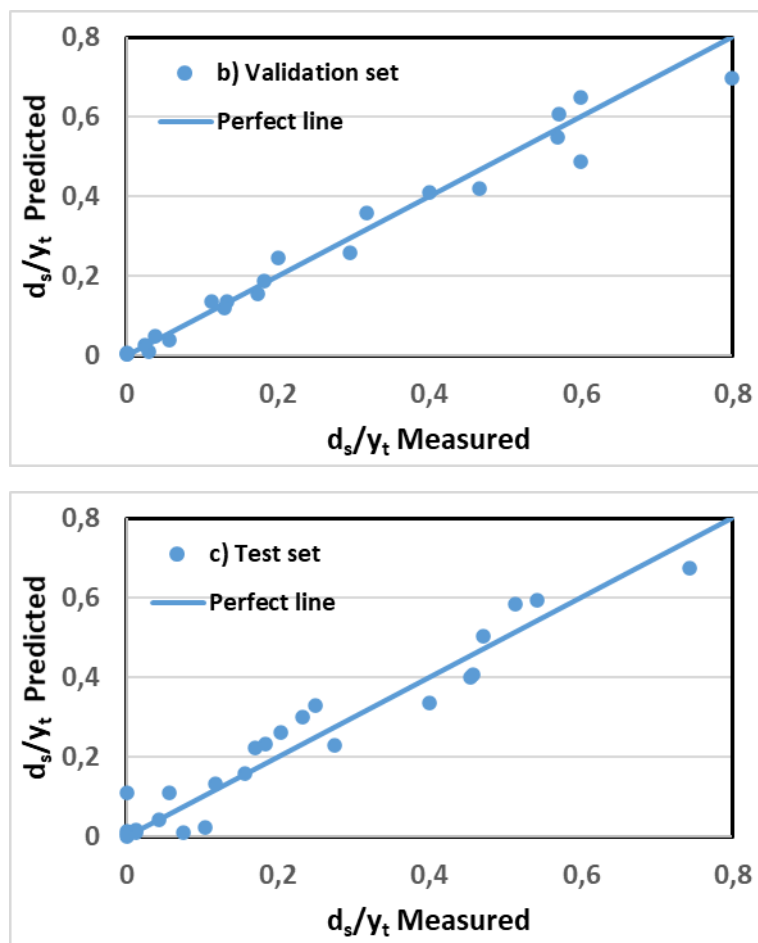


Figure 4. Comparison between actual and simulated d_s/y_t values for the 7-10-1 ANN model, using the training, validation, and testing datasets.

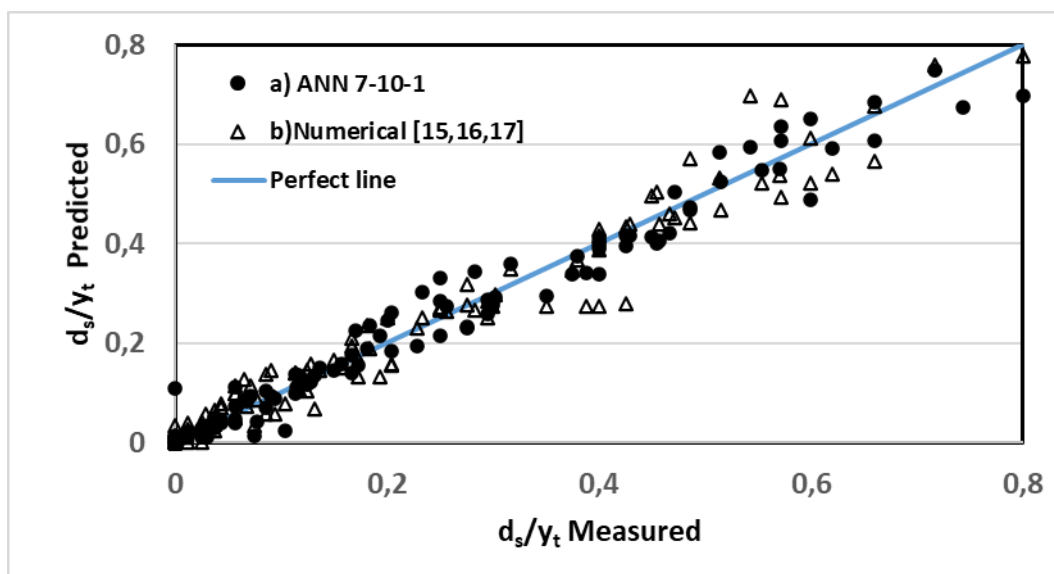


Figure 5. The comparison of the actual and predicted scour depths using both the numerical solution and the 7-10-1 ANN model.

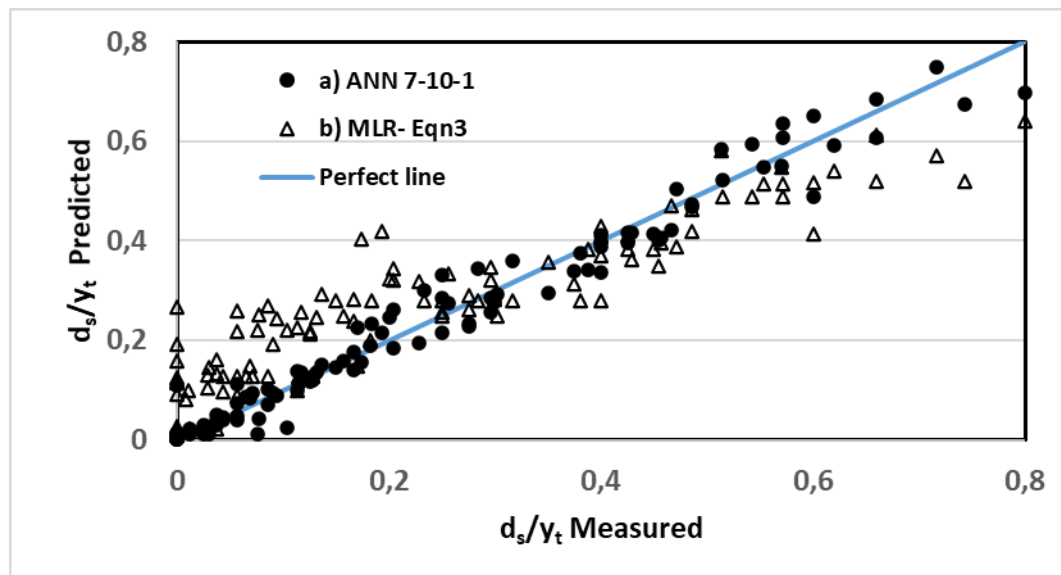


Figure 6. Comparison of actual and predicted scour depths using the multiple linear regression model (Equation 3) and the 7-10-1 ANN model.

CONCLUSION

This study demonstrates the effectiveness of artificial neural networks (ANNs) in accurately predicting local scour depth at bridge abutments. Scour poses a significant threat to the safety of hydraulic structures and can lead to catastrophic failures. By leveraging experimental data, the developed ANN model effectively captured the complex relationship between scour depth and various parameters, including bridge abutment dimensions, entrance angle, and collar configurations. The ANN model consistently outperformed both numerical simulation and multiple linear regression (MLR) methods, achieving a higher coefficient of determination (R^2) of 98.3% compared to 97.4% for the numerical model and 79% for the MLR model. These findings highlight the potential of AI-driven approaches for improving the design and maintenance of bridge foundations and enhancing overall structural safety.

REFERENCES

- Abdel-Aal, G.M., Mohamed, Y.A., 2010. The effect of collar size and shape on scour depth around bridge piers. *Scientific Bulletin, Faculty of Engineering, Ain Shames University, Faculty of Engineering, Cairo, Egypt*.
- Azmathullah, H.M.D, Deo M.C, Deolalikar, P.B., 2006. Estimation of scour below spillways using neural Networks. *Journal of Hydraulic Research*, 44(1), 61–69.
- Barkdoll, B.D, Ettema, R., Melville, B.W., 2007. Countermeasures to protect bridge abutments from scour. National cooperative highway research program (NCHRP) Rep. No. 587. Washington, D.C.: Transportation Research Board.
- Bogdan, M., Wilamowski, J., David Irwin, 2011. *The industrial electronics handbook*, 2nd Edition, Intelligent systems. Taylor and Francis Group, LLC.

- Cornelius T, Leondes, 1998. Neural network systems techniques and applications. Academic Press Limited; London; UK.
- Cybenkot, G., 1989. Approximation by superpositions of a sigmoidal function. *Math. Control Signals Systems*, 2, 303-314.
- Deng, L., Cai, C.S., 2010. Bridge scour: prediction, modeling, monitoring and countermeasures, review *Practice Periodical Struct Des Construct*, 15 (2).
- Ivan Nunes da Silva, 2017. Artificial neural networks a practical course. Springer International Publishing AG, Switzerland.
- Johnson, P.A., Dock, D.A., 1998. Probabilistic bridge scour estimates. *J. Hydraul. Eng.*, ASCE, 124 (7), 750-754.
- Kasabov, Nikola K., 1998. Foundations of neural networks, fuzzy systems, and knowledge engineering. A Bradford Book The MIT Press Cambridge, Massachusetts, London, England,.
- Kose, O., Yanmaz, M.A., 2010. Scouring reliability of bridge abutments. Aksaray University, Aksaray, Turkey. Middle East Technical University, Ankara, Turkey, Published in *Teknik Dergi*, 21(1), 4919-4934.
- Kurt Hornik, Maxwell Stinchcombe, Halbert White, 1989. Multilayer feed forward networks are universal approximators. *Neural Networks*, 2, 359-366.
- Lagasse, P.F., Clopper, P.E., Zevenbergen, L.W., 2007. Girard LG. Countermeasures to protect bridge piers from scour. National cooperative highway research program (NCHRP) Rep. No. 593. Washington, D.C3: Transportation Research Board.
- Li, H., Kuhnle, R., Barkdoll, B., 2005. Spur Dikes as an Abutment Scour Countermeasure. *Impacts of Global Climate Change*, 1-12.
- Melville, B.W., Coleman, S.E., 1999. Bridge scour. *Water Resources Publications*.
- Mohamed, Y.A, Abdel-Aal, G.M., Nasr-Allah, T.H., Awad, A.S., 2016a. Experimental and theoretical investigations of scour at bridge abutment" *Journal of King Saud University, Engineering Sciences*, 28, 32-40.
- Mohamed, Y.A, Nasr-Allah, T.H., Abdel-Aal, G.M. Awad, A.S., 2016b. Investigating the effect of curved shape of bridge abutment provided with collar on local scour, experimentally and numerically. *Ain Shams Engineering Journal*, 6 (2), 403-411.
- Mohamed, Y.A, 2020. prediction of reference evapotranspiration using ANNs. *Ain Shams Engineering Journal*.
- Muzzammil, M., 2008. Application of neural networks to scour depth prediction at the bridge abutments. *Engineering Applications of Computational Fluid Mechanics*, 2(1),30-40
- Nasr-Allah, T.H., Mohamed, Y.A, Abdel-Aal, G.M. Awad, A.S., 2016. Experimental and numerical simulation of scour at bridge abutment provided with different arrangements of collars. *AEJ*, 55,1455-1463. <http://dx.doi.org/10.1016/j.aej.2016.01.021>.
- Parker, G.W., Bratton L., Armstrong, D.S., 1997. Stream stability and scour assessments at bridges in Massachusetts. U.S. Geological survey open file Report No. 97-588 (CD-ROM). Marlborough, Mass.: Massachusetts Highway Dept. Bridge Section.

- Pu, J.H., Lim, S.Y., 2013. Efficient numerical computation and experimental study of temporally long equilibrium scour development around abutment, *Environmental Fluid Mechanics*.
- R., Mohammadpour, A., Ghanib, H.M., Azamathullac, 2013. Estimation of dimension and time variation of local scour at short abutment *Int J River Basin Manage*, 11(1),121 – 135.
- Ra'ul Rojas, 1996. *Neural networks a systematic introduction*. Springer-Verlag, Berlin.
- Richardson E.V, Abed L., 1993. Top width of pier scour holes in free and pressure flow. *Proceeding of international conference of hydraulic engineering, Part 1*, 25–30.
- Richardson, E.V., Davis, S.R., 2001. Evaluating scour at bridges. *Hydraulic Engineering Circular no. 18, 4th Ed.*, Federal Highway Administration (FHWA); Arlington, VA.-11.
- Şarlak, N., Tiğrek, Ş., 2011. Analysis of experimental data sets for local scour depth around bridge abutments using artificial neural networks. *Water SA*, 37(4).
- Sturm, T.W., 2006. Scour around bankline and setback abutments in compound channels .*J Hydraul Eng*, 132 (1), 21–32
- Sung-Uk Choi, Sanghwa Cheong, 2020. Prediction of local scour around bridge piers using artificial neural networks”, *Journal of the American Water Resources Association*, 487-494.
- Teruzzi, A., Ballio, F. 2021. Numerical investigation of the turbulent flow around a bridge abutment. *River Flow*, Ferreira, Alves, Leal & Cardoso.
- Xie, J.X, Cheng, C.T, Chau, K.W, Pei Y.Z., 2006. A hybrid adaptive time–delay neural network model for multi-step-ahead prediction of sunspot activity. *International journal of Environment and Pollution*, 28(3), 364–381.

**DESIGN AND SIMULATION OF RECTANGULAR MICROSTRIP PATCH
ANTENNA FOR SATELLITE COMMUNICATIONS AND IOT DEVICES USING FR-
4 SUBSTRATE**

Aremu, O.A.

Department of Physics with Electronics, The Polytechnic, Ibadan. Nigeria

Makinde, O.S.

Department of Physics with Electronics, The Polytechnic, Ibadan. Nigeria

Oyinkanola L.O.A.

Department of Physics with Electronics, The Polytechnic, Ibadan. Nigeria

Mufutau, J. A.

Department of Physics with Electronics, The Polytechnic, Ibadan. Nigeria

Anie, N. O.

Physics unit, GNS Department, Federal School of Surveying, Oyo Nigeria

ABSTRACT

In this paper, the design and simulation of an innovative single element inset fed Rectangular Microstrip Patch (RMPA) Antenna for Satellite communications, GPS systems and IoT devices is presented. The proposed antenna design used an operating frequency of 1.93 GHz, a FR-4 substrate with dielectric constant of 4.30 mm, and a substrate height of 1.6 mm. All the performance parameters such as return loss, bandwidth, VSWR, gain, directivity, beam width **and radiation efficiency** were analyzed and investigated using Computer Simulation Technology (CST) studio suit 2024. The simulation results showed that the designed antenna resonated at 1.93 GHz, with a return loss (S_{1,1}) of -10.966 dB, narrow bandwidth of 35 MHz, VSWR of 1.789, maximum gain of 6.91 dBi, minimum gain of -33.1 dB, directivity of -2.32 dBi, and a wider beam width of 167.2°. The significant difference between the maximum and minimum gains of the novel designed RMPA indicates a highly directional antenna which makes it useful in applications where energy is needed to be concentrated in one direction like Satellite communication and IoT while minimizing energy in others to avoid interference or wasted power.

Keywords: Microstrip Satellite communication, FR-4, Bandwidth, Return loss

**ATTITUDES TOWARD LEARNING MATHEMATICS AND PERFORMANCE OF
GRADE 11 STUDENTS IN THE NEW NORMAL**

Chabelita S. Sabanal

Southern Philippines, Agri-business and Marine and Aquatic School of Technology
Malita, Davao Occidental, Philippines

Jelyan S. Bago

Southern Philippines, Agri-business and Marine and Aquatic School of Technology
Malita, Davao Occidental, Philippines

Carlito B. Balandra

Southern Philippines, Agri-business and Marine and Aquatic School of Technology
Malita, Davao Occidental, Philippines

Aldwin T. Miranda

Southern Philippines, Agri-business and Marine and Aquatic School of Technology
Malita, Davao Occidental, Philippines

ABSTRACT

This study aimed to determine the relationship between students' attitudes toward learning mathematics and their mathematical performance in the New Normal at a secondary school in Davao region. Utilizing a descriptive-correlational design and a stratified random sampling technique, 286 students were selected as respondents. Quantitative data were gathered using an adopted questionnaire. Results indicate that students' confidence in learning mathematics is moderate and occasionally felt. Engagement in mathematics is frequently observed. Students place importance on mathematics and understand its purpose in their lives. The mathematics performance of the students is approaching proficiency level, indicating they require minimal guidance from teachers and assistance from peers. The students' overall attitude toward learning mathematics is high, and their mathematics performance in the New Normal is satisfactory. Among the indicators, only confidence in mathematics showed a significant correlation with mathematics performance.

Keywords: Attitude Towards Mathematics, Students' Mathematics Performance, New Normal

**HUMAN RIGHTS OF DOMESTIC WORKERS: UNTANGLING NATIONAL AND
INTERNATIONAL LEGAL FRAMEWORKS**

Dalia Das

BA.LLB 4th Year, Student, Faculty of Legal Science, Shoolini University of Biotechnology and Management
Sciences, Solan (HP), India

Dr. Harish Kumar Verma

Associate Professor and Dean, The ICFAI University Law School, The ICFAI University, Jaipur, India.

Dr. Bhumika Sharma

Assistant Professor, Sharda School of Law, Sharda University, Greater Noida, India

Poonam Pant

Assistant Professor, Faculty of Legal Science, Shoolini University of Biotechnology and Management Sciences,
Solan (HP), India

ABSTRACT

The study critically examines the human rights issues surrounding domestic workers from both international and national perspectives, focusing on the persistent challenges they face, such as labour exploitation, inadequate legal protections, and widespread discrimination. Domestic workers, often women and migrants, are vulnerable to abuse due to the informal nature of their work, long working hours, and lack of social security benefits. Despite the vital role they play in households, they remain one of the most marginalized groups in the labour force. At the international level, efforts to protect domestic workers' rights are spearheaded by organizations such as the International Labour Organization (ILO). The ILO's Convention No. 189, adopted in 2011, is a landmark legal framework aimed at safeguarding domestic workers' rights, ensuring fair working conditions, social protections, and access to justice. This convention urges countries to recognize domestic work as legitimate and ensure these workers enjoy the same rights as other workers. On the national level, progress varies across countries. Some have taken steps to incorporate domestic workers into their labour laws, offering protections such as minimum wage, working hours, and social security. Others, however, still lack adequate measures, leaving domestic workers vulnerable to abuse and exploitation. Through a comparative analysis, the study highlights disparities in the protection of domestic workers' rights worldwide. It emphasizes the need for a more consistent and unified approach to guarantee that domestic workers are afforded the same basic rights and dignity as other workers, contributing to broader efforts toward equality, fair treatment, and human rights recognition globally.

Keywords: Human Rights, Domestic, Work, labour, equality, India

I. INTRODUCTION

Domestic work refers to employment within a household where individuals, often termed domestic workers, are engaged to perform a range of tasks that are essential to the upkeep of the home and its residents. These tasks may include cleaning, laundry, cooking, taking care of children or the elderly, and running errands like grocery shopping. Domestic workers are found in most households around the world, where they play a vital role in supporting the daily lives of families. Their work can range from cleaning and sweeping to cooking meals and assisting with childcare or elderly care. Some domestic workers even live with the families they serve, though this can often lead to exploitative living conditions. Unfortunately, despite the necessity of domestic work, it remains an undervalued and underpaid sector. Many domestic workers, especially in certain countries, are treated poorly, subjected to long working hours, and receive minimal wages. In extreme cases, they face conditions that can be likened to modern-day slavery. These workers, especially those living with their employers, may face limited privacy, poor living conditions, and are sometimes denied basic rights such as breaks, fair wages, or even time off. Some are forced to sleep on the floor or in shared spaces, and their work is often taken for granted.

The lack of legal protection for domestic workers is one of the key reasons for their exploitation. In many countries, domestic work is not regulated by labour laws, making it difficult for workers to access justice in cases of abuse or mistreatment. Though there have been attempts to address these issues, the enforcement of laws protecting domestic workers remains weak. As a result, domestic workers often find themselves in vulnerable positions, subject to exploitation and abuse. Nevertheless, as awareness grows, many countries are beginning to implement stronger legal frameworks to ensure the fair treatment of domestic workers, though significant challenges remain in achieving full protection.

II. CONCEPT AND MEANING OF DOMESTIC WORKERS

• INTERNATIONAL LABOUR ORGANIZATION

Domestic workers are individuals employed to perform tasks within or for private households, playing a crucial role in the care economy. Their responsibilities span both direct and indirect care services, including housekeeping, cooking, laundry, and childcare. They may also provide specialized services such as elder care, tending to the sick, gardening, house guarding, driving, and even caring for pets. These essential services contribute significantly to the functioning of households, especially in families with demanding schedules or those requiring additional support. Domestic workers can be employed on either a full-time or part-time basis. They may work for a single household or be hired through a service provider. In some cases, they live in the employer's home, referred to as "live-in" workers, while others maintain their own residence, known as "live-out" workers. A significant portion of domestic workers are migrants, working in countries where they are not citizens, making them particularly vulnerable to exploitation. Despite their indispensable contribution to the household, domestic workers often face challenges, such as low pay, lack of social protection, and, in many cases, legal recognition. As members of the care

economy, domestic workers highlight the critical need for stronger protections and fairer treatment across the globe.

- **UNESCO (UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION)**

Domestic work refers to tasks performed within or for a household, encompassing duties such as cleaning, cooking, childcare, and elderly care. A domestic worker is any individual engaged in these tasks under an employment relationship, whether full-time or part-time. This includes workers who are hired to perform regular household duties but excludes those who provide these services occasionally or sporadically without a formal occupational role. Domestic workers are essential contributors to the functioning of households, and their role is recognized as distinct from casual or infrequent help, emphasizing the professional nature of their work.

III. ISSUES OF DOMESTIC WORKERS IN INDIA

Domestic workers, especially in countries like India, are an integral part of the household economy, but they face widespread exploitation and discrimination. Many of these workers are women or girls, with nearly 90% of the domestic workforce in India comprising female workers, often from disadvantaged socio-economic backgrounds. Shockingly, 25% of these workers are below the age of 14, exposing the high prevalence of child labour in this sector. Most domestic workers are illiterate, further limiting their opportunities for advancement and leaving them vulnerable to exploitation. Engaged in tasks like cooking, washing, and cleaning—work traditionally seen as "women's work"—domestic workers are frequently regarded as subservient and inferior. The stigma attached to domestic work is exacerbated by India's caste system, where menial tasks such as sweeping and cleaning are associated with individuals from so-called "lower castes," reinforcing the marginalization of these workers. Domestic workers often endure gruelling conditions. Live-in workers typically labour for 15 hours a day, seven days a week, with little to no time off. In contrast, part-time domestic workers usually juggle jobs in multiple households, working up to 8-10 hours daily without adequate compensation. They are frequently paid wages far below the legal minimum for unskilled or semi-skilled workers, and the lack of formal employment contracts further entrenches their vulnerability.

In addition to harsh working conditions, domestic workers are often subjected to suspicion and mistreatment. If anything goes missing in a household, domestic workers are often the first to be blamed, facing accusations of theft, physical abuse, or threats of police involvement. Many workers are coerced into confessions they may not be responsible for, further highlighting the power imbalance between them and their employers. This lack of legal protection and the absence of a social safety net make domestic workers one of the most vulnerable groups in the labour market. The situation calls for urgent reforms, including the implementation of better laws, stricter enforcement of minimum wage regulations, and the recognition of domestic workers as skilled professionals deserving of respect and humane working conditions.

IV. INTERNATIONAL INSTRUMENTS FOR PROTECTION OF RIGHTS OF DOMESTIC WORKERS

The recognition of domestic workers' rights to protection has been a key focus of international labour regulations for many years. Organizations like the International Labour Organization (ILO) have played a crucial role in shaping guidelines and policies aimed at safeguarding domestic workers' rights. Notably, the ILO's Domestic Workers Convention, 2011 (No. 189), marked a milestone by setting international standards for the fair treatment of domestic workers, emphasizing their right to decent working conditions, fair wages, and protection from abuse and exploitation. These global guidelines have influenced national policies in various countries, encouraging governments to establish legal frameworks that address the vulnerabilities of domestic workers. The fundamental principles guiding these efforts include ensuring freedom from discrimination, establishing fair wages and working hours, and promoting social protection for domestic workers. Despite progress in several regions, the implementation of these guidelines varies significantly, and many domestic workers worldwide still face significant challenges in realizing their full rights to protection and fair treatment.

- **MASTER AND SERVANT ACT, 1823**

The 1823 Master and Servant Act was enacted to regulate relations between employers and employees during the 18th and 19th centuries. Its primary objective was to ensure the "better regulation of servants, labourers, and work people," essentially formalizing the rights and responsibilities of both parties within the employment relationship. The Act was designed to enforce contractual obligations, often favouring employers, and it served as a model for the development of similar labour laws in other nations. While initially aimed at maintaining order in the labour market, it laid the foundation for later reforms in labour rights and domestic service laws.

- **HOLIDAYS WITH PAY CONVENTION, 1936**

The topic on domestic workers first gained prominence in 1936, when the International Labour Conference adopted the Holidays with Pay Convention, 1936 (No. 52), which established the right to six days of paid leave for workers in manufacturing and a range of other industries. The Convention excluded domestic workers, a shortcoming that prompted the Conference to request that "the question of holidays with pay for domestic servants [be put] on the agenda of [...] a future Session of the Conference [...] and to consider at the same time whether other conditions of domestic servants' employment could form the subject of international regulation.

- **INTERNATIONAL LABOUR ORGANIZATION, 1919**

Through International labour organization (ILO), United Nations have aimed to set the standards and improve the conditions for the labours in the world. Based on the statistics taken from 117 countries all around the world, it has been estimated that the workforce of the domestic workers includes more than 60 million of which more than half the population is women. It has been estimated that out of every 25 working women in the world, one is a domestic worker.

V. NATIONAL INSTRUMENTS FOR THE PROTECTION OF RIGHTS OF DOMESTIC WORKERS

- **DOMESTIC WORKERS ACT, 2008**

The Ministry of Labour had introduced a Domestic Workers Act in the year 2008 for the welfare of the domestic labour/workers and helps them get fair wages and prevent any trafficking or exploitation. Since this sector is greatly unorganized and the workers themselves are unorganized, it is practically not possible to cover each one of the workers and always check up on him/her to prevent certain circumstances.

The Domestic Workers Act is applicable to the whole country of India. It is strictly prohibited to employ any child in domestic work commercially. The workers who have been immigrated are strictly not included under this Act. As stated by the act, all those people who are in the age range of 18 to 60 years and have been engaged in any sort of domestic work for a minimum of 3 months out of the last one year can be registered to be a domestic worker in the country.

- **UNORGANIZED WORKERS SOCIAL SECURITY ACT, 2008**

This social security act was set up to ensure secured places of the unorganized sector, which comprises of the daily wage workers, the home-based workers, and the self-employed people in the country. It initially aimed at providing future insights and ensuring the availability of health benefits, old age help, maternity leaves and/or any other benefits which might feel apt for the people of the Unorganized Sector.

- **CODE ON SOCIAL SECURITY, 2020**

The Social Security Code aims to provide comprehensive protection to employees and workers in both organized and unorganized sectors. It seeks to extend social security benefits such as healthcare, maternity leave, disability support, and income security during critical contingencies like sickness, old age, or workplace accidents. By unifying various existing social security laws, the Code strives to ensure that all workers, regardless of their employment type, receive adequate protection and benefits. This legal framework is designed to create a safety net, promoting the well-being and economic stability of workers across different industries and sectors, thereby improving their overall quality of life.

VI. CONCLUSION

Safeguarding the human rights of domestic workers requires concerted efforts at both international and national levels. While international frameworks, such as the International Labour Organization's (ILO) Domestic Workers Convention (No. 189), provide a solid foundation for protecting the rights of these workers, true progress depends on the willingness of individual nations to translate these principles into actionable laws and policies. Many countries still face challenges in fully implementing these protections due to cultural, social, and economic barriers. The real challenge lies in the enforcement of such laws, ensuring domestic workers

enjoy dignified working conditions, fair wages, and freedom from abuse. Governments must adopt a multi-pronged approach that includes strict regulation, public awareness campaigns, and social support mechanisms. Collaborative efforts between international organizations, governments, civil society, and employers are essential in fostering a culture that recognizes the value of domestic work and upholds the dignity of every worker. Only through this collective commitment can we ensure the well-being and rights of domestic workers worldwide.

VII. SUGGESTIONS

- a. Preparation of a database of domestic helps at the local and regional levels with complete details about personal profile, educational qualifications and skill competencies acquired.
- b. Organizing adult education programmes for them to enhance their literacy levels.
- c. Organizing training programmes on small investment options made available by the government for the low-income families.
- d. Organizing awareness programmes to make them aware of their rights under the various laws framed for their welfare.
- e. A collaborative approach of NGO's, Government agency, skill development agency Unions and local RWA's can form an employment exchange specifically for domestic help at district level. This is essential for forming an organized sector of this unorganized sector.
- f. Establishing a grievance redressal mechanism – Create a dedicated helpline or support centres where domestic workers can report cases of abuse, exploitation, or non-payment of wages, with legal and counselling support provided.
- g. Providing health and social security benefits – Develop schemes to ensure domestic workers have access to healthcare, insurance, maternity benefits, and pension schemes, offering them protection against life's uncertainties.
- h. Organizing financial literacy workshops – Educate domestic workers about basic financial management, savings, and government welfare schemes to enhance their economic independence.
- i. Creating legal aid cells for domestic workers – Set up legal aid services specifically for domestic workers to help them understand their rights, navigate labor laws, and access justice in case of disputes or violations.
- j. Issuing identity and work cards – Issue formal identification and work registration cards for domestic workers, which can serve as proof of employment, ensuring fair wages and safeguarding their rights.
- k. Promoting awareness about fair employment practices among employers – Conduct awareness campaigns for employers on fair employment practices, the importance of humane treatment, and the rights of domestic workers to prevent exploitation.

1. Encouraging unionization – Facilitate the formation of domestic worker unions to represent their interests, fight for fair wages, and advocate for better working conditions.

REFERENCES:

1. Agarwal, Dr. H. O. International Law and Human Rights (15th ed., Gaziabad: Central Law Publications, 2008).
2. Agrawal, Dr. P. K., & Chaturvedi, Dr. K. N., Constitution of India, (Delhi: Prabhat Prakashan, 2020).
3. Bandopadhyay, R., Dubey, R., Singh S. & Mandal, S., Women Rights Human Rights (1st ed., Kolkata: R. Cambray & Co. Pvt. Ltd., 2010).
4. Basu, D., Human Rights in Constitutional Law, (2nd Edition, Nagpur: LexisNexis Butterworths Wadhwa Publications, 2003).
5. Bishoyi, D., Dimensions of Gender Problems: Policies and Prospects, (New Delhi: Discovery Publishing House.2007)
6. Chandrashekhar, Dr. M., Human Rights: Women and Violation, (Edu creation Publishing, 2016).
7. Devan, V. K., Law Relating to Offences Against Women, (Second Edition, (New Delhi: Orient Law House, 2000).
8. Devasia, L. & Devasia, V.V., Empowering Women for Sustainable Development (1st ed., New Delhi: Ashish Publishing House, 1994)
9. Fish, J. N. Domestic Workers of the World Unite! A Global Movement for Dignity and Human Rights, Look Deep in Your Hearts (2nd ed., SAGE Publication India Pvt. Ltd., 2018)
10. John, Dr. Mrs. A. (Ed.), Violence against Women-Need to Awaken the Conscience of Humanity, (Hyderabad: Asia Law House, 2013).

**GEOLOGICAL, PETROGRAPHIC, AND MINERALOGICAL CHARACTERISTICS
OF BASALTIC ROCKS IN THE TOPRAKKALE (OSMANIYE) REGION**

Hande SONSUN

Çukurova Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü
Çukurova University, Faculty of Engineering, Department of Geological Engineering

ORCID ID: 0000-0003-4784-5070

Nil YAPICI

Çukurova Üniversitesi, Mühendislik Fakültesi, Maden Mühendisliği Bölümü
Çukurova University, Faculty of Engineering, Department of Mining Engineering

ORCID ID: 0000-0001-9761-9122

Nusret NURLU

Çukurova Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü
Çukurova University, Faculty of Engineering, Department of Geological Engineering

ORCID ID: 0000-0002-3293-150X

ABSTRACT

The aim of this study is to conduct a detailed geological, petrographic, and mineralogical analysis of the basaltic pumice and lava outcrops located in Türkmen town, Toprakkale district, Osmaniye Province. The conducted analyses reveal the mineralogical and petrographic composition and textural characteristics of these rocks, with the existing mineral structures being identified in detail. The basalts in the study area are generally classified into three types: pyroclastic, vesicular basalts (pumice), and columnar (massive) basalts. The first type, described as pyroclastic rocks, consists of volcanic pumice, tuff, and volcanic bombs, with diameters reaching up to approximately 1 meter. The second type of volcanic product is represented by vesicular pumice layers. In the lower levels of pumice-rich rocks, massive structures have been observed. These basalts generally exhibit intergranular porphyritic and ophitic textures, with pumice-type rocks containing abundant cooling vesicles. The massive basaltic rocks, which lack vesicles, are composed of olivine, pyroxene, and plagioclase microlites, and are found as a layer of 1.5 to 2.2 meters in thickness, overlying the pumice-type volcanic rocks.

Keywords: Osmaniye, Basalt, Pumice, Massive, Toprakkale

INTRODUCTION

The research area is located within the borders of Türkmen town in the Toprakkale district of Osmaniye Province. The closest settlements to the study area are Türkmen Town, Lale Lake, and Sazlık Town. The region is surrounded by volcanic masses, with its highest point being

Deli Halil Hill (456 m), which is a volcanic mass. One of the small parasitic cones surrounding this mass is Tüysüz Hill (320 m), located on the northeastern slope of Deli Halil Hill. Lava flows extending from Deli Halil Hill spread towards the plain floor with a decreasing slope in the directions of south, west, southeast, southwest, east, and north. Opposite Deli Halil Hill, to the northwest of Toprakkale, there are inclined lava flows belonging to the Üçtepeliler volcanic mass (132 m). In the southeastern part of the plain, there is a mountainous mass that is not very high but covers a large area. The highest point of this mass is Kafalı Hill, at an elevation of 314 meters. To the northeast of this mass, in the same direction as the plain, is Bahadır Hill, with an elevation of 300 meters. Further north of Bahadır Hill are Toprakepe, with an elevation of 147 meters, and Küçükger Hill, with an elevation of 162 meters. In the study area, the mineralogical and lithological properties of basaltic pumice rocks have been detailed, and a lithology map has been created. To investigate the added value of the rocks in the region and to detail their industrial usability, rock mineral determination was conducted based on the licensing of mining activities.



Figure 1. Location map of the study area (Google Earth, 2024).

MATERIAL AND METHODS

The mineralogical and lithological characteristics of basaltic pumice rocks in the study area have been detailed, and a lithology map has been created. During the licensing process of mining activities, rock mineral analyses were conducted to evaluate the contribution of the rocks in the region to added value and to determine their industrial utilization potential. Comprehensive field studies were carried out to prepare the current lithology map of the study area and to make lithological classifications based on the mineral contents of the rocks. During the field studies, rock samples taken from outcrops and surface locations were initially examined with a hand lens and then reduced to millimetric size using a crusher. These samples were then analyzed using a binocular microscope, and the thin sections prepared from these samples were examined using a stereomicroscope. Through these methods, the mineralogical contents and petrographic features of the rocks were identified, and the rocks were named accordingly. Additionally, the textural and structural properties of the rocks, as well as their organic matter contents, were also determined.

2.1 Field Studies

Rock samples were collected from outcrops and surface locations in the field for thin section preparation and petrographic analysis. The coordinate information and map of the sampling locations are provided in Figure 2 and Table 1. The location codes of the collected samples have been labeled as "OB."



Figure 2. Locations of the samples collected from the study area (Google Earth, 2024).

Table 1. Locations of the samples collected from the study area.

Sample	x	y
OB-1	241867.00 d D	4099199.00 m K
OB-2	241734.00 d D	4099309.00 m K
OB-3	241688.00 d D	4099242.00 m K
OB-4	241645.00 d D	4099352.00 m K
OB-5	241680.00 d D	4099373.00 m K
OB-6	241542.00 d D	4099302.00 m K
OB-7	241390.00 d D	4099248.00 m K
OB-8	241144.00 d D	4099336.00 m K
OB-9	241053.00 d D	4099338.00 m K
OB-10	241975.00 d D	4099328.00 m K
OB-11	241872.00 d D	4099416.00 m K
OB-12	241972.00 d D	4099587.00 m K
OB-13	241941.00 d D	4099619.00 m K
OB-14	241880.00 d D	4099770.00 m K
OB-15	241028.00 d D	4099940.00 m K
OB-16	241876.00 d D	4099191.00 m K

A total of 10 rock samples were collected from each group and subjected to petrographic analysis. Vertical stratigraphic rock descriptions were made based on the identification of rock samples from each outcrop, and cross-sections were created accordingly.

RESULTS

The study area is situated between the regions where the Iskenderun Bay lies to the south and the Ceyhan River bends to the north. In this area, young basaltic volcanic outcrops extending in a northeast-southwest direction are present. All rock units covering the study area are overlain by Quaternary-aged plateau basalts. When examining the Cenozoic-aged rock units in the region, the lowermost unit is the Andırın Formation, which has a complex structure and dates back to the Upper Lutetian- Lower Miocene (Aquitanian). The Andırın Formation generally consists of an alternation of sandstone, marl, and sandy limestone layers, forming a flysch unit that can exhibit olistostromal characteristics in certain parts. Moreover, variously sized olistoliths may also be present within this formation. The Quaternary-aged basalts within the study area are observed sporadically as surface outcrops along a northeast-southwest orientation (Figure 3).

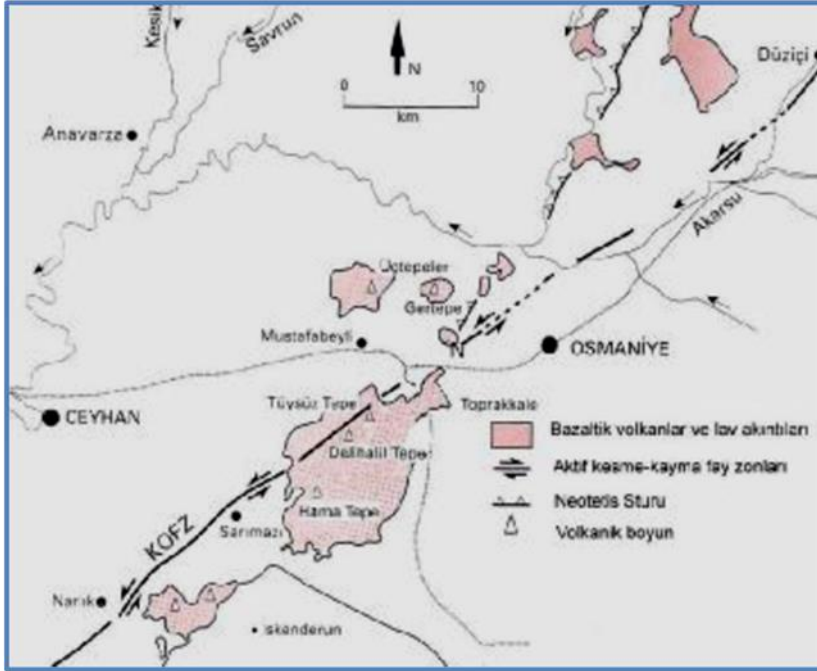


Figure 3. Distribution of Quaternary basalts in the Osmaniye-Ceyhan region [1, 2].

The pink, loose-textured tuffs present in the study area are indicative of basaltic lava. The Üçtepe cone and Delihalil Tepe within the study area consist of basaltic pumice and pyroclastic materials. Surrounding Karataş Tepe and Küçükger Tepe, basaltic lava flows are situated over Pliocene-Quaternary conglomerates. In the vicinity of Düdenbaşı Tepe, lava flows progress across the expansive Haruniye Plain, with Pliocene-Quaternary conglomerates observed beneath these flows.

The research area holds critical importance in terms of Turkey's tectonic plate dynamics. As seen in Figure 2, the study area is located at the convergence of the Arabian, African, and Aegean-Anatolian plates. In recent years, studies concerning the tectonics of the Eastern Mediterranean and Turkey have increased, leading to numerous differing opinions. However, a common agreement among most researchers pertains to the positioning of the plate boundaries in this region. Southeastern Anatolia is considered an extension of the Arabian Plate, which, along with the African Plate, is moving northward. Eastern Anatolia is characterized as a compression zone. The Aegean-Anatolian Plate is bordered to the north by the North Anatolian Fault and to the south by a subduction zone that begins south of the island of Crete and extends along the Marmaris-Cyprus route. This subduction zone continues eastward, reaching the study area, and subsequently separates the Aegean-Anatolian Plate from the Van Plate along the East Anatolian Fault, which is a transform fault.

The "Dead Sea Transform Fault," which delineates the Arabian and African plates, extends as far as the southern part of the study area. Basic composition rocks that intersect Neogene units are observed along the northeast-southwest-trending left-lateral Karataş-Osmaniye Fault Zone. These basic rocks are concentrated in four main regions: Hama Tepe, Delihalil Tepe, Üç

Tepeler, and Gertepe. The volcanic vents in these four regions are considered the origins of the basic composition rocks [2]. At Delihalil Tepe, located west of Toprakkale, volcanic cones related to these basic volcanics can be observed. This unit derives its name from Delihalil Tepe, situated within the borders of Osmaniye Province [3]. The unit surfaces over a wide area, typically manifesting as fissure eruptions along young tectonic faults. These basic composition rocks consist of porous, black basalts interlayered with reddish-gray and black tuffs. The eruption age of this unit, occasionally covered by Quaternary alluvium, is estimated to be shortly after the Upper Pliocene[4]. A generalized geological map of the region and its vicinity is provided in Figure 4. The most extensive surface exposure is observed around Delihalil Tepe, which is regarded as the main volcanic vent. Several parasitic cones are located around this peak. These basalts, known as Delihalil Basalts, appear as lava flows that form a single volcanic cone comprising the three peaks. These formations rest upon all other formations as plateau basalts. Delihalil Tepe is characterized as a cone group containing 2-3 main vents and several parasitic vents. Typically, volcanic cones are composed of basaltic pumice. At the southernmost edge of the basaltic surfaces, tuff units displaying horizontal stratification are observed beneath lava flows at Arnavut Tepe and Hayıtlı Tepe.

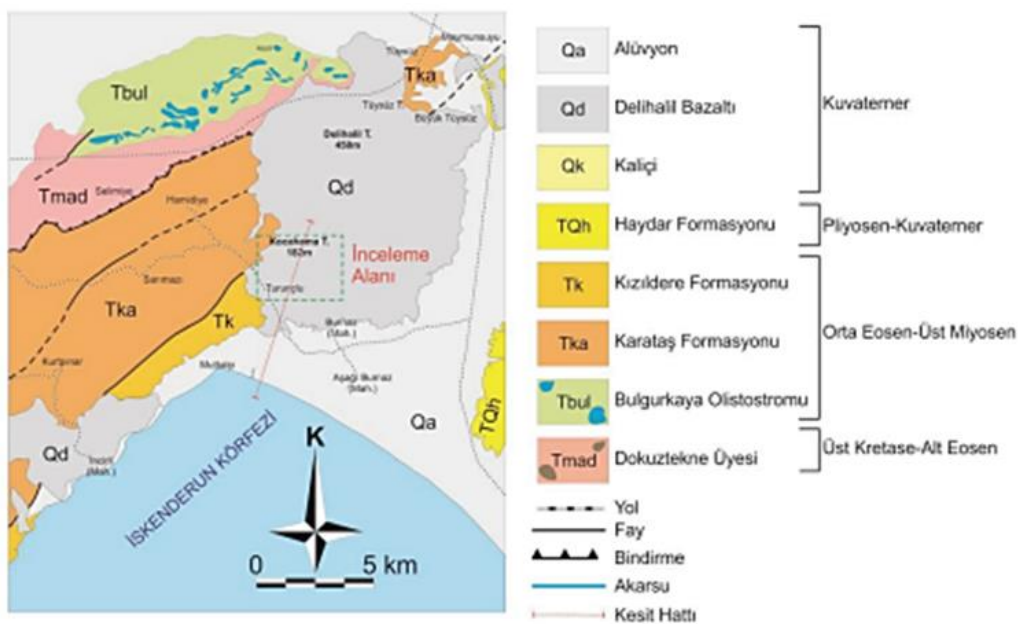


Figure 4. Geological map included in the study (taken from [1] and [3]).

3.2. Petrographic Studies

A total of 64 rock samples have been collected from various levels of the OB1-OB16 outcrops for rock identification purposes. The thin section images and descriptions of the rocks are provided below.

3.2.1. Systematic Petrographic Examination of Samples Collected from Coordinates

Mineralogical Examination of the Sample Collected from Coordinates OB1

Mineralogical composition: The massive basalt sample contains 11-13% olivine, 6-8% orthopyroxene, 39-41% plagioclase microlites, volcanic glass and presents 1-2% vesicles (voids). The pumice basalt sample contains 4-6% olivine, 1-2% orthopyroxene, 38-40% plagioclase microlites, volcanic glass and presents 25-27% vesicles (voids) (Fig.5).

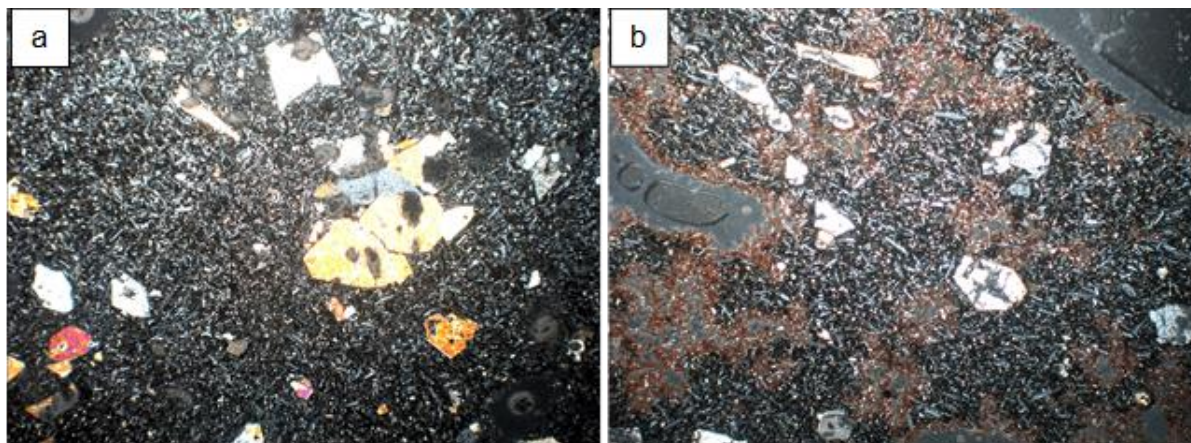


Figure 5. Thin section view of the sample taken from coordinate OB1 a) massive basalt b) pumice

Mineralogical Examination of the Sample Collected from Coordinates OB2

Mineralogical composition: The massive basalt sample contains 7-9% olivine, 3-4% orthopyroxene, 55-57% plagioclase microlites, volcanic glass and presents 1-2% vesicles (voids). The pumice basalt sample contains 7-8% olivine, 1-2% orthopyroxene, 29-31% plagioclase microlites, volcanic glass and presents 35-37% vesicles (voids) (Fig.6).

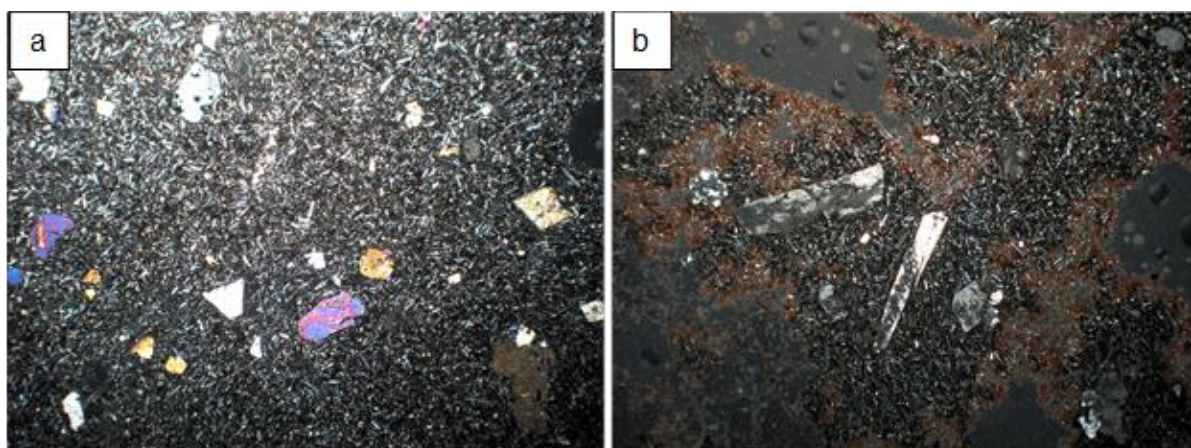


Figure 6. Thin section view of the sample taken from coordinate OB2 a) massive basalt b) pumice

Mineralogical Examination of the Sample Collected from Coordinates OB3

Mineralogical composition: The massive basalt sample contains 15-17% olivine, 5-6% orthopyroxene, 40-42% plagioclase microlites, volcanic glass and presents 2-3% vesicles (voids). The pumice basalt sample contains 8-10% olivine, 3-5% orthopyroxene, 32-34% plagioclase microlites, volcanic glass and presents 22-24% vesicles (voids) (Fig.7).

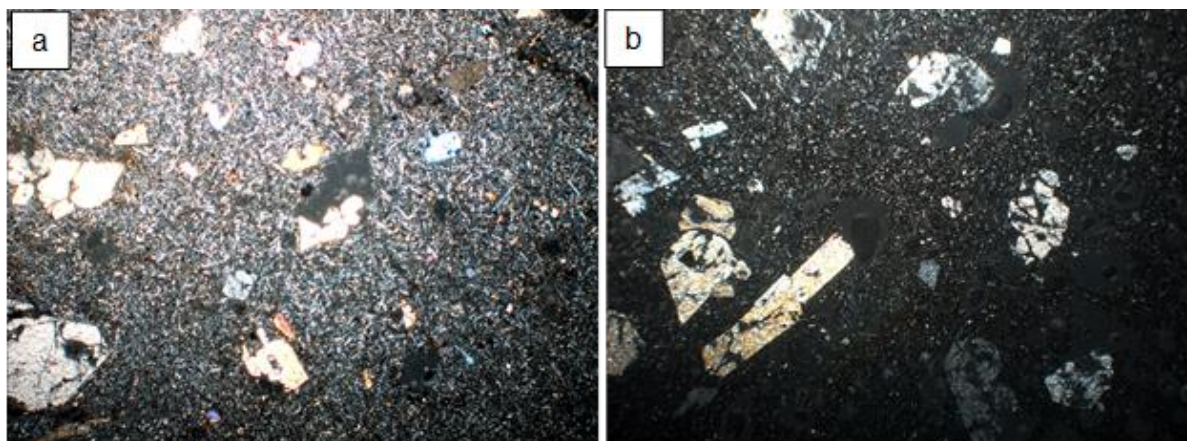


Figure 7. Thin section view of the sample taken from coordinate OB3 a) massive basalt b) pumice

Mineralogical Examination of the Sample Collected from Coordinates OB4

Mineralogical composition: The massive basalt sample contains 13-15% olivine, 4-5% orthopyroxene, 43-45% plagioclase microlites, volcanic glass and presents 2-3% vesicles (voids). The pumice basalt sample contains 10-11% olivine, 2-3% orthopyroxene, 34-36% plagioclase microlites, volcanic glass and presents 32-34% vesicles (voids) (Fig.8).

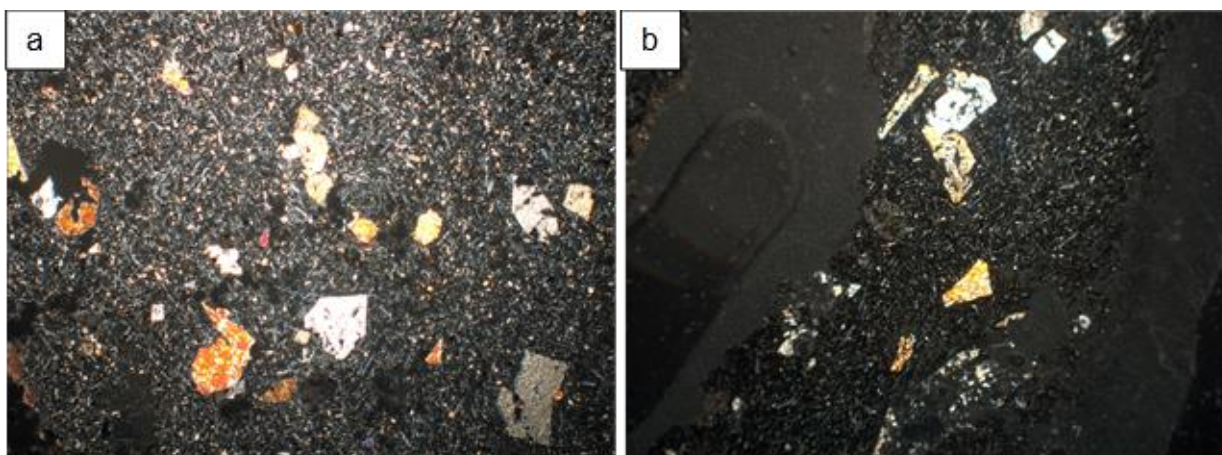


Figure 8. Thin section view of the sample taken from coordinate OB4 a) massive basalt b) pumice

Mineralogical Examination of the Sample Collected from Coordinates OB5

Mineralogical composition: The massive basalt sample contains 5-7% olivine, 2-3% orthopyroxene, 52-54% plagioclase microlites, volcanic glass and presents 1-2% vesicles (voids). The pumice basalt sample contains 8-10% olivine, 2-3% orthopyroxene, 33-35% plagioclase microlites, volcanic glass and presents 23-25% vesicles (voids) (Fig.9).

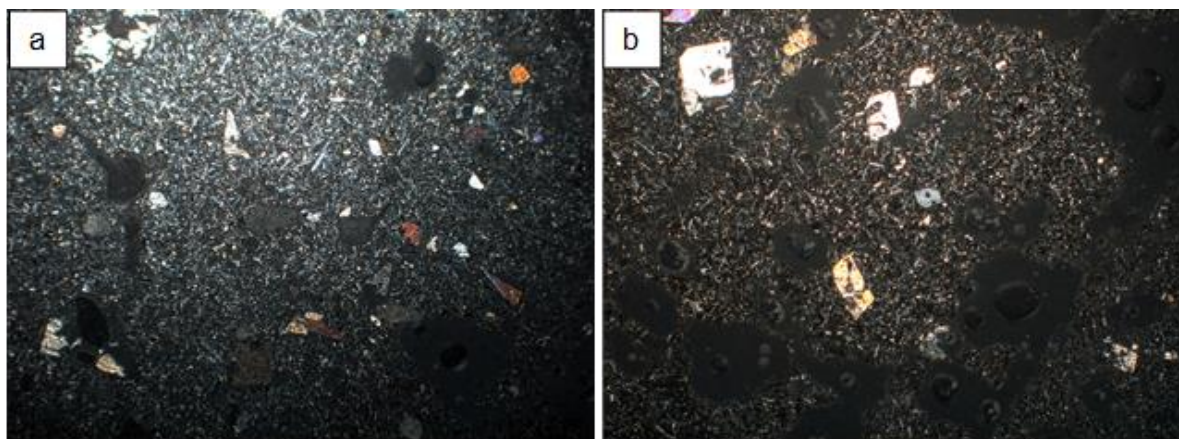


Figure 9. Thin section view of the sample taken from coordinate OB5 a) massive basalt b) pumice

CONCLUSIONS

In the study area, volcanic rocks with a basic composition are generally observed in three types: pyroclastic, vesicular basalts (pumice), and columnar (massive) basalts. In some sections of the study area, pyroclastic rocks are seen resting upon massive lava flows, indicating that volcanic activity has occurred in multiple stages. The second type of volcanic product features weathered surfaces with a brown color, while fresh surfaces are characterized by black, vesicular (pumice) layers. Vesicular (pumice) levels are generally distributed throughout the area. In this study, pumice levels were identified at depths of approximately 4 meters, above which massive basaltic flows were encountered. As deeper pumice levels were explored, it was noted that massive levels reappeared intermittently. The age of this volcanic unit has been established as Serravallian based on studies conducted in the Yumurtalık region [5,6]. The basalts in the area have been classified into two groups: pumice and massive, and their petrographic characteristics have been delineated. A thorough examination of numerous thin sections revealed that the basalts (both pumice and massive) generally exhibit intergranular porphyritic and ophitic textures, with pumice-type rocks containing a substantial number of cooling gas voids. Additionally, the matrix includes opaque minerals in microformations and a small amount of calcite. Opaque minerals occasionally contain iron, and rare inclusions of biotite are found within the phenocrysts of augite and olivine. Petrographic investigations confirmed that the lavas (both pumice and massive) are classified as basalt. Massive basalts are primarily composed of plagioclase, olivine, and orthopyroxene phenocrysts, situated within a matrix formed from these same crystals. The extinction angles

of the plagioclases were measured, revealing that nearly all are of labradorite composition, with olivine phenocrysts ranging between 18-22%. The second group of rocks examined in this study is identified as pumice basalt. The primary components of pumice basalts consist of plagioclase, olivine, and orthopyroxene phenocrysts, along with a matrix and volcanic glass derived from these same crystals. In the olivine crystals observed in pumice basalts, weathering is sometimes seen as iron-bearing weathering, while the majority appear unweathered. The average thickness of the pumice basalts in the region was measured to be between 1.8-2.1 meters, whereas the average thickness of the massive basalts was measured to be between 3.3-3.5 meters. This indicates that pumice basalts continuously extend below the level of massive basalts. It has been suggested that the Misis Mountains in the study area represent a structural segment of an underwater ridge similar to Cyprus Island [7].

REFERENCES

1. Bilgin, Z., Ercan, T., 1981. Ceyhan–Osmaniye yöresindeki kuvaterner bazaltların petrolojisi. Türkiye Jeoloji Kurumu Bülteni, 24, 22-30.
2. Yurtmen, S., Rowbotham, G., İşler, F. And Floyd, P.A., 2000. Petrogenesis of basalts from Southern Turkey: The Plio-Quaternary volcanism to the North of İskenderun Gulf. Tectonics and Magmatism in Turkey and the Surrounding Area. Geological Society, London, special Publications, 173, 489512
3. Kozlu, H., 1982. İskenderun baseni jeolojisi ve petrol olanakları. TPAO Rapor no: 1921, Ankara.
4. Kozlu, H., 1997. Doğu Akdeniz Bölgesinde yer alan Neojen basenlerinin (İskenderun, Misis-Andırın) Tektono-Stratigrafi birimleri ve bunların tektonik gelişimi. Çukurova Üniversitesi Fen Bilimleri Enstitüsü Doktora Tezi, s 189, (yayınlanmamış).
5. Akıncı, A.C., Nurlu, N., Güney, A., 2023. Origin and geodynamic implications of basaltic rocks intercalated with Miocene turbidites around the Iskenderun Basin (Eastern Mediterranean/Turkey). Journal of African Earth Sciences, 198, 104780, 1-19.
6. Akıncı, A.C., Nurlu, N., Güney, A., 2023. Origin and geodynamical implications of basaltic rocks intercalated in the Miocene turbiditic deposits around the İskenderun Basin (Eastern Mediterranean/Turkey). 7th International Mediterranean Science And Engineering Congress, 29, 94-94.
7. Stride, A.V., Belderson, R.H., Kenyon, N.H., 1977, Evolving Miogeanticlines of the East Mediterranean (Hellenic, Calabrian and Cyprus outer ridges): Phil. Trans. Roy. Soc. Lond., 284, 1316- 1326.

HAFİF YAPI MALZEMESİNDE GENLEŞTİRİLMİŞ KİL KULLANIMI
USE OF EXPANDED CLAY IN LIGHTWEIGHT BUILDING MATERIAL

Ercüment BİLGER

Öğr. Gör., Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Maden Mühendisliği Anabilim Dalı
Inst. Çukurova University, Institute of Science and Technology, Department of Mining Engineering

ORCID ID: 0000-0002-8557-0576

Nil YAPICI

Dr. Öğr. Üyesi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Maden Mühendisliği Anabilim Dalı
Asst. Prof., Çukurova University, Institute of Science and Technology, Department of Mining Engineering

ORCID ID: 0000-0001-9761-9122

ÖZET

Mühendislik uygulamalarında yapı malzemelerinin mümkün olduğunca hafif olması istenmektedir. Günümüzde hafif betonların yüksek ısı ve ses yalıtımına sahip olmalarından dolayı yapı sektöründe kullanımı giderek yaygınlaşmaktadır. Hafif beton karışımı oluşturulurken farklı agregalar ve çeşitli katkı malzemelerinden yararlanır. Agregada içeriğinde doğal malzemelerin yanı sıra ısıl işlem sonucu genleşme özelliği gösteren killer de kullanılmaktadır. Beton karışımına silis dumanı, uçucu kül ve yüksek fırın cürufu gibi çevre sorunu yaratan atıklar da ilave edilerek betonun dayanım özellikleri de arttırılabilmektedir. Bu çalışmada hafif yapı malzemesi için alternatif bir yapay agregada türü olan genleştirilmiş kil agregasının kullanım olanakları araştırılmıştır. Ankara/Akyurt bölgesi kili 1150 ve 1200 °C sıcaklıkta genleştirilmiş ve en iyi genleşme oranı 6,2 ile 1200 °C’de 10 dakika için sağlanmıştır. Ankara-Akyurt bölgesi genleştirilmiş kil agregasının birim hacim ağırlığı 0,32 gr/cm³ olarak bulunmuştur. Genleşme işleminin ardından agregada malzemesi olarak Kayseri/Tomarza bölgesinden temin edilen pomza ile birlikte puzolan katkılı hafif yapı malzemesinde kullanılabilirliği araştırılmıştır. Oluşturulan hafif betonun 28 günlük birim hacim ağırlık, tek eksenli basınç dayanımı, ultrases geçiş hızı tespit edilmiştir. Hazırlanan hafif beton karışımına puzolan olarak uçucu kül, silis dumanı ve kuvars kumu %5, %10, %15 ve %20 oranlarında ilave edilmiştir. Hafif beton karışımlarında pomza ve genleştirilmiş kil agregalı %15’lik silis dumanı puzolanı ilavesi olan karışımların tek eksenli basınç değeri 125,12 kg/cm² (12,27 MPa)’dır. TS EN 206’ya göre LC 12/13 hafif beton sınıfındadır. Ankara-Akyurt genleştirilmiş kil agregasının yalıtım özellikleri de araştırılmış ultra ses geçiş hızı ise 2,28 km/s olarak bulunmuştur. Ultra ses ölçüm değeri ise TS 12504-4’e göre 3,0 km/s den düşük olan hafif beton sınıfına girmektedir.

Anahtar Kelimeler: Hafif Beton, Genleşmiş Kil, Tek Eksenli Basınç Dayanımı, Ultra Ses.

ABSTRACT

As in the rest of the world, the increase in population in our country has led to a rise in multi-story buildings. In engineering applications, it is desired that construction materials be as lightweight as possible. Due to their high thermal and acoustic insulation properties, lightweight concretes are becoming increasingly popular in the construction sector. Various aggregates and additives are used to create lightweight concrete mixtures. Alongside natural materials, clays that exhibit expansion properties due to thermal processing are also utilized as aggregates. Additionally, waste materials such as silica fume, fly ash, and blast furnace slag, which pose environmental problems, can be added to the concrete mix to enhance its strength properties. This study explores the potential of using expanded clay aggregate, an alternative artificial aggregate, for lightweight building materials. Ankara/Akyurt clay was expanded at temperatures of 1150 and 1200°C, with the best expansion ratio of 6,2 achieved at 1200°C for 10 minutes. The bulk density of the Ankara-Akyurt expanded clay aggregate was found to be 0,32 g/cm³. After the expansion process, the feasibility of using the aggregate material in lightweight construction materials with pumice obtained from the Kayseri/Tomarza region, along with pozzolanic additives, was investigated. The 28-day bulk density, uniaxial compressive strength, and ultrasonic pulse velocity of the prepared lightweight concrete were measured. Pozzolans such as fly ash, silica fume, and quartz sand were added to the lightweight concrete mixtures in proportions of 5%, 10%, 15%, and 20%. For mixtures containing pumice and expanded clay aggregate with 15% silica fume as a pozzolan, the uniaxial compressive strength was 125,12 kg/cm² (12.27 MPa). According to TS EN 206, this concrete falls into the LC 12 / 13 lightweight concrete class. The insulation properties of the Ankara-Akyurt expanded clay aggregate were also investigated, with an ultrasonic pulse velocity of 2,28 km/s, which is below the 3,0 km/s threshold for lightweight concrete as per TS 12504-4.

Keywords: Lightweight Concrete, Expanded Clay, Uniaxial Compressive Strength, Ultra Sound.

GİRİŞ

Dünyada olduğu gibi ülkemizde de artan nüfus ile birlikte çok katlı yapılarda artış görülmüştür. Mühendislik uygulamalarında yapı malzemelerinin mümkün olduğunca hafif olması istenmektedir. Günümüzde hafif betonların yüksek ısı ve ses yalıtımına sahip olmalarından dolayı yapı sektöründe kullanımı giderek yaygınlaşmaktadır. Hafif beton karışımı oluşturulurken farklı agregalar ve çeşitli katkı malzemelerinden yararlanılır. Agregalar olarak doğal malzemelerin yanı sıra ısı işlem sonucu genleşme özelliği gösteren killer de kullanılmaktadır.

Yapılarda hafifliğin sağlanması ve yalıtım özelliğinin kazandırılması amacıyla hafif agregalar kullanımı yaygınlaşmıştır. Doğal agregalar olarak pomza, perlit ve vermikülit gibi yalıtım

özelliđi oldukça iyi olan agregalar kullanılmaktadır. Yapay agregalar, ısıl işlem sonucu elde edilen sinter kabuđu ve gözenekli yapısıyla genleřtirilmiř kil veya genleřtirilmiř perlit gibi malzemelerdir. Kil potansiyeli aısından zengin olduđu halde atıl halde bırakılmıř muhtelif kil alanlarının, genleřtirilmiř kil hammaddesi olarak kullanılmak üzere tekrardan ele alınması gerekmektedir (Özgüven 2009; andır 2018).

Genleřme özelliđi yüksek olan killerin 1000-1300 °C'de piřirilmesi sonucunda meydana gelen granüller, boşluklu seramik malzemeleri olarak homojen bir dađılım gösteren ve boşluklar arasında herhangi bir bađlantısı olmayan küçük hücreler ihtiva etmelerinin yanında sinterleřme sonucu sert bir kabuđa da sahiptirler (řekil 1). Bahsi geen bu özellikleri sayesinde genleřtirilmiř killer kısacası yüksek dayanıma sahip, hafif ve ısı izolasyon özelliđi de sađlarlar (Gündüz 2006; Subařı 2009; Serin, 2012). Genleřtirilmiř kil agregalarının kullanımı ile yapı ađırlıklarının gözle görölür bir azalma yařadıđı ve depremlerin yıkıcı etkilerinin de azadıđı bilinmektedir (Serin, 2012).



řekil 1. Genleřmiř kil agregası sinter kabuđu ve boşluklu i yapısı

İnřaat sektöründe kullanımı deđerlendirilirken özellikle basın dayanımı göz önünde tutulur. eřitli arařtırmacılar tarafından yapılan alıřmalarda inřaat sektöründe kullanımından dolayı demir malzeme kullanımından %20 tasarruf, ısı yalıtım özelliđi nedeniyle de ısıtma veya sođutma masraflarının da yarı yarıya azadıđı belirlenmiřtir (Dođan ve řener 2004; Özgüven 2009).

Bu alıřmada Adana, Mersin, Osmaniye ve Ankara bölgelerinde yapay hafif agrega sınıfında genleřtirilmiř kil iin arazi alıřmaları gerekleřtirilmiřtir. Alınan numuneler önce kimyasal analize tabi tutulmuř ardından genleřtirme iin testler yapılmıřtır. Testler onucunda optimum genleřme oranının sađlandıđı Ankara-Akyurt kilinin genleřtirilmiř kil olarak hafif beton ierisinde kullanılabilirliđi ve genleřtirilmiř killerin bu betonların fizikomekanik özelliklerine etkisi arařtırılmıřtır. Beton karıřımına kuvars kumu, silis dumanı, uçucu kül ve yüksek fırın cürufu gibi evre sorunu yaratan atıklar da ilave edilerek betonun dayanım üzerine etkisi arařtırılmıřtır. Hafif beton deneyleri ile genleřtirilmiř kil agregasının dayanım ve yalıtım

özellikleri tespit edilerek konuyla ilgili ileride yapılacak çalışmalara alt yapı oluşturulması amaçlanmıştır.

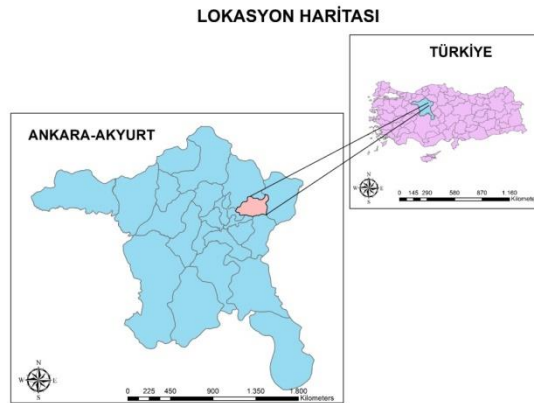
YÖNTEM

Adana-Aladağ, Mersin-Yenice, Adana-Karaisalı, Osmaniye-Toprakkale ve Osmaniye-Bahçe, Ankara-Akyurt bölgelerinde arazi çalışmaları gerçekleştirilmiştir. Kütahya-Emet, İzmir-Uşak, Tokat-Reşadiye ve Ankara-Çankırı bölgesinden ise kil örnekleri getirilmiştir. Çalışma dört farklı aşamada tamamlanmıştır. Bu aşamalar Şekil 2.'de olduğu gibi arazi çalışmaları, kimyasal analizler, geliştirilmiş kil üretim prosesi ve geliştirilmiş kil agregası kullanılarak oluşturulan betonun fiziko-mekanik özelliklerinin belirlenmesidir.



Şekil 2. Genleştirilmiş kil agregası ile oluşturulan hafif beton çalışmasının aşamaları

Ankara-Akyurt Çalışma Alanı: Çalışma kapsamında Akyurt yöresinde yayılım gösteren siyah şeyllerin ayrışımı sonucunda oluşan siyah, gri renkli kil bandından numuneler alınmıştır (Şekil 3.).



Şekil 3. Ankara-Akyurt çalışma alanına ait yer bulduru haritası

Çalışma alanında parçalanma mekanizmasına bağlı olarak hakim tektonizmanın etkin olduğu görülmektedir. Yataklanma alanının ortasına denk gelen kısımda fay çatlağının varlığı bölgenin oluşumunda tektonizmanın varlığını açıkça göstermektedir (Şekil 4.). Bu tektonik

zonda basınç gerilmelerinin kil oluşumuna neden olduğu ve genişleme mekanizmasına bu oluşum mekanizmasını olumlu yönde etki gösterebileceği düşünülmektedir. Ayrışma olayını oluşturan bu fay çatlağına doğru akan su kaynakları çatlağın şekillenmesinde etkili olduğu da izlenmiştir. Yatağın yakın çevresinde bu kadar belirgin bir zuhurun daha görülmemesi tektonizma sonucunda yatağın oluştuğu düşüncesini güçlendirmektedir.



Şekil 4. Akyurt bölgesi Karakocaş formasyonu kil yatağının oluşumunda etkin fay yapısı

Karakterizasyon: Kimyasal analizler killerin genişleme potansiyelinin önceden tahmin edilebilmesi için ilk adımdır. Kimyasal içerik olarak eriticilerin (Na_2O , MgO , K_2O , CaO , Fe_2O_3) ve SiO_2 miktarının genişlemede önemli etkisi vardır. Bu yüzden alınan numunelerin öncelikle XRF analizleri ve ardından mineral analizleri (XRD ve SEM) çalışmaları gerçekleştirilmiştir.

Killerin Genleştirilmesi: Kimyasal ve mineral analizlerinin ardından sonraki aşama geliştirme çalışmalarıdır. Bu çalışmalar aşağıdaki adımlardan oluşmaktadır (Şekil 5).

1. Potansiyel bölgenin tespit edilerek malzemenin temin edilmesi
2. Sahadan alınan numunelerin kırma-öğütme ve eleme işlemlerine tabi tutulması
3. Elek altına geçirilen yeteri miktarda numunenin önce ıslatılarak hamur haline getirilmesi ve şekil verilmesi
4. Şekil verilerek oluşturulan numunenin etüvde kurutularak nemden uzaklaştırılması
5. Genleşme için yüksek sıcaklığa ($900\text{ }^\circ\text{C}$ - $1200\text{ }^\circ\text{C}$) maruz bırakılması



Şekil 5. Genleştirme prosesinin aşamaları

Genleştirme aşamaları arasında kuvvetli bir bağıntı vardır. Numunenin araziden alınıp genleştirme çalışmasının tamamlanmasına kadar olan süreçte dikkatli olmak gerekmektedir. Genleşme öncesi nemden numunenin bünyesinden tamamen uzaklaşması gerekmektedir.

Genleşme oranı Eşitlik 1’deki formül ile elde edilebilir.

$$\text{Genleşme oranı} = \frac{\text{Ham Peletin Birim Hacim Ağırlığı}}{\text{Genleşen Kil Agregasının Birim Hacim Ağırlığı}} \quad (1)$$

Yapı sektöründeki kullanım özelliklerini belirlemek amacıyla, en iyi genleşme oranının sağlandığı Ankara-Çankırı yolu Akyurt yakınlarından “Karakocaş” formasyonundan alınan örnekler ile elde edilen genleştirilmiş kil hafif beton içerisinde doğal hafif agrega olan Kayseri bölgesi pomzası ile birlikte puzolan katkısıyla kullanılmıştır.

Hafif Beton Karışımı ve Deneysel Çalışma: Kayseri pomzası ile TS 2511: 2017’ye göre uygun agrega boyutu ile sabit çimento/su oranları kullanılarak 5 cm x 5 cm boyutlarında küp numuneler oluşturulmuştur. Yapılan bu beton çalışmaları iki aşamada yürütülmüştür. Kod olarak bu çalışmalar A Grubu ve B Grubu olarak ayrılmıştır. Numuneler isimlendirilirken başlarına ait olduğu gurubun harflerini almıştır. A koduyla biten kısaltmalar CEM I 42,5 R çimento ve 0-12 mm pomza agregasından oluşturulan betonu, B koduyla biten kısaltmalar ise CEM I 42,5 çimento ve 0-2 mm genleştirilmiş kil agregası ile 2-12 mm pomza agregasından oluşan betonu ifade etmektedir. Hafif beton karışımlarının adlandırılması, kullanılan katkı türü ve katkı oranları göz önünde tutularak yapılmıştır. Hafif beton karışımlarında, üç farklı endüstriyel atık katkı kullanılmıştır. Bu katkılar; silis dumanı (SD), uçucu kül (UK) ve kuvars kumunun tozu (KK)’dir. Kontrol numunesi (KT) koduyla verilecektir. Çizelgelerde ve açıklamalarda çimento karışımları bu kodlar ile verilecektir. Bu kodlardaki ilk 2 harf hangi katkıyla oluşturulduğunu rakamlar ise yüzde oranı ve sondaki harf ise hangi gruba ait olduğunu göstermektedir. Örneğin SD10A “A test grubuna ait %10 silis dumanlı karışımı”

ifade etmektedir. Çizelge 1. ve Çizelge 2.'deki çimento (Ç), mineral katkı (MK) ve su/çimento (S/Ç) kodu ile gösterilmiştir. Hafif beton karışımlarında endüstriyel atıklar, çimento oranına göre dört farklı oranda (%5, %10, %15 ve %20) ilave edilmesi ile karışıma dahil edilmiştir. Hafif beton karışımlarının tamamında 4 farklı boyutta (0/2, 2/4, 4/8 ve 8/12 mm) agrega kullanılmıştır. Çalışma kapsamında hazırlanan tüm karışımlarda çimento oranı sabit tutulmuştur (Çizelge 1, 2).

Çizelge 1. A grubu 0-12 mm pomza agregalı betonun karışım oranları 1 m³

No	Kod	Ç (CEM I 42,5 R) (kg)	MK (%)	Pomza (kg)				S/Ç
				0/2	2/4	4-8	8-12	
1	KT01A	300		275	180	285	115	0,55
2	SD05A	300	14	261	180	285	115	0,55
3	SD10A	300	28	247	180	285	115	0,55
4	SD15A	300	41	234	180	285	115	0,55
5	SD20A	300	55	220	180	285	115	0,55
6	UK05A	300	14	261	180	285	115	0,55
7	UK10A	300	28	247	180	285	115	0,55
8	UK15A	300	41	234	180	285	115	0,55
9	UK20A	300	55	220	180	285	115	0,55
10	KK05A	300	14	261	180	285	115	0,55
11	KK10A	300	28	247	180	285	115	0,55
12	KK15A	300	41	234	180	285	115	0,55
13	KK20A	300	55	220	180	285	115	0,55

Çizelge 2. B grubu 0-2 mm genişletilmiş kil 2-12 mm pomza agregalı betonun karışım oranları 1m³

No	Kod	Ç (CEM I 42,5 R) (kg)	MK (%)	Genleştirilmiş Kil (kg)	Pomza (kg)			S/Ç
					0/2	2/4	4-8	
1	KT01B	300		275	180	285	115	0,55
2	SD05B	300	14	261	180	285	115	0,55
3	SD10B	300	28	247	180	285	115	0,55
4	SD15B	300	41	234	180	285	115	0,55
5	SD20B	300	55	220	180	285	115	0,55
6	UK05B	300	14	261	180	285	115	0,55

7	UK10B	300	28	247	180	285	115	0,55
8	UK15B	300	41	234	180	285	115	0,55
9	UK20B	300	55	220	180	285	115	0,55
10	KK05B	300	14	261	180	285	115	0,55
11	KK10B	300	28	247	180	285	115	0,55
12	KK15B	300	41	234	180	285	115	0,55
13	KK20B	300	55	220	180	285	115	0,55

ARAŞTIRMA BULGULARI VE TARTIŞMA

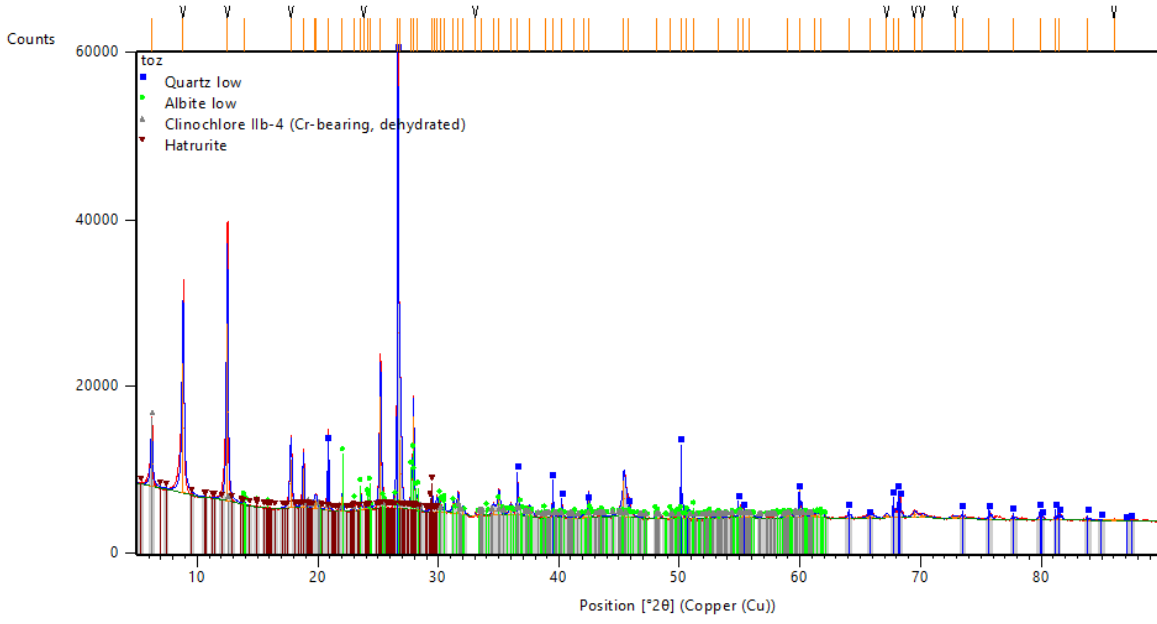
Bu çalışmada çeşitli bölgelerden alınan kil numunelerinin genişleme testleri gerçekleştirilmiştir. Yapılan genişleme çalışmalarının sonuçlarında yalnızca Tokat-Reşadiye, Ankara-Çankırı ve Ankara-Akyurt Bölgesi killlerinde genişleme elde edilmiştir. En yüksek genişleme oranı Ankara-Akyurt kilinde sağlanmıştır.

Kimyasal Analiz: Ankara-Akyurt çalışma alanından 5 farklı noktadan alınan AA 1, AA 2, AA 3, AA 4 ve AA 5 örneklerinin XRF analiz sonuçları Çizelge 3’de verilmektedir.

Çizelge 3. Ankara-Akyurt sahası numunelerin kimyasal analiz (XRF) sonuçları

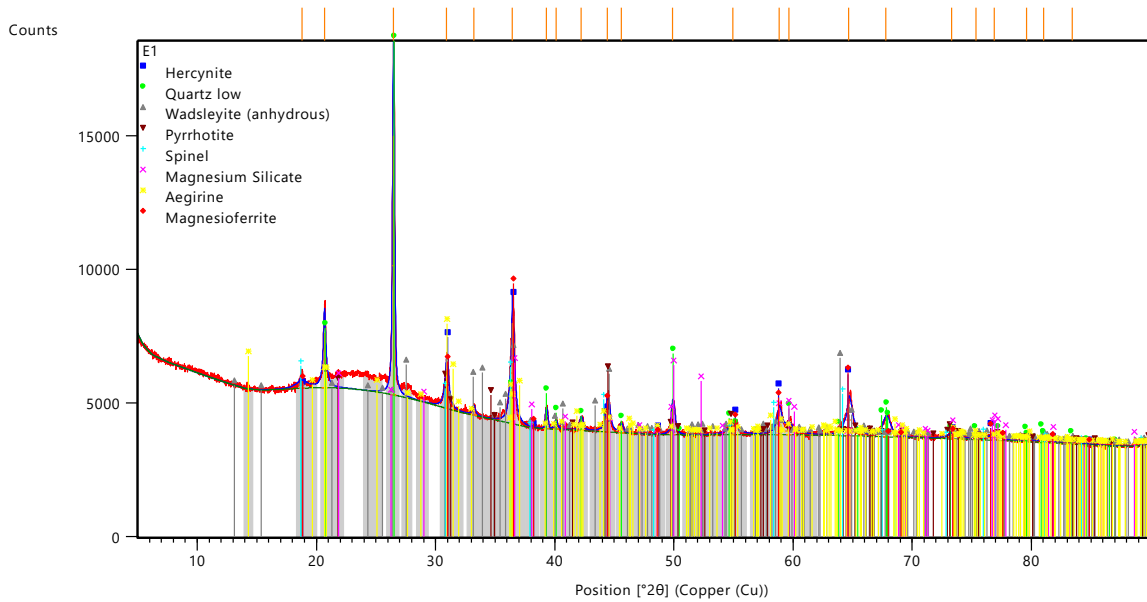
Bileşen	% İçerik					
	AA1	AA2	AA3	AA4	AA5	AA ORT
Al ₂ O ₃	23,00	20,00	24,00	23,00	22,00	22,40
SiO ₂	50,00	50,00	54,00	49,00	55,00	51,60
CaO	2,67	7,65	1,91	3,53	2,63	3,68
TiO ₂	1,35	1,69	1,30	1,36	1,09	1,36
MnO	0,11	0,19	0,11	0,13	0,10	0,13
Fe ₂ O ₃	14,86	15,69	12,00	14,00	12,00	13,71
CuO	0,05	0,05	0,05	0,05	0,04	0,05
SrO	0,03	0,05	0,02	0,03	0,03	0,03
SO ₃	-	-	-	2,30	1,70	0,80
K ₂ O	5,84	3,73	5,95	5,59	5,06	5,23

Mineral Analiz: Ankara-Akyurt Bölgesi kilinin genişletirme çalışması öncesi yapılan mineral analizine ait XRD deseni Şekil 6’da verilmiştir.



Şekil 6. Ankara bölgesi killerinin genleştirme öncesi XRD sonuçları

Ankara-Akyurt kilinin genleşme öncesi gerçekleştirilen XRD çalışmaları malzemenin içerik olarak kuvars, muskovit, illit ve demirin çeşitli bileşikleri şeklinde olduğu görülmüştür. Bu analizin ardından genleştirme işlemi sonrasında oluşan değişimin gözlemlenmesi için XRD analizi gerçekleştirilmiş ve Şekil 7’deki XRD deseni elde edilmiştir.



Şekil 7. Ankara Akyurt bölgesi kilinin genleştirme sonrası XRD analizi

Genleşme sonunda XRD analizinde yüksek sıcaklıkta kuvarsin kararlı hali olan Tridimit mineraline, refrakter özelliği yüksek Hercynite ($FeAl_2O_4$)’e dönüştüğü görülmektedir. Ayrıca yine yüksek sıcaklık ürünü olan Spinel ($MgAl_2O_4$), Magnezyoferrit ($MgFe_2O_4$) ve Magnezyum Alüminyum Oksit (Al_2MgO_4) oluşumları da gözlenmektedir.

Genleşme Testleri: Genleşme sağlanan çalışma alanlarına ait genleşme oranları Çizelge 4’de verilmektedir.

Çizelge 4. Genleşme sıcaklıkları ve genleşme oranları

GENLEŞME SONUÇLARI					
	Sıcaklık (°C)	Süre (dk)	Ham Pelet Birim Hacim Ağırlığı (gr/cm³)	Genleşmiş Pelet Birim Hacim Ağırlığı (gr/cm³)	Genleşme Oranı
Akyurt/ANKARA	1150	15	1,98	0,50	3,96
	1200	5	1,98	0,64	3,09
	1200	10	1,98	0,32	6,20
	1200	15	1,98	0,34	5,82
Reşadiye/TOKAT	1150	15	1,37	0,82	1,67
	1200	15	1,37	0,61	2,45
Çankırı/ANKARA	1150	15	1,71	0,45	3,83
	1200	15	1,37	0,53	3,24

Hafif Beton Testleri: Oluşturulan hafif beton karışımlarının su emme, birim hacim ağırlık ultra ses geçiş hızı (pundit) ve tek eksenli basınç dayanımları Çizelge 5 ’de verilmiştir.

Çizelge 5. Hafif beton ağırlıkça su emme, birim hacim ağırlık, tek eksenli basınç dayanımı ve ultra ses ölçüm değerleri

No	Kod	Ağ. Su Emme (%)	BHA (gr/cm ³)	Tek Eksenli Basınç Dayanımı (kgf/cm ²)	Ultra Ses Ölçüm Vp (km/s)	No	Kod	Ağ. Su Emme (%)	BHA (gr/cm ³)	Tek Eksenli Basınç Dayanımı (kgf/cm ²)	Ultra Ses Ölçüm Vp (km/s)
1	KT01A	33,6	0,82	115,42	2,42	14	KT01B	33,4	0,81	109,04	2,38
2	SD05A	28,4	0,98	122,00	2,50	15	SD05B	32,7	0,85	109,10	2,55
3	SD10A	26,2	1,01	131,00	2,55	16	SD10B	31,1	0,89	112,66	2,57
4	SD15A	25,4	1,08	141,97	2,63	17	SD15B	29,3	0,91	125,12	2,61
5	SD20A	23,7	1,10	132,62	2,69	18	SD20B	28,6	0,95	114,10	2,63
6	UK05A	33,9	0,78	118,36	2,51	19	UK05B	34,0	0,79	115,68	2,45
7	UK10A	33,5	0,81	126,74	2,56	20	UK10B	33,5	0,82	120,02	2,52
8	UK15A	31,5	0,86	132,10	2,56	21	UK15B	32,1	0,86	120,84	2,55
9	UK20A	30,6	0,88	123,63	2,59	22	UK20B	30,7	0,85	118,60	2,58
10	KK05A	32,3	0,86	110,20	2,25	23	KK05B	33,3	0,84	105,34	2,51
11	KK10A	28,6	0,91	118,46	2,39	24	KK10B	32,7	0,86	119,06	2,53
12	KK15A	27,7	1,00	120,10	2,45	25	KK15B	31,5	0,87	115,56	2,55
13	KK20A	26,5	1,03	115,44	2,47	26	KK20B	29,0	0,91	105,56	2,56

Hafif betonun birim hacim ağırlığı artışı ile birlikte boşluklu yapısı azaldığı için su emme değerlerinin de düştüğü görülmektedir. İnce boyutlu pomza agregası yerine daha küçük tane çapına sahip puzolanların ilavesi yapılarak gerçekleştirilen bu çalışmada boşluk oranının azalmasına orantılı olarak birim hacim ağırlıklarının da arttığı görülmüştür. Artan birim hacim ağırlığı ve azalan boşluk oranıyla birlikte ultra ses hızında da artış olmuştur. Sonuç olarak CEM 1 42,5 R çimento ile oluşturulan A ve B grupları beton karışımlarından A grubunda oluşturulan beton karışımının B grubu beton karışımına göre daha üstün olduğunu söyleyebiliriz. Bu sonuçlar bize CEM I 42,5 çimento için doğal agrega olan pomzanın 0-2 mm boyutunun yerine yapay agrega olarak 0-2 mm genişletilmiş kil agregası kullanılmasının hazırlanan beton karışımının dayanımını azalttığını göstermektedir.

SONUÇLAR

Arazi çalışmaları yapılan bölgelerden ve potansiyel alanlardan sağlanan killeri için genişletme çalışmaları yapılmış ve sadece üç bölgenin killeri geliştirilebilmiştir. Genleşme sağlanan bölgeler Ankara-Akyurt, Ankara-Çankırı ve Tokat-Reşadiye Killeri'dir. Genleştirme çalışmaları ile Ankara-Akyurt killerin 1200 °C'de 10 dakikada gerçekleşen genleşme oranı 6,2 olarak bulunmuştur. Bu daha önce bu bölgeye yakın alanlarda yapılan diğer çalışmalara kıyasla oldukça yüksektir. Genleşen killerden Ankara-Akyurt kilinin genleşme sonucundaki birim hacim ağırlığı 0,32 gr/cm³, Ankara-Çankırı kilinin birim hacim ağırlığı ise 0,45 gr/cm³ ve Tokat-Reşadiye kilinin birim hacim ağırlığı 0,61 gr/cm³ olarak bulunmuştur. Genleşme sonucunda Ankara-Akyurt'a ait killerin üst kısımlarında SiO₂'nin sinterleşmesi sonucunda camsı bir fazın oluştuğu görülmüştür. Farklı tür ve oranlarda puzolan ilavesi ile oluşturulan hafif betonların ultrases geçiş hızı ve tek eksenli basınç dayanımları araştırılmıştır. Genel olarak betonun dayanımı %10-15 oranlarındaki puzolanın etkisiyle artmış fakat %15'den sonra basınç dayanımlarında bir miktar düşüş kaydedilmiştir. Ultrases geçiş hızının malzemenin birim hacim ağırlık artışıyla yükselmektedir. En yüksek değer ise CEM I 42,5 R çimentolu ve silis dumanının %15 ilaveli 0-12 mm pomza agregası olan örneklerde 141,97 kg/cm² (13,92 MPa) olarak elde edilmiştir. Sonuç olarak genişletilmiş kil agregasının dayanım üzerine olumsuz etkisi olduğu görülmüştür. Bu konuyla ilgili daha sonraki yapılacak olan çalışmaların ısı yalıtımı veya ses yalıtımı gibi uygulamalar için geliştirilmesi gerekmektedir.

KAYNAKLAR

- ASTM C493-98: 1998. Standard test method for bulk density and porosity of granular refractory materials by mercury displacement.
- Çandır, İ. 2018., Bentonitlerden Genleştirilmiş Kil Agregası Üretimi ve Karakterizasyonu, Doktora Tezi, Adana.
- Doğan, H., Şener, F. 2004. Hafif yapı malzemeleri (pomza-perlit-ytong-gazbeton) kullanımının yaygınlaştırılmasına yönelik sonuç ve öneriler. TMMOB. The Newsletter of the Chamber of Geology Engineers, vol. 1, p. 51-3 [in Turkish].

- Gündüz L., Şapcı N., Bekar M., Yorgun S., 2006. Genleşmiş kilin hafif agregası olarak kullanılabilirliği. Kil Bilimi ve Teknolojisi Dergisi, 1(2), 43-49.
- Özgüven, A., 2019., Killerde genleşmenin üçgen diyagram ile tahmini, MTA Dergisi (2019) 158: 303-315
- Serin, S., 2012., Geleneksel Asfalt Beton Ve Genleştirilmiş Kil Agregası İle Üretilmiş Hafif Asfalt Betonun Çok Yönlü Karşılaştırılması, syf 55-64
- Subaşı, S., 2009., Genleştirilmiş Kil Agregası İle Taşıyıcı Hafif Beton Üretimi, Gazi Üniv. Müh. Mim. Fak. Der., Cilt 24, No 3, 559-567, 2009
- TS EN 206+A2 Beton - Özellik, performans, imalat ve uygunluk
- TS EN 12504-4, 2012. Beton Deneyleri, Bölüm4: Ultrasonik Atımlı Dalga Hızının Tayini. TSE, Ankara
- TSE 2511: 2017 Taşıyıcı hafif betonların karışım hesap esasları

**THE STRATEGIC PERSPECTIVE IN ORGANIZATIONS DURING POST
EARTHQUAKE PROCESSES: A RESEARCH WITHIN THE SCOPE OF 6TH
FEBRUARY EARTHQUAKES**

Ömer ÖZKAN

Dr., SOCAR Türkiye, Group Quality Management Systems Department

ORCID ID: 0000-0002-0752-307X

Nezih Metin ÖZMUTAF

Prof. Dr., İzmir Katip Çelebi University, Faculty of Economics and Administrative Sciences, Department of
Business Administration

ORCID ID: 0000-0003-1330-409X

ABSTRACT

Due to its geographical location, Turkey is faced with earthquakes at all times and will continue to be so. This cyclical earthquake process affects the state, citizens and various organizations, as well as directly concerns the businesses and employees at a strategic level. In other words, an earthquake is a dynamic natural disaster that occurs suddenly and with high impact, creating a balance within the imbalance of nature. This is at the center of the strategic nature of organizations to survive in a dynamic environment, reach the future safely and develop and grow. This imbalance manifests itself unexpectedly, suddenly and with different intensities, but it cannot be prevented, but it is a reality that can be met with strategic proactivity by being prepared. In this context, the main purpose of the research is to determine the perceptions of managers in regional businesses regarding basic strategic perspectives in the post-earthquake processes after the February 6, 2023 earthquakes in Turkey. The survey prepared for this purpose was applied to 27 managers in 27 businesses in various organizations located in the earthquake region between March 2024 and July 2024. Within the scope of the study, 11 propositions that are predicted to be important for the strategic perspective in the post-earthquake process with a future orientation were grouped under four factors as a result of factor analysis. These factors were named as “analysis, scenario, purpose and target, customer, stakeholder, competition”, “leadership and vision”, “institutional culture, environment, health and safety, disaster preparedness” and “participation and human resources” in accordance with the propositions they contain. As a result of the statistical analysis, in terms of post-earthquake strategic processes, “institutional culture, environment, health and safety, disaster preparedness” and “participation and human resources” factors were determined as the main factors perceived as important in this process. It was also determined that the majority of the participants had the perception that the strategic perspective was important in this process, but that this was not reflected in the implementation

at the desired level at approximately 37% and was reflected at the level of 63% in both senior and operational managerial activities.

Keywords: February 6 earthquakes, organizations, post-earthquake processes, strategic perspective

1. LITERATURE REVIEW

1.1. Strategic Perspective

Within the scope of strategic perspective, discussing organizational theories and strategic tendency from past to present comparatively, it is observed how affective they are on strategic decision makers to make decisions and practice the strategic subjects like determining both internal and external problems of the organizations and revealing the solutions, discovering the opportunities etc (Greve, 2021: 17). In this frame, strategic perspective will be able to be figured as articulation of multi relationality and interaction in a flexible structure by managers' perspective besides Porter's (2011) tendency for future practising the current activities ideally and Mintzberg's (Mintzberg and Waters 1985) conditionality (intended and realised strategy etc).

Strategic management process basically includes administrative processes formed in the frame of mission and vision. In short reason for being/ mission (Byars, 1987: 12) and vision are defined as a long termed encouraging and compelling target (Tankovic, 2013: 332). Within a wide frame, strategic perspective do not only focus on institutional mission and vision, besides considers determining and analysis processes relational and interactive issues individually, organizationally and institutionally. It provides this within the frame of dynamic, flexible and motivative creative thought (Özgür, 2004: 213).

Organization culture is created and carried on by strategic perspective as ideal for the organization with concrete (logos, concretes etc) and abstract constituents (values, beliefs, norms etc) (Nahavandi and Malekzadeh, 1999: 95). Culture is already the main tool of vision, leadership and strategic practises (Nukic and Josipa, 2014: 26). In brief, for an organization culture is a strategy and strategy is a culture phenomenon. All cultural changes are also strategic changes. Organizational culture also structures the future (Bate 1995). Strategic perspective benefits from various analysis results (existence, recognition of talents, SWOT, shareholder, risk, PEST, financial competition etc) while making decisions. As an advisor, existence of strategic analyses is mandatory (Özmutaf, 2019: 24).

Another significant dimension of strategic perspective is practicing competitive advantage while obtaining on the other hand. Businesses develop effective competitive strategies therefore, they take important steps for complying with market conditions and achievement goals (Dixit and Nalebuff, 2005:1). But it is not easy to receive information about components continuously in practice. Administrators generally move with some crumbs of information

about components and tendencies within a non-systematic, informal, hypothetical and intuitive frame. Even so, this heavy scene can be overcome with strategic perspective (Porter, 1980: 48).

Strategic perspective brings innovativity and creativity over in a visioner frame. In this frame, holistically, a perspective which changes content and course, produces value for customers, affects and forms strategic processes is revealed (Palmer and Kaplan, 2015: 5). Businesses become ready for the future with proactive solutions free from the past (Karabulak, 2009: 28).

Strategic perspective influences internal and external environment in a holistic frame. The main idea is to practise taking a proactive position towards external environment and changing conditions and tendencies of actors, not by oneself but in relation with primary external stakeholder (customers, suppliers, financiers, societies) and secondary external stakeholder (government agencies, NGOs, media, consumer protector groups etc) according to proper internal classification (beneficiaries, administrators, employees etc) (Freeman et.al (2010: 24). Opportunities around external environment can be taken with opportunities and talents in internal environment. Strategic perspective will try to find healthy answers for the questions like “Who are the external stakeholders?” “What do they want and What is the order of requests?”, “How will they try to get?” and “What are the relevances of their seses?” (Frooman, 1999: 191).

Strategic perspective is a leadership that brings over strategic leadership. Strategic leadership basically is a kind of leadership that includes other leadership types expected senior administrators to have. In strategic leadership with strategic perspective some qualities an administrative leaders has to have can be listed as; holistic view, global perspective, to be open to change, supporting creative thought, taking cognizance of information and information management, having intuitive talents, supporting employees, caring about human relations, relating the process and result, being confident about the future, being faithful for success, being respected, confidence and being humble etc (Ireland and Hitt, 2005: 63-73).

In strategic perspective making decisions in a participative environment will reveal the effect of spreading the risks to base and minimise the fault risk (McDaniels and Small, 2004: 301). Participation will provide strategic processes (creating, practising, control, revision and remediation etc) to be managed productively at each level in strategic perspective. Around a democratic frame while asking for the opinions of administrators and other employees increases productivity, it will influence motivation and accordingly performances positively (Akdemir, 2012: 16). Within the frame of participation a process that strengthen the employees and mobilise creativities will be faced giving initiative to others (Rolková and Farkašová, 2015: 1384). Conflicts can also be solved in an ideal style with participant decision strategy. (Fareo and Jajua, 2018: 325). These are nothing but strategic perspective.

Both ruling and directed are human. Today employees are scarce source of a business with their potential of knowledge, talent, experience, ability, education, motivation, job

satisfaction, creativity, performance etc. Strategic perspective can be exist and carry into future successfully with a compedent HR. strategically, the most important capital is human. They must be educated, improved and organizational commitment must be provided (Schultz, 1961: 2). Within this framework, with strategic perspective senior management is a collimator for all processes like defining the goals and values in visioner leadership, developing general and market strategies, providing and supporting operational strategies to achieve targets, customer relations etc. Middle management, in the context of details in the previous sentence, starts new policies and applications strategically but carry out them within the frame of responsibilities (Armstrong, 2006: 79). In strategic perspective, climbing the steps, existence of an inclusive sense will appear (Bateman and Zeithaml, 1990: 196).

Strategic view also includes creating or transferring new technologies with RD activities and using these opportunities by HR compedently. To have rapidly changing and transforming new technologies will also bring the sustainable competitive advantage in market (Akdemir, 2012: 8). Therefore, in the strategic perspective strategies have to be reviewed and innovative approaches have to be adopted (Ersoyand Tehci, 2020:2).

One of the strategical goals of human resources can be defined as forming an employee profile with positive job satisfaction and pleasure discussing their both work and private life holistically. Within this frame, win win strategy will be important within the scope of strategic perspective, right to labor, union rights, labor negotiation processes, improving business conditions, providing decent salary, protecting and developing legal rights, labor health (occupational diseases, injuries etc) and job security (work accidents) (Rakesh et.al, 2021: 159).

Consequently, strategic perspective is an essential factor for organizations to obtain a sustainable competitive advantages today and in the future. This perspective, with total and detailed approaches will enable the organizations to remain firm not only in current conditions but also against the future uncertainties. Accordingly, having an effective strategic perspective is not only a management tool, in the same time it can be defined as the main keystone of organizational achievement.

1.2. Reality of Earthquake

Reality of earthquake is a type of disaster. AFAD (2014: 23) (Disaster and Emergency Management Presidency) identifies disaster as a nature, technology or human oriented events that are impossible to manage by the damaged regions and people, they produce physical, economical and social losses for whole or particular regions, stop or interrupt normal life and human activities. Disaster can be identified not as the event but the result produced by the event. Disasters are collected in two groups as natural (earthquake, tsunami, storms, typhoon, fire, flood, heavy snow and snowslide, freezing, landslide, volcanic eruption an gases, firedamp, metan, fog, desertation, meteor, bangs inside the sun etc) and human oriented disasters (nuclear and chemical gases, terrorist incidents, wars etc) (TMMOB İMOAŞ 2023).

As it is observed in preceding classification, earthquakes which are natural disasters are sudden vibrations formed by seismic waves and occur as a result of releasing the energy collected in earth crust. Every year averagely 3,5-4 million different magnitude earthquakes have been recorded around the world (TBMM, 2023: 185). Earthquakes suddenly damage constructions/buildings, infrastructure systems, economy, industry, businesses and other organization types, other technologic systems, transportation and communication systems, moreover, cause fires, affect clean water negatively, cause landslides, affect individuals' life negatively (death, injuries, losses, stress, panic, sadness, loss of consciousness, desperation, broken home, unemployment etc. reveal), also may bring pandemic and some undesired issues (robbery, human/organ smuggling, abuse etc.) (Jurukovski, 1997: 626-628). Within this frame, prevention aimed approaches and awareness can minimize the level of being affected by negative results of earthquakes, but it can also be expressed that earthquakes and results are not possible to be destroyed.

Geographically 92 % of Türkiye (66% 1st and 2nd level) take place on one of the most active seismic belts (Mediterranean, Alpi and Himalaya belt) (Aksoy, 2024: 7). From past to present, too many magnitude and intensive earthquakes have been occurred in Türkiye. Within this frame, two major earthquakes occurred in 6th February 2023 with intensity of 7.8 and 7.6 and affected 10 provinces directly are one of the major disasters in Türkiye's history and it brought too many multi dimensioned and deep problems (strategic, national/regional, economical, social, cultural immigration etc) (Salik Ata, 2023: 60).

As well as the problems earthquakes cause in short term, they also cause deep psychological injuries in society; trauma the individuals face complicates the social improvement and reconstruction processes in long term (Nakajima, 2012: 150). Therefore, earthquakes are not only physical disasters but also complicated nature phenomena that change lives radically by social and psychologic effects. Because these reasons, managing post earthquake processes effectively has a significant importance for increasing endurance of societies and being ready for the future disasters

2. RELATION OF STRATEGIC PERSPECTIVE AND EARTHQUAKE

Reality of earthquake is one of the most important subjects for the organizations at every stage as before-during and after. Large and middle scale earthquakes cause long term and high degree of economical, social and psychological effects besides destruction (Say and Doğan, 2023: 91). In short term workplaces break down/ damage, moral and motivation collapse but in long term job losses appear, financial facilities are directed to repair the damages of earthquake, businesses go into financial difficulties, employees may have psychological problems as well as physical problems (So and Plat 2014). In this context, it can be remarked that developing strategic perspectives during post earthquake processes has a critical importance for organizations (businesses, NGOs, State Institutions and Organizations etc.) to reduce the effects of these kind of disasters.

Organizations, have to be prepared for earthquakes that can be barriers against maintaining well conditions and existences in the future, enforcing weaknesses with a strategic perspective. Strategic thought will be able to bring organizations the ability of flexibility and adaptation against emergent and improvided conditions. Therefore, the organizations can be affected by the effects of these disasters minimally and may recover rapidly (Salik Ata, 2023:63).

Earthquakes necessitate organizations to interrogate not only the physical substructure of businesses but also human resources, customer relations, security protocol and environment management strategies (So and Plat 2014). Risk management which is one of the main factors plays a critical part in post earthquake processes (Tetik and Öner, 2023: 84). Organizations, with strategic perspective should prepare risk analyses about earthquakes within the frame of precautionary approach and prepare scenario. They have to focus on leadership and visioner perspective in post earthquake processes. Putting up a strong leadership will increase employees' motivation and more effective approaches will be practised in crisis management (Ağaç, 2022: 43). Proper strategic leadership approaches of administrators will reinforce employees' confidence and increase solidarity, survival value of tendencies can be expressed here (Genç, 2009: 8).

A shared organizational culture will play a significant role for forming strategic perspective during post earthquake processes. In this context, a strong organizational culture can be remarked to direct values, beliefs and objectives of the organization (Erdem and Dikici, 2009: 206). Concordantly, sensibility of organizational culture towards environmental factors, health and security is essential in post earthquake processes. Organizations may organise training programs and create secure medium to prepare employees for these kind of disasters.

Participation and human resources management are important factors of strategic perspective as it is defined in previous explanations. While employees' participation to the processes increases endurance of organizations, it will also gain the ability of acting effectively during and after the seismic crisis. Human resources are the most important existences of organizations in before and post earthquake processes, therefore, talents and motivation of employees will play a critical role in seismic crisis management (Hofstede, 1984: 105).

Considering the explanations so far, it can be deduced that having a strategic perspective against treats caused by natural disasters like earthquakes, will not only provide organizations to maintain but also will help them to get prepared against future uncertainties.

At this point,it can be remarked that emphasising on strategic perspective in terms of businesses has a critical importance not only during the crisis but also achieving long-term sustainability objectives (Tetik and Albulut ,2023:101).

3. RESEARCH

3.1. Purpose of the Research

The main purpose of this research is to determine the perceptions of administrators in businesses towards basic strategic perspectives in post earthquake processes. In organizational context, profit-oriented business structuring is preferred. Within this scope, administrators opinions who work in the businesses around regions faced the earthquake processes personally within the frame of 6th February 2023 earthquakes, have been taken .

3.2. Data Collecting Tools

The survey form used in the research is formed in three main parts. In the first part socio-demographic variables of the research like age, gender, educational level, position (administrator, other), vocational experience duration and the sector they work in take place. In the second part, the questions “What is the reflection level of strategic perspective in post earthquake processes?”, “What is the reflection level of strategic perspective on senior management activities?” “What is the reflection level of strategic perspective on operational (on the basis of department) activities have been asked to determine the administrators’ opinions towards post earthquake processes. In the third part, 11 propositions that are predicted to be important for the strategic perspective in the post-earthquake process for strategic perspective have been included as future oriented. For statistical evaluations 5 Likert scale is used. Within the scope of the scale weight value is given as strongly disagree 1, disagree 2 medium 3, agree 4, strongly agree 5

3.3. Collecting and Analysis of Data

The survey was applied within the frame of 27 managers in 27 businesses in various organizations located in 6th February 2023 earthquake regions in Türkiye between March 2024 and July 2024. In the research factor analysis one sample t test and correlation analysis have been included. Statistics have been practised with SPSS and the data obtained interpreted in the light of literature.

3.4. Main Hypotheses of the Research

Main hypotheses of the research are as follows:

H₁: In businesses around earthquake regions..... factor is perceived as important in post earthquake processes within the scope of strategic perspective (f1: Analysis, scenario, purpose and objective, customer, shareholder, competition, f2: Leadership and vision, f3: Corporate culture, environment, health and security, preparation for the disasters, f4: Participation and human resources)

4. FINDINGS

4.1. Findings towards Socio-Demographic Variables

Age average of the participants (n=27) is (min – max= 24-50) and standard deviation is $37,1 \pm 6,74$. For female participants (n=11, %40,7) it is $36,7 \pm 6,40$ and for male participants (n=16, %59,3) it is $37,4 \pm 7,16$. For educational distribution; licence %77,8 (n=21) and postgraduate %22,2 (n=6). Participant are administrator positioned.

Distribution for experience duration is determined as; 1-9 years experience %29,6 (n=8), 10 years and over experience %70,4 (n=19). The sectors that managers remarked as open-ended are like production %11,1 (n=3), health %3,7 (n=1), chemistry %22,2 (n=6), textile %29,6 (n=8), food %25,9 (n=7), tourism %6,1 (n=2)

4.2. Strategic Perspective Findings in Post Earthquake Processes

Within the frame of answers for the question “What is the importance level of strategic perspective in post earthquake processes?” it is determined that great majority of participants (%74,1) care at “high and very high level”. Interestingly, considerable amount of the ones perceive as “medium and very low” are about one quarter (%25,9) (Table1).

Table 1. Importance level of Strategic Perspective in Post Earthquake Processes

Level	N	%
Very low	2	7,4
Medium	5	18,5
High	14	51,9
Very High	6	22,2
Total	27	100,0

For the question “What is the reflection level of strategic perception on senior management activities in post earthquake processes?”, “high and very high” is %63 (n=17) “medium, low, very low, ” is %37 (n=10) (Table 2). Moreover, although it is remarked to be considered at high level in table1, middle level is thought to be meaningful.

Table 2. Reflection Levels of Strategic Perspective on Senior Management

Level	N	%
Very low	1	3,7
Low	1	3,7
Medium	8	29,6
High	14	51,9
Very high	3	11,1
Total	27	100,0

For the question “What is the reflection level of strategic perception on operational (on the basis of department) activities in post earthquake processes?”, “high and very high is ” %59,2 (n=16) and “medium, low, very low is” %40,8 (n=11) (Table 3)

Within the context of operational activities, occurring “low and very low” perception more than table 2 can also be commended as meaningful.

Table 3. Reflection Level of Strategic Perspective on Operational Activities in Post Earthquake Processes

Level	n	%
Very low	1	3,7
Low	3	11,1
Medium	7	25,9
High	12	44,4
Very High	4	14,8
Total	27	100,0

4.3. Validity and Reliability of Measurement Tool

Principal components analysis is applied within the scope of factor analysis for the propositions predicted as important for future oriented strategic perspective in post earthquake process take place in the third part. Kaiser-Meyer-Olkin = 0,758 and Bartlett test of sphericity result revealed properly ($\chi^2 = 316,806$, Sd=55, p=0,000). Diagonal values of anti-image correlation matrix is between 0,813 - 0,716. In the light of these findings practising factor analysis is determined to be proper. Total variance explained by four consisted factors is %71,766. Total variance is clarified by the first factor as %22,934, by the second factor as %17,440, by the third factor as %17,389 and by the fourth factor as %14,002 level. Cronbach Alfa value of four factor structure is 0,891. Within this frame, internal consistency is provided. According to this result, it is presented that the factors pointed by the propositions in the survey explain the subject at a high level reliability (Table 4). Item average is 3,485 and average variance is 1,401. Occurred four factors are named as follows accord with the propositions they include (f1: Analysis, scenario, purpose and objective, customer, shareholder, competition, f2: Leadership and vision, f3: Corporate culture, environment, health and security, preparation for the disasters, f4: Participation and human resources)

Table 4. Validity and Reliability Towards Propositions

... is important in post earthquake process future orientedly	Factor				Cronbach Alfa	
	1	2	3	4	General=,89	1
Updating strategic analyses (SWOT, risk, fşnance, stakeholder etc) within the possible scenarios frame	,837	-,199	,172	,289	,843	,849
Predicting and configuration of the future in relations with the scope of customer, shareholder and competition	,823	,384	,003	-,037	,820	

Forming strategic aims and objectives in a future positioned structure	,723	,083	-,103	,051	,841	
Exhibiting a faithful and reliable future oriented leadership	,028	,915	,222	-,013	-	,797
Integrating the visions of management extending from past to future	,348	,590	-,214	,382	-	
Legal programmed tendencies about occupational health and safety and environmental courses	-,053	-,151	,753	,163	,795	,813
Exhibiting environmental (far, external, market, internal) and future oriented approaches to identify the strategies	-,121	,554	,680	,134	,763	
Preparation for natural (earthquake, flood etc) and unnatural (by human) disasters	,369	,153	,643	-,194	,734	
Ripening corporate culture future orientedly	-,045	,183	,554	-,408	,798	
Participate the decision making and applying processes as much as possible	,087	,269	-,024	,842	-	,716
Turning to future with human resources and behavioural activities creating perception awareness	,581	-,285	,167	,591	-	

4.4. Findings Towards Factors

When the emergent factors are tested by Shapiro-Wilk Normality Test to check whether they are proper for normal distribution to practise parametric tests, it has been deduced that all factors are proper for normal distribution, therefore, no problems will be faced to practice advancing parametric tests (Table 5).

Table 5. Shapiro-Wilk Test for Normality

Factor	Statistic	df	P
Analysis, scenario, purpose and objective, customer, shareholder, competition (f1)	,936	27	,096
Leadership and vision (f2)	,935	27	,090
Corporate culture, environment, health and safety, preparation for disasters (f3)	,931	27	,081
Participation and human resources (f4)	,926	27	,055

Within the scope of research, H₁ hypothesis (in the scope of strategic perspective..... factor is perceived as important in businesses around earthquake regions) has been accepted for the factors “Corporate culture, environment, health and safety, preparation for disasters (f3)” and “Participation and human resources (f4)” (Table 6). In other words, participants focused on the subjects like corporate culture, environment, safety, preparation for disasters towards strategic perspective in post earthquake processes. Within this frame it can be said that human

resources are primarily important and human resources potential has to be prompted participantly. But it does not mean that “Leadership and vision” and Analysis, scenario, purpose and objective, customer, shareholder, competition” are insignificant. On the contrary, these factors should have been included in the application sufficiently due to strategic perspective but because of the imbalanced process “corporate culture, environment, health and safety, preparation for disasters, participation and human resources” are determined as major subjects (Table 6).

Table 6. One Sample t Test within the scope of Factors

Factor	n	$\bar{x} \pm s$	Test Value = 3	
			t	P
Analysis, scenario, purpose and objective, customer, shareholder, competition (f1)	27	3,3±1,0	1,770	,088
Leadership and vision (f2)	27	3,3±1,1	1,473	,153
Corporate culture, environment, health and safety, preparation for disasters (f3)	27	3,6±,74	4,846	,000
Participation and human resources (f4)	27	3,4±,99	2,324	,028

5.CONCLUSION

Aftermath of 6th February 2023 Kahramanmaraş earthquakes, this research aimed at evaluating administrators’ perceptions who work in businesses located in earthquake region towards strategic perspective in post earthquake processes intends to reveal what kind of strategic approach the post disaster organizations adopt. Significance of organizations’ strategic thought and management abilities against unexpected natural disasters in a geography with high earthquake risk like Türkiye is revealed once again. Research findings show that a great majority of the administrators comprehend the significance of strategic management and planning but this comprehension reflect on neither managerial nor organizational practices satiablely.

Among strategic perspective components especially “Corporate culture, environment, health and safety, preparation for disasters participation and human resources” factors have been perceived as significant by administrators. These factors have been expressed to be critical for the organizations during crisis periods to get flexibility and to be afloat. In the research it is remarked that having a strong corporate culture in post earthquake processes increases employees’ motivation and endurance; preparations towards environment and safety measures are determinant for both protecting human resources and sustainability of operational activities.

While 63% of the administrators remark that reflection of strategic perspective on management activities occur at high and very high level, 37% of them express insufficiency of the reflection. This condition shows that strategic perspective has to be developed more and

integrated in whole grades effectively at implementation stage. It has been observed that this strategic thought remains at lower level and also it has been understood that businesses have difficulties with making and performing quick decisions during time of crisis.

According to factor analysis results the most important factors for the businesses to exhibit a successful strategic management in post earthquake processes are determined as “corporate culture, environment, health and safety, preparation for the disasters.” This result reveals the necessity of focusing not only on competitive strategies and leadership vision but also on some factors like human resources management and corporate culture. Prime importance of human resources during post earthquake processes and managing these sources with a participant approach have been found out to increase recovery capacity of the organization.

Consequentially, not only during crisis period but also for long-term sustainability strategic perspective is an essential management approach for the businesses that act in a country like Türkiye, which has a high earthquake risk. While being prepared for the unpredictable disasters as earthquakes give the businesses opportunity of making more effective and quick decisions in time of crisis, also provides to be more resistive against uncertainties they may face in the future. Therefore, organizations should apply strategic thought not only at managerial level but also in whole work processes and generalize it companywidely. The research expresses that strategic perspective plays a critical role not only in time of crisis but also for achieving the long-term success.

REFERENCES

- 1.AFAD, Afet ve Acil Durum Başkanlığı. Açıklamalı Afet Yönetimi Terimleri Sözlüğü, <https://www.afad.gov.tr/kitaplar>, (Erişim Tarihi 17.9.2024).
- 2.Ağaç, A. İ. (2022), Emrullah Efendi: Glokal Liderlik Bağlamında Çözümleme, Uluslararası Liderlik Çalışmaları Dergisi: Kuram ve Uygulama, 5(1), 40-52.
- 3.Akdemir, A., İşletmeciliğin Temel Bilgileri, Ekin Yay., Bursa, 2012.
- 4.Aksoy, Y. (2024). *Kahramanmaraş merkezli depremi yaşamış depremzede sağlık çalışanlarının travma sonrası stres bozukluğu düzeyi ve deprem stresi ile baş etme stratejilerinin değerlendirilmesi* (Tıpta Uzmanlık Tezi). Kahramanmaraş Sütçü İmam Üniversitesi, Tıp Fakültesi, Aile Hekimliği Anabilim Dalı, Kahramanmaraş.
- 5.Armstrong, M. (2006), Strategic Human Resource Management, Printed and Bound by Thomson-Shore, Inc, The United States.
- 6.Aşık M. Deprem Psikososyal Destek Çalışmalarında Görev Alan Psikolojik Danışman Ve Rehber Öğretmen Görüşleri. 2021
- 7.Bate, S.P., Strategies for Cultural Change, Antony Rowe Ltd., Great Britain,1995.
- 8.Bateman, T.S. ve Zeithaml, C.P., Management: Function and Strategy, Richard D. Irwin Inc., USA, 1990.
- 9.Byars, Lloyd L., Strategic Management, Harper and Row Publishers, New York, 1987.

- 10.**Dixit, Avinash K. Ve Barry J. Nalebuff, (2005), *Stratejik Düşünme: İş, Politika Ve Günlük Yaşamın Rekabetçi Yanı*, Nermin, Arık, (Çev.), Sabancı Üniversitesi Yayını, 3. Baskı, İstanbul.
- 11.**Erdem, O. & Dikici, M. (2009), *Liderlik Ve Kurum Kültürü Etkileşimi*, *Elektronik Sosyal Bilimler Dergisi*, 8(29), 198-213.
- 12.**Ersoy Y. ve Tehci A. (2020), *Lojistik Pazarlama: Veri Zarflama Analizi İle Lojistik Hizmetler Alanında Faaliyet Gösteren İşletmelerde Performans Değerlendirmesi*. *The Journal of International Scientific Researches*, 5(1), 1-9.
- 13.**Fareo, D. O. ve Jajua, M. A. (2018), *Conflict Management Strategies in Ondo State Tertiary Institutions*, *European Scientific Journal* February 14(4), 315-328.
- 14.**Freeman, R. E., Harrison, J.S., Wicks, A.C., Parmar, B. de C., Simone, *Stakeholder Theory: The State of the Art*, Cambridge University Press, New York, 2010.
- 15.**Frooman, J. (1999), *Stakeholder Influence Strategies*, *Academy of Management Review*, 24(2), 191-205.
- Genç, F. N. (2009), *Kriz Yönetimi ve Kamu Yönetiminde Uygulanabilirliği*. *Verimlilik Dergisi*, 4), 7-22.
- 16.**Greve, H. R. (2021), *The Organizational View Of Strategic Management*, In book: *Strategic Management*, 43-60.
- 17.**Hofstede, Geert, (1984), *Culture's Consequences: International Differences in Work Related Values*, Sage Publications, Newburg Park.
- 18.**Rakesh, D., Muhammed, M.G., Kumara, M. N.V. Abhilash, P., *Human Resource Management*, Archers & Elevators Publishing House, India, 2021.
- 19.**Ireland, R.D. ve Hitt, M.A. (2005), *Achieving and Maintaining Strategic Competitiveness in the 21st. Century: The Role of Strategic Leadership*. *Academy of Management Executive*, 19(4), 63-74.
- 20.**Jurukovski, D. (1997), *Earthquake Consequences and Measures for Reduction of Seismic Risk*, *Renal Failure*, 19(5), 621-632.
- 21.**Karabulak, E. (2009), *KOBİ'lerde Stratejik Bakış Açısından Rasyolar Yöntemiyle Finansal Öngörü ve Bir İmalat İşletmesinde Uygulama (Yüksek Lisans Tezi)*. Dumlupınar Üniversitesi, Kütahya.
- 22.**McDaniels, T. ve Small, M.J., *Risk Analysis and Society*, Cambridge University Press, UK, 2004.
- 23.**Mintzberg, H. ve Waters, A. J. (1985), *Of Strategies, Deliberate and Emergent*, *Strategic Management Journal*, 6, 257-272.
- 24.**Nahavandi, A. ve Malekzadeh, A.R., *Organizasyonel Behavior*, Ptentice-Hall Inc., USA, 1999.
- 25.**Nakajima, Ş. (2012). *Deprem ve sonrası psikolojisi*. *Okmeydanı Tıp Dergisi*, 28(Ek sayı 2), 150-155.
- 26.**Nukic, I.S. ve Matotek, J. (2014), *Importance and Trends of Organizational Culture in Construction in Eastern Croatia*, *Econwiews*, 27(1), 25-20.

- 27.Özgür, H., (2004), Kamu Örgütlerinde Stratejik Yönetim, Nobel Kitabevi, Ankara.
- 28.Özmutaf, N.M., Çağdaş Yönetici Nitelikleri ve Yönetimsel Konular, Detay Yay., Ankara, 2019.
- 29.Palmer, D. ve Kaplan, S., A Framework for Strategic Innovation, InnovationPoint LLC, 2015.
- 30.Porter, M. E., Competitive Strategy: Techniques for Analyzing Industries and Competitors, The Free Press, USA, 1980.
- 31.Porter, M. E., “Strateji Nedir?”, Strateji, Çev.: Melis İnan, Optimist Yay., İstanbul, 2011.
- 32.Rolková, M. ve Viera, F., The Features of Participative Management Style, 2nd Global Conference On Business, Economics, Management And Tourism, 30-31 October 2014, Prague, Czech Republic, Published by Elsevier B.V., 2015.
- 33.Salik Ata, N. (2023). Kahramanmaraş Merkezli 6 Şubat Depremlerinin Kriz Yönetimi Bağlamında Değerlendirilmesi. Meriç Uluslararası Sosyal ve Stratejik Araştırmalar Dergisi, 7(Özel Sayı), 59-77.
- 34.Say, S. ve Doğan, M. (2023), Depremlerin Hisse Senedi Getirileri Üzerindeki Etkisi: 2023 Yılı Kahramanmaraş Depremi Örneği, Social Sciences Research Journal, 12 (1), 90-97.
- 35.Schultz, T. W. (1961), Investment in Human Capital. American Economic Review, 51, 1-17.
- 36.So, E. ve Platt, S. (2014)., Earthquakes And Their Socio-Economic Consequences, https://www.researchgate.net/profile/Stephen-Platt-6/publication/331131945_Earthquakes_and_their_Socio-Economic_Consequences/links/5f7d81a6299bf1b53e1325db/Earthquakes-and-their-Socio-Economic-Consequences.pdf, (Erişim Tarihi: 11.09.2024).
- 37.Tankovic, Ana C., Efining Strategy Using vision and Mission Statements of Croatian Organizations in Times of Crisis, The 6th International Conference “The Changing Economic Landscape: Issues, Implications and Policy Options”, May 30th - June 1st 2013
- 38.Tetik, N. & Öner, A. (2023). 6 Şubat 2023 Kahramanmaraş merkezli depremin bölgede yer alan KOBİler üzerindeki olası ekonomik ve finansal etkileri. Kahramanmaraş Merkezli Depremler Sonrası İçin Akademik Öneriler.Özgür Yayınları.
- 39.Tetik, N. & Albulut, İ. İ. (2023). 6 Şubat 2023’te yaşanan depremin ekonomik ve finansal etkileri: İhracat üzerinden bir inceleme. Kahramanmaraş Merkezli Depremler Sonrası İçin Akademik Öneriler. Özgür Yayınları.
- 40.TMMOB İMOAŞ, Rapor – 1 Afet Yönetimi Bilgi Kitapçığı, Hazırlayan: İMO Ankara Şubesi Afet Hazırlık Ve Müdahale Komisyonu, TMMOB İnşaat Mühendisleri Odası Ankara Şubesi Yay., https://imop.imo.org.tr/resimler/dosya_ekler/76bb2697ef75e44_ek.pdf, (Erişim Tarihi 20.09.2024).
- 41.Türkiye Büyük Millet Meclisi. (2023). *Kahramanmaraş merkezli depremlerin sonuçlarının tüm yönleriyle araştırılması, depreme dirençli yapı stokunun oluşturulması ve kentsel dönüşüm uygulamalarının etkinliğinin artırılması için alınması gereken tedbirlerin belirlenmesi amacıyla kurulan Meclis Araştırması Komisyonu Raporu* (27. Yasama Dönemi, Sıra Sayısı 449). Mayıs 2023.

**KOMBİ CİHAZININ YOĞUŞMA BÖLGESİNDEKİ YOĞUŞMA
KARAKTERİSTİĞİNİN SAYISAL YÖNTEMLERLE İNCELENMESİ**
NUMERICAL INVESTIGATION OF THE CONDENSATION CHARACTERISTICS IN
THE CONDENSATION REGION OF A COMBI BOILER UNIT

Ahmet Yakup CUMBUL

Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü, İzmir
Dokuz Eylül University, Engineering Faculty, Mechanical Engineering Department, Izmir

ORCID ID: 0000-0002-3553-9829

Dilek KUMLUTAŞ

Prof. Dr., Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü, İzmir
Prof. Dr., *Dokuz Eylül University, Engineering Faculty, Mechanical Engineering Department, Izmir*

ORCID ID: 0000-0002-0778-785X

Utku Alp YÜCEKAYA

Dr., Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü, İzmir
Dr., Dokuz Eylül University, Engineering Faculty, Mechanical Engineering Department, Izmir

ORCID ID: 0000-0003-0934-5593

Özgün ÖZER

Dr., Manchester Üniversitesi, Makine, Havacılık ve İnşaat Mühendisliği Bölümü, Manchester, UK
*Dr., Department of Mechanical, Aerospace and Civil Engineering, The University of Manchester, Manchester,
UK*

ORCID ID: 0000-0003-4130-2323

ÖZET

Günlük yaşamımızda aşmamız gereken en önemli zorluklardan birisi iklim üzerindeki negatif etkilerdir. Bu etkilere sebep olan başlıca unsurlardan biri gaz emisyonlarıdır. Bu emisyonlar endüstriyel ihtiyaçlardan kaynaklanabileceği gibi günlük yaşamımızdaki ısınma ve sıcak su ihtiyacımızdan da kaynaklanabilmektedir. Bu ihtiyaçlarımızı karşılamak üzere kombiler yaygın olarak tercih edilmektedir. Yanma sonucu açığa çıkan ısıyı kullanma prensibi ile çalışan kombi cihazları, atık gaz emisyonları ile çevre kirliliğine negatif etki etmektedir. Bu etkileri azaltmak için kombi cihazlarının enerji verimliliğini artırmaya yönelik çalışmalar ön plana çıkmaktadır. Bu kapsamda yanma işlemi sonucu oluşan gazların yoğunlaşmasından dolayı açığa çıkan gizli ısının kullanılması ile yoğunlaşmalı kombilerin tasarımları önem kazanmıştır. Bu çalışmada, enerji verimliliğini artırmak amacıyla kombilerin yoğunlaşma karakteristiği sayısal yöntemlerle incelenmiştir. Literatürde yer alan deneysel çalışmalar ile elde edilen baca gazı çıkış sıcaklığı, eşanjör yüzey sıcaklıkları ve atık gaz kompozisyonu çalışma kapsamında

sınır koşulu olarak tanımlanmıştır. Çalışma kapsamında gerçekleştirilen sayısal çalışmalar ile su buharının yoğuşma karakteristikleri ve yoğuşma oranları elde edilmiştir. Bu sonuçlar, yoğuşmanın gerçekleştiği bölgeleri belirleyerek yoğuşma sürecinin optimizasyonu için önemli bilgiler sağlamaktadır. Yoğuşmanın az olduğu bölgelerin tespiti ile, kombi cihazlarında kullanılan eşanjör tasarımları için veriler sağlanmıştır. Ek olarak yoğuşma bölgesinde oluşan suyun konum ve yoğunluğunun sayısal olarak elde edilmesi, kombilerin yoğuşma performansını ve enerji verimliliğini artırmak için imkân yaratmaktadır.

Anahtar Kelimeler: Çok fazlı akış, yoğuşma analizi, yoğuşmalı kombi, enerji verimliliği, sayısal analiz.

ABSTRACT

The negative impact on the climate is one of the most pressing challenges we encounter in our daily lives, largely due to gas emissions. These emissions result not only from industrial activities but also from our everyday need for heating and hot water, for which boilers are commonly used. Operating on the principle of harnessing heat from combustion, boiler systems contribute to environmental pollution through waste gas emissions. Efforts to enhance the energy efficiency of boiler systems have gained prominence in addressing these challenges. In this context, the design of condensing boilers, which capture the latent heat released during gas condensation, has become increasingly important. This study conducts a numerical investigation into the condensation characteristics of boilers to improve energy efficiency. By utilizing boundary conditions derived from experimental studies in literature, such as flue gas exit temperature, heat exchanger surface temperatures, and exhaust gas composition, the numerical analyses offer insights into the condensation characteristics and condensation rates of water. These findings provide valuable information for optimizing the condensation process by identifying areas where condensation occurs and determining regions with low condensation. Additionally, the numerical determination of the location and density of water in the condensation zone presents opportunities for enhancing the condensation performance and energy efficiency of boilers.

Keywords: Multiphase flow, condensation analysis, condensing boiler, energy efficiency, numerical analysis.

**İSG UZMANI İLE DAİMİ NEZARETÇİNİN GÖREV ÇAKIŞMASININ
VARLIĞINDA NEZARETÇİYLE İSG UZMANININ MADENLERDE VERİMLİ
ÇALIŞABİLMESİNİN SAĞLANABİLİRLİĞİ MÜMKÜN MÜ?**

IS IT POSSIBLE TO ENSURE THAT THE PERMANENT SUPERVISOR AND THE OHS
EXPERT CAN WORK EFFECTIVELY IN THE MINES IN THE EXISTENCE OF A
CONFLICT OF DUTIES BETWEEN THE OHS EXPERT AND THE SUPERVISOR?

Taşkın Deniz YILDIZ

Doç. Dr., Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi, Maden Mühendisliği Bölümü
Assoc. Prof. Dr., Adana Alparslan Türkeş Science and Technology University, Department of Mining
Engineering

ORCID ID: 0000-0003-4043-2257

Murat MARAL

Maden Yüksek Mühendisi, İstanbul Teknik Üniversitesi, Maden Mühendisliği Bölümü
MSc., Istanbul Technical University, Department of Mining Engineering

ORCID ID: 0000-0002-4066-419X

ÖZET

Daimî nezaretçi, Enerji ve Tabii Kaynaklar Bakanlığı'na bağlı Maden ve Petrol İşleri Genel Müdürlüğü (MAPEG) tarafından, iş güvenliği (İSG) uzmanı ise Çalışma ve Sosyal Güvelik Bakanlığı tarafından görevlendirilmekte ve görevlerinin takibi bu kurumlar tarafından yapılmaktadır. Mevzuata göre daimî nezaretçinin görevi özetle maden işletme projesine uygunluğun ve işletmede uygun üretimin sağlanmasının denetlenmesidir. İSG uzmanının görevi ise madenlerde İSG'nin sağlanmasıdır. Her iki uzman aynı saha içerisinde farklı açılardan madenlerin denetiminin sağlanmasına yardımcı olmaktadır. Bu da her iki uzmanın görevlerinde, yetkilerinde ve sorumluluklarında çakışmaları beraberinde getirmektedir. Bu görev çakışmaları maden kaza sorumluluğunda da önem arz etmekte ve yargısal incelemelerde hem nezaretçi defteri hem de İSG uzmanı defteri dikkate alınmaktadır. Ancak, incelemelerde bu iki çalışanın görevlerinin net olarak ayrımının yapılamadığı ortaya çıkmaktadır. Belirtildiği üzere Maden Yönetmeliği'nde tek bir madde ile, madenlerin işletme projesine uygunluğunun denetleneceği belirtilmesine rağmen maden sahalarının nasıl denetleneceği ile ilgili bir ayrıntı mevzuatta bulunmamaktadır. Daimî nezaretçinin aynı zamanda İSG uzmanı olması zorunluluğunun bulunmaması nedeniyle bu durum oluşabilecek bir boşluk yaratmaktadır. Bu görev çakışmaları ve oluşan boşluk dikkate alınarak, bu çalışmada, daimî nezaretçinin genel görevleri içerisinde sorumluluklarının İSG uzmanlığı görevleri ile kesiştiği hususlarda nelere dikkat edilmesi gerektiği belirtilmiştir. Ayrıca, bu sorumlulukların denetime ve verimli madencilğe hizmet edebilecek doğrultuda hangi hususlara dikkat edilmesi gerektiği irdelenmiştir. Çalışmanın ana amacı, daimî nezaretçi ile İSG uzmanının görev çakışmalarının maden iç ve dış denetimindeki olumsuz etkilerinin

azaltılması, bu denetimlerin kolaylaştırılması ve verimli hale getirilmesidir. Dolayısıyla bu çalışmada her iki çalışanın görev çakışması dikkate alınarak bu çalışanların nasıl birlikte verimli çalışabileceğine dikkat çekilmesi hedeflenmiştir.

Anahtar Kelimeler: Nezaretçilik, İş güvenliği, İş güvenliği kültürü, Madenlerde İSG, Maden denetimi, Madencilik.

ABSTRACT

The permanent supervisor is appointed by the Ministry of Energy and The General Directorate of Petroleum Affairs (MAPEG) and the occupational health and safety (OHS) specialist is appointed by the Ministry of Labor and Social Security and their duties are monitored by these institutions. According to the legislation, the duty of the supervisor is to supervise compliance with the mining operating project and to ensure appropriate production in the operation. The duty of the OHS expert is to ensure OHS in mines. Both experts help to inspect the mines from different angles in the same field. This brings about conflicts in the duties, authorities, and responsibilities of both experts. These conflicts of duties are also important in mine accident liability and both the supervisor's book and the OHS expert book are considered in judicial investigations. However, the investigations reveal that the duties of these two experts cannot be clearly differentiated. As mentioned, although the Mining Regulation states in a single article that mines will be inspected for compliance with the operation project, there is no detail on how the mine sites will be inspected in the legislation. Since there is no obligation for the supervisor to be an OHS expert at the same time, this creates a gap. Considering these overlaps of duties and the resulting gap, this study states what should be considered when the responsibilities of the supervisor intersect with the OHS specialist duties in the general duties of the supervisor. In addition, the aspects of these responsibilities that can serve for supervision and efficient mining are analyzed. The main purpose of the study is to reduce the negative effects of the overlapping duties of the supervisor and OHS specialist on the internal and external audits of the mine and to facilitate and make these audits easier and more efficient. Therefore, this study aims to draw attention to how these employees can work together efficiently by considering the task overlap of both employees.

Keywords: Mine supervision, Occupational safety, Occupational safety culture, OHS in mines, Mine inspection, Mining.

**THE EFFECT OF ROASTING ON THE EXTRACTION OF RUBIDIUM FROM
BORON ORE WASTES INTO SOLUTION**

**BOR CEVHER ATIĞINDAN RUBİDYUMUN ÇÖZELTİYE ALINMASINDA
KAVURMANIN ETKİSİ**

Aysegul YUCEL

Dr. Öğr. Üyesi, İskenderun Teknik Üniversitesi, İskenderun Meslek Yüksekokulu, Çevre Koruma Teknolojileri
Bölümü, Hatay, Türkiye

*Asst. Prof., İskenderun Technical University, İskenderun Vocational School, Department of Environmental
Protection Technologies, Hatay, Türkiye*

ORCID ID: 0000-0001-7069-7518

Musa SARIKAYA

Prof. Dr. İnönü Üniversitesi, Mühendislik Fakültesi, Maden Mühendisliği Bölümü, Malatya, Türkiye
Prof. Dr. Inonu University, Faculty of Engineering, Department of Mining Engineering, Malatya, Türkiye

ORCID ID: 0000-0003-4942-4472

ÖZET

Optoelektronik ve kimyasal özelliklerinden dolayı rubidyumun kuantum hesaplamalarından biyomedikale, havacılıktan kuantum ısı motorlarına kadar kullanım alanlarında araştırmalar devam etmektedir. Rubidyum (Rb), periyodik tabloda alkali metaller grubunda yer alan yumuşak, gümüşü beyaz renkte bir elementtir. Rubidyum, kolayca iyonlaşmakta ve bu özelliği onu çeşitli bilimsel ve endüstriyel alanlarda kullanışlı hale getirmektedir.

Rubidyum yer kabuğunda bir mineral yatağına sahip olmamakla birlikte lityum rezervlerinin olduğu kaynaklarda mevcut olduğu bilinmektedir. Lityum kaynağı olarak bilinen bor cevher atıklarında da 135,9 ppm rubidyumun varlığından söz edilebilir [1]. Rubidyum genellikle lepidolit gibi lityum kaynaklarından kavurma ve su liçi yöntemlerinin kullanılarak lityum kazanımı esnasında yan ürün olarak elde edilmektedir [2 – 4].

Bu çalışmanın amacı bor cevher atığında bulunan rubidyumun çözeltiye alınmasında kavurma süresinin ve kavurma sıcaklığının etkisi araştırılmasıdır. Bor cevher atığının termal analizinde ilk kütle kaybı yaklaşık 200°C’de gerçekleşirken, 750°C’de yapısında bulunan karbonatlı bileşiklerin de uzaklaşması ile birlikte yaklaşık %30’luk bir kütle kaybının meydana geldiği görülmüştür [1]. Bu sonuca göre kavurma sıcaklığı 800°C, 850° ve 900°C olarak tercih edilmiştir. Ayrıca kavurma işlemi esnasında bir katkı maddesi ilave edilmemiş, sıcaklığın rubidyumun çözeltiye geçmesinde kavurma sıcaklığının etkisi incelenmiştir. Bir diğer çalışma parametresi ise kavurma süresidir. Bu parametrede ise her üç sıcaklıkla bor cevher atığı örnekleri 5 dk, 10 dk, 15 dk, 30 dk, 60 dk, 90 dk ve 120 dk muamele edilmiştir. Ardından tüm örnekler saf su içerisine ilave edilerek 24 saat su liçi prosesi gerçekleştirilmiştir. Süreç sonunda örnekler alınarak ICP-MS ölçümleri yapılarak rubidium konsantrasyonları

belirlenmiştir. Elde edilen sonuçlar kıyaslandığında ısıtma işlemine maruz kalan numuneler arasında en yüksek çözeltiye geçen rubidyum miktarı 2092,47 ppb ile 30 dakikada yapılan kalsinasyon işlemi olmuştur. 30 dakikadan daha az sürede kalsinasyona maruz bırakılan numunelerde rubidyum miktarının oldukça az olduğu görülmüştür. Sıcaklığın artması ile de aynı şekilde rubidyum miktarı azalmıştır.

Anahtar Kelimeler: Bor Cevher Atığı, Rubidyum, Kavurma, Su Liçi

ABSTRACT

Due to its optoelectronic and chemical properties, rubidium is being investigated for applications ranging from quantum computing to biomedicine, from aerospace to quantum heat engines. Rubidium (Rb) is a soft, silvery-white element in the group of alkali metals in the periodic table. Rubidium ionizes readily, making it useful in various scientific and industrial fields.

Although rubidium does not have a mineral deposit in the earth's crust, it is known to be present in sources with lithium reserves. It can also be noted that boron ore wastes, which are known as a source of lithium, contain 135.9 ppm of rubidium. [1]. Rubidium is obtained from lithium sources such as lepidolite as a by-product during lithium recovery using roasting and water leaching methods [2 - 4].

The aim of this study was to investigate the effect of roasting time and roasting temperature on the extraction of rubidium from boron ore wastes into solution. The findings of this study have significant implications for the fields of chemistry, materials science, and environmental science. Thermal analysis of boron ore waste showed that while the first mass loss occurred at approximately 200°C, a mass loss of approximately 30% occurred in the structure at 750°C with the removal of carbonated compounds in the structure [1]. According to this result, roasting temperatures of 800°C, 850° and 900°C were preferred. In addition, no additives were added during the roasting process, and the effect of roasting temperature on the extraction of rubidium into solution was examined. Another study parameter is the roasting time. In this parameter, boron ore waste samples were treated for 5 minutes, 10 minutes, 15 minutes, 30 minutes, 60 minutes, 90 minutes, and 120 minutes at each of the three temperatures. Then, all samples were added to pure water and water leaching process was carried out for 24 hours. At the end of the process, samples were taken and rubidium concentrations were determined by ICP-MS measurements. When the results obtained were compared, the highest amount of rubidium in solution among the samples exposed to heat treatment was the calcination process carried out in 30 minutes with 2092.47 ppb. In samples exposed to calcination for less than 30 minutes, it was observed that the amount of rubidium was quite low. The amount of rubidium decreased with increasing temperature.

Keywords: Boron Ore Waste, Rubidium, Roasting, Water Leaching

Teşekkür/Acknowledgments:

Tüm yazarlar, maddi desteklerinden dolayı TÜBİTAK 1002 – A Programına (Proje No: 122M910) teşekkür ederler.

All authors would like to thank TUBITAK 1002 - A Program (Project No: 122M910) for financial support.

Kaynaklar/References:

- [1] Yücel, A. (2022). Bor Cevher Atıklarından Lityum Titan Oksit Üretimini Araştırılması, (Doktora Tezi), İnönü Üniversitesi, Fen Bilimleri Enstitüsü, Malatya.
- [2] Yan, Q. X., Li, X. H., Wang, Z. X., Wang, J. X., Guo, H. J., Hu, Q. Y., Peng W.J ve Wu, X. F. (2012). “Extraction of lithium from lepidolite using chlorination roasting–water leaching process”, Transactions of Nonferrous Metals Society of China, 22(7): 1753-1759.
- [3] Vieceli, N., Nogueira, C. A., Pereira, M. F., Durão, F. O., Guimarães, C., & Margarido, F. (2017). Optimization of lithium extraction from lepidolite by roasting using sodium and calcium sulfates. Mineral Processing and Extractive Metallurgy Review, 38(1), 62-72.
- [4] Luong, V. T., Kang, D. J., An, J. W., Dao, D. A., Kim, M. J., & Tran, T. (2014). Iron sulphate roasting for extraction of lithium from lepidolite. Hydrometallurgy, 141, 8-16.

RANDOM VERTICAL SEISMIC VIBRATION OF LARGE SPAN ROOFING TRUSSES

Sergo Esadze

Prof., Georgian Technical University, Construction Faculty, Department of Civil and Industrial Engineering,
GEORGIA

ABSTRACT

The engineering analyses of high-magnitude earthquakes, especially in the epicenter, often show that the vertical component of seismic acceleration is one of the major factors causing damage/demolition of a building or its structural elements.

Almost in all standard methodology the vertical seismic load calculation is required for certain types of structures. Large-span roof structures, mainly with the spans of 24m and more, are the ones these structures. In these standards the mode of analysis and definitions of vertical seismic loads and effects caused by them, are based on the same approach and formulae which we use for defining horizontal seismic loads, changing only some of the coefficients and using correction factors for a reaction spectrum. Also do not take into account the special aspects of vertical oscillations - strains from static loads in supporting structures and as the resulting from that, the asymmetric oscillations of the examine structure towards to the horizontal axis.

In presented article above-mentioned factors are taken into account in determining of the dynamic characteristics of large span steel roofing trusses. The vertical seismic impact represented as multiplication of determined envelope function and stationary random process. This makes possible to consider article impacts with different values of the amplitude frequency and duration. Problem solved with using of the correlation theory.

Keywords: Random process; seismic loads, elastic support; fundamental mode.

INTRODUCTION

Vertical seismic acceleration of the foundation is one of the main factors having a destructive effect on buildings and structures located in the epicentral zone (J. Papazoglou, A.S. Elnashai. 1996) and especially for the large-span structures. Large-span steel roof trusses are widely used in single-story industrial buildings. In the case we are considering, when their spans varies within the range of 24 ... 40m, as noted above (see abstract), according to seismic resistance standards (ASCE 7 2013, Eurocod 8 2004, SP 14.13330 2013, Ordinance №71 2014), they must be calculated on action of the vertical seismic load.

When determining the seismic load, the dynamic characteristics of the considering structure has significant importance. For the solution of this problem and similar problems, the choice of the method determines by the degree of accuracy of the results obtained and the efficiency of the solution algorithm. Proceeding from the above mentioned, to determine the dynamic characteristics of the studing structure, we consider the beam with an equivalent rigidity (the method of equivalent rigidity beam) on elastic supports (taking into account the deformability of bearing) with concentrated masses (Figure 1). When solving this part of the general problem, we follow the solution algorithm given in (Esadze Pavliashvili 2023). There is also a list of works related to bringing the calculation model of the beam truss to an equivalent rigidity beam. Note also that to determine the vertical seismic load according to the normative methodology (Central Research Institute of Industrial Buildings) recommended taking into account the first vibration mode when $T \leq 0.5 \text{sec}$ and not less than three vibration modes when $T > 0.5 \text{sec}$.

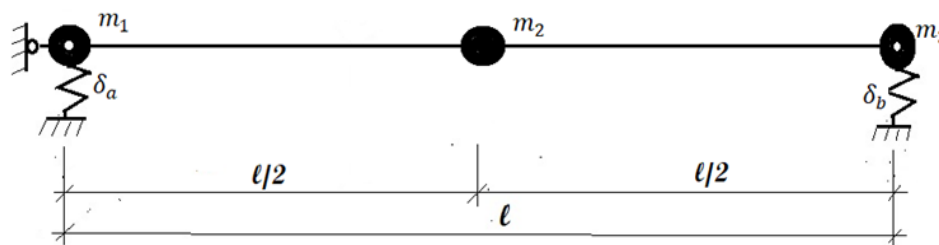


Figure 1. Beam with an equivalent rigidity on elastic supports

In contrast to the normative approach, we represent seismic impact as a random process. By its physical nature, seismic impact is a random phenomenon, so solving related problems on the basis of the theory of random processes is the closest to the physical nature of the phenomenon.

RESULTS AND DISCUSSION

Consider the effect on the structure of a random seismic impact when the latter is represented as a product of a deterministic envelope function and a stationary random process (Bolotin V.V.). For the vertical acceleration we have:

$$a(t) = A(t)\varphi(t) \quad (1)$$

where $A(t)$ is the envelope function and $\varphi(t)$ is a stationary random process. Depending on the problem, they can be expressed by different expressions. In this case, for the envelope function we take the expression:

$$A(t) = A_0 e^{-ct} \quad (2)$$

where A_0 is the maximum acceleration, and the parameter c characterizes the duration of the process. The function $\varphi(t)$ characterizes the frequency spectrum of the effect of vertical seismic acceleration. For the autocorrelation function we take the expression:

$$K_{\varphi\varphi}(\tau) = K_0 e^{-\alpha|\tau|} \cos \beta\tau \quad (3)$$

where α coefficient characterizes the degree of correlation; β characterizes the dominant frequency of influence, and the coefficient K_0 is determined from the condition:

$$\int_0^{\infty} \Phi(\omega) d\omega = 1 \quad (4)$$

where $\Phi(\omega)$ the spectral density corresponding to expression (3).

For this system (Figure 1) the oscillation equations using the direct method without considering damping can be written as follows (Kiselev V.A.):

$$m_i \ddot{y}_i + \sum_{k=1}^3 (k_{ik} y_k) = -m_i a(t) \quad (i = 1, 2, 3) \quad (5)$$

Writing the system (5) in matrix form

$$\bar{m}\ddot{\vec{y}} + \bar{K}\vec{y} = -\vec{a}(t) \quad (6)$$

and passing to normal coordinates (the condition of orthogonality of fundamental modes), instead of the system of differential equations (5) we obtain a system of partite differential equations (Kiselev V.A. Panovko J.G):

$$\ddot{q}_i + \omega_i^2 q_i = P_m(t) \quad (i, m = 1, 2, 3) \quad (7)$$

where

$$P_m(t) = - \left(\sum_{i=1}^3 a_i(t) u_{im} / \sum_{i=1}^3 m_i u_{im}^2 \right) \quad (8)$$

where u_{im} are the vibration mode coefficients. The impulse function corresponding to each equation (7) will be:

$$h_i(t) = \sin \omega_i t / \omega_i \quad (i = 1, 2, 3) \quad (9)$$

after we use the correlation theory to find the dispersion of displacement $Dq_i(t)$ ($i=1,2,3$) of the normal coordinates. Since they are similarly defined for all three, we give here the sequence for one coordinate q_1 . We use the expression

$$K_{q_1 q_1}(t, t) = \iint_{00}^{tt} h_i(t - \tau_1) h_i(t - \tau_2) A_1(\tau_1) A_1(\tau_2) K_{p_1 p_1}(\tau_1 - \tau_2) d\tau_1 d\tau_2 \quad (10)$$

and also

$$k_{p_1 p_1}(\tau) = \sigma_{p_1}^2 e^{-\alpha|\tau|} \cos \beta\tau \quad (11)$$

according to the formilas (8) for σ_{p_1} , we will have

$$\sigma_{p_1} = - \frac{u_{11} + u_{21} + u_{31}}{m_1 u_{11}^2 + m_2 u_{21}^2 + m_1 u_{31}^2} \sigma \quad (12)$$

Substituting all the corresponding expressions into equation (10) we obtain

$$k_{q_1 q_1}(t, t) = \iint_0^t \frac{\sin \omega_1(t - \tau_1)}{\omega_1} \cdot \frac{\sin \omega_1(t - \tau_2)}{\omega_1} \cdot A_0 e^{-\alpha \tau_1} \cdot A_0 e^{-\alpha \tau_2} \sigma_{p_1}^2 e^{-\alpha |\tau_1 - \tau_2|} \cdot \cos \beta(\tau_1 - \tau_2) d\tau_1 d\tau_2 \quad (13)$$

Integration of the expression (13) is not associated with fundamental difficulties. At the same time, for the case when $c \ll \omega$ (the case we are considering), it is possible (Luzhin O.V.) to restrict ourselves to a finite expression for the displacement root mean square deviation in the form of

$$\sigma_{p_1}(t) = \frac{A}{\omega_1} \cdot \frac{\sigma_{Q_1}}{\sqrt{2\omega_1 c}} \Psi_1(t) \quad (14)$$

where $\Psi = e^{-ct} \sqrt{Y_1(t)}$ and $Y_1(t) = \int_0^t e^{-(\alpha-c)\tau} \cos \beta \tau \cos \omega_1 \tau d\tau$

The maximum value of the normal coordinate is determined by the rule ``3σ``, and for the value of displacement of mass concentration points we will have

$$y_i = \sum_{k=1}^3 q_k u_{ik} \quad (i = 1, 2, 3) \quad (15)$$

Setting different groups of numerical values of parameters α (degree of correlation), β (frequency), c (duration), A_0 (amplitude) from the limits of their change characterizing random seismic impact and parameters m_i (mass), ω_i (frequency) characterizing the studied structures, following the algorithm described above, we obtain the desired values of displacement of characteristic points.

CONCLUSION

The article presents a methodology allowing on the basis of a calculation model (equivalent rigidity beam with concentrated masses) taking into account the influence of support of the considering structure on frequency characteristics and representation of seismic impact in the form of a random process, to determine displacements/strengths in characteristic points/elements of the structure with high reliability within the framework of correlation theory

REFERENCES

- ASCE 7: (2013) Minimum Design Loads for Buildings and other Structure p.408
- Bolotin V.V. (1979) Random Vibrations of Elastic Systems p.336
- Central Research Institute of Industrial Buildings (1977). Guidelines for the design of single-storey and multistory industrial buildings with a steel frame in seismic areas p.291
- Esadze S., Pavliashvili N. (2023) Vertical seismic load on a long-span steel truss Work of GTU 2(528) 63-67
- Eurocod 8: (2004) Design of structures for earthquake resistance – Part 1. p.231
- Kiselev V.A. (1980). Construction mechanics. Special course p.615
- Luzhin O.V. (1983) Probabilistic methods for analysis of structures p.121
- Ordinance №71 (2014) by Government of Georgia. Tbilisi. Technical regulation - Earthquake engineering p.161
- Panovko J.G. (1971) Introduction to the Theory of Mechanical Vibration p.240
- Papazoglou J, Elnashai A.S. (1996) Analytical and field evidence of the damaging effect of vertical earthquake ground motion. Earthquake Engineering and Structural Dynamics. 25. 1109 – 1137
- SP 14.13330 (2013) Construction in Seismic Regions SNIIP - II-7-81 2013 p. 126

**HYDROGEOCHEMICAL INVESTIGATION OF SHALLOW GROUNDWATER IN
PART ABUJA MUNICIPAL AREA COUNCIL, (AMAC) FCT, NIGERIA**

Abiodun Naeemdeen ADEJUMO

Department of Geology, School of Physical Science, Federal University of Technology Minna, Niger State.
Nigeria.

ABSTRACT

The study aims to evaluate the hydrogeochemical constituents of shallow groundwater in part of kurudu to establish the overall hydrogeochemical characteristics and its suitability for domestic use. Geologic and hydrologic mapping was conducted, representative samples were collected from fifty-five(55) hand dug wells, analysed, interpreted and correlated with known and approved standards. The geologic mapping shows that the area falls within the basement complex and consist of metamorphic rocks. Depth of well in the area ranges from 3m to 11.98m with an average depth of 6.59m. pH ranged from 5 to 10.9 with an average value of 6.5; EC 100 - 1190 $\mu\text{S/cm}$ with a mean value of 568.1 $\mu\text{S/cm}$; TDS 50 - 880 mg/L with a mean value of 275.5 mg/L. For cations, magnesium concentration value ranged between 13.6 mg/L to 25.9 mg/L with a mean value of 18.54 mg/L, potassium concentrations, ranged between 3.5 mg/L to 39.1 mg/L with mean concentration of 15.95 mg/L, sodium concentration in the groundwater ranged between 2.6 mg/L and 67.6 mg/L with an average value of 31.3 mg/L, calcium ranged from 12.8 mg/L to 44 mg/L with a mean value of 34.239 mg/L. For anions, sulphate concentrations in the groundwater ranged between 2 mg/L to 28 mg/L with mean value 11.3 mg/L, chloride ranged between 10 mg/L to 206 mg/L with average concentration of 85.1 mg/L, bicarbonate concentration in the groundwater ranged between 35 mg/L to 75 mg/L with mean value of 55.5 mg/L. the groundwater is slightly acidic to slightly alkaline. Magnesium, Chlorine and Nitrate concentration in sample 3 was higher than the standard concentration, this anomaly can be attributed to be from anthropogenic activities such as sewage water contamination, poor sanitary habits and agricultural activities.

**ASSESSMENT AND INCREASING OF ELECTRICITY AVAILABILITY OF
PHOTOVOLTAIC PANELS USING FUZZY LOGIC PRINCIPLES AND CONTROL**

Andrea Amalia MINDA

Dr., „Babeş Bolyai” of Cluj Napoca, Faculty of Engineering Reşiţa, ROMANIA

Olga Ioana AMARIEI

Dr., University „Babeş Bolyai” of Cluj Napoca, Faculty of Engineering Reşiţa, ROMANIA

Marius Savu LOLEA

Dr., University of Oradea, Faculty of Constructions, cadastre and architecture, ROMANIA

Emeric Remus SZABO

Eng., University of Oradea, Doctoral School of Engineering sciences, ROMANIA

ABSTRACT

This paper deals with a possibility of assessing the availability of electricity generated by photovoltaic panels but also a way of increasing it by acting in a certain direction using fuzzy logic. The factors that influence the efficiency of the photovoltaic panels of the climate type, the configuration of the environment or the design of the placement method are presented. Depending on the influencing factors of the availability of electricity, a fuzzy analysis system is designed, the input data being the factors of interest and the output data being the parameters that characterize the availability of energy. The authors have designed a flow diagram in which the ways of adjusting the parameters of the photovoltaic panels are reproduced so that the availability of electricity can be changed. As a solution to increase the availability, the authors propose the realization of a system of orientation of the photovoltaic panels towards the sun that can be controlled based on the principles of fuzzy logic and which is operated with a step-by-step electric motor. The proposed stepper tracker system is actuated on two axes. There are also systems for orientation on one axis or on three or more axes of movement. Other examples of such trackers are presented in the paper. The estimation of the availability of electricity is done with the use of the fuzzy tool-box existing in the Matlab software. A short theoretical description of fuzzy logic is presented at the beginning of the paper, followed by the application part. The analysis of the results and the effects produced on the availability of electrical energy in photovoltaic systems, together with the authors' conclusions regarding the treated problems, are presented at the end of the paper.

Keywords: Electricity availability, fuzzy logic, photovoltaic panels

**GEOHERMAL ENERGY EXPLOITATION AND APPLICATIONS IN THE AREA
OF BEIUȘ CITY, ROMANIA. PRESENT AND PERSPECTIVES**

Andrea Amalia MINDA

Dr., „Babeș Bolyai” of Cluj Napoca, Faculty of Engineering Reșița, ROMANIA

Olga Ioana AMARIEI

Dr., University „Babeș Bolyai” of Cluj Napoca, Faculty of Engineering Reșița, ROMANIA

Marius Savu LOLEA

Dr., University of Oradea, Faculty of Constructions, cadastre and architecture, ROMANIA

Emeric Remus SZABO

Eng., University of Oradea, Doctoral School of Engineering sciences, ROMANIA

ABSTRACT

The paper presents some aspects regarding the structure of the geothermal system in the Beiuș mouth, Romania and the neighboring territory. Geothermal energy in the form of hot water has a potential in the western and northwestern areas of Romania. The main cities in Bihor county have installations for the use of geothermal water both for space heating and for balneology. In some localities, geothermal water is used to heat greenhouses. On the other hand, there is no cascade use of geothermal water anywhere on the territory of the county. This form of use is necessary to increase the yield and financial profitability of a geothermal exploitation. The authors analyze the evolution of the geothermal system of the city of Beiuș and for future development propose several expansion solutions so as to reach a greater degree of capitalization for the benefit of the citizens of the area, who, in addition to the jobs generated by the operation of the geothermal installations, can increase their thermal comfort from homes and the reduction of heating costs because the price of thermal energy supplied in a centralized system based on geothermal water is the lowest in Romania. For the proposed solutions, the gains in yield and financial return on the entire analyzed geothermal system will be highlighted. At the end, are presented the conclusions resulting from the study and the authors' observations regarding the ability to integrate the proposed solutions into the structure of the existing geothermal system in terms of location, social and ecological implications.

Keywords: Geothermal energy, heating systems, balneology

**ASSESSMENT OF THE EFFECTS OF UNREGULATED SOLID WASTE DISPOSAL
ON URBAN FLOODING IN KADUNA METROPOLIS**

Aliyu Hassan

Department of Civil and Environmental Engineering, Air Force Institute of Technology, Nigerian Air Force,
Kaduna.

ABSTRACT

Urban flooding has become a recurrent issue in many cities, with indiscriminate solid waste disposal being a significant contributing factor. Flooding in developing countries is driven by multiple factors, such as uncontrolled population growth, insufficient preparedness, lack of political commitment, intense rainfall, construction on waterways, rising sea levels, soil moisture conditions, and dam operations, especially in border areas. This study investigates the impact of unregulated waste management practices on the incidence of flooding in Kaduna Metropolis. By analyzing waste disposal patterns and their relationship to drainage blockages and flood occurrences, the study aims to highlight the role of improper waste handling in exacerbating flood risks. Data was collected through field surveys, observations, and interviews with local residents and municipal officials. The findings reveal a strong correlation between indiscriminate waste dumping in drainage systems and increased flood frequency, particularly during the rainy season. Recommendations are made for improved waste management policies, public awareness campaigns, and infrastructural improvements to mitigate urban flooding risks in the area.

Keywords: Urban flooding, Waste management, Drainage blockage, Kaduna Metropolis, Flood risk, Environmental impact, Flood mitigation

**THE IMPACT OF EDUCATIONAL PROGRAMMES OF AKBC (RADIO) ON
STUDENT OF UYO CITY POLYTECHNIC. AKWA IBOM STATE, NIGERIA.**

EYO, Uwem-obong Joseph

Author, Department of Mass Communication, Heritage Polytechnic, Akwa Ibom State. Nigeria.

AGADA Raymond Chubiyo

Co-author 2, Department of Mass Communication, Benue State University Makurdi, Benue State. Nigeria.

AKOR, Ochefije Rita

Co-author 2, Department of Mass Communication, Nasarawa State University Keffi Nasarawa State. Nigeria.

ABSTRACT

This study investigated the impacts of educational programmes of AKBC(radio) on students of Uyo City polytechnic. AKBC radio has allotted 90.5 Fm radio station from which to broadcast educational programmes for the benefit of students and general public in Akwa Ibom State. The FM radio station delivered through Akwa Ibom Broadcast co-operation network, cater to learners seeking to gain knowledge in the areas of basic, primary higher and extension education. Radio programming covers various subject areas. It is anticipated that the opening AKBC airwaves will prove beneficial to the states general population, thus fostering the democratising principals of empowerment, advocacy, and community participation. This study examines the result of a survey conducted to obtain feed back from a representative sample of the AKBC network's projected audience, the survey focused on audience's perceived need for a radio channel dedicated exclusively to educational programming. It also provided an opportunity for respondents to suggest possible programme content and formats. Respondents in general, indicated that they looked towards the network AKBC to fulfill personal and educational goal by offering certified vocational courses coaching for entrance exams, updated information on careers, courses, etc. A total of 300 subjects were sampled randomly. Information was gathered using a twenty two item questionnaire and observation. Four research questions were formulate for the study. Simple percentages were used for analysis of data.

Keywords: Educational Programmes, Radio Programming, Media Campaign, Vocational Courses.

1. INTRODUCTION

The provision of information skills has gain popularity in the quest to empower Uyo City Polytechnic students with AKBC radio as a unique and effective tool.

Chapman et al(2003) reported that the growth of rural radio station reflects both the improvements in information technologies and the shifting of development paradigm towards a more participatory style of information and knowledge transfer. Kumar(2004) identified radio as an avenue for participatory communication and as a tool relevant in both education, economic, and social development. AKBC radio is a type of radio service that offers a model of radio broadcasting beyond commercial and public service. AKBC radio serves geographic communities and communities' interest. The content of broadcasting is largely popular and relevant to a local and specific audience but which may often be overlooked by commercial or mass media broadcasters.

The establishment of AKBC radio by Edict No.4 of April, 1998, was an important milestone in Akwa Ibom State's educational history.

through the use open and distance modalities, AKBC radio currently provides an array of educational options to those desiring to improve their qualifications and upgrade their academic skills. By design, AKBC radio establishes a direct bridge between education and vocation, thus extending the scope and reach of higher education to groups and individuals, many of whom reside in Akwa Ibom State.

AKBC's mandate is to provide higher educational opportunities to one and all, a principle that acts to democratize higher education in Akwa Ibom State. Its effort is to provide student support services and to deliver open and distance programmes.

AKBC has developed a diversified delivery system comprising of regional study centers. Reflecting differences in the needs of learners and didactic nature of programmes, different types of study centers have been developed. AKBC institutional network is further augmented through the use of such electronic media and computer network as: radio, television, cable T.V, audio/video cassettes, CD-ROMS, internet, interactive systems (one-way video/two-way-audio teleconferencing), and interactive radio counseling. In this educational mix, radio is an important medium that helps support students studying at a distance, as well as those generally interested in expanding their knowledge.

AKBC radio is a powerful mass medium used in education for disseminating information, imparting instruction and giving entertainment. It serves with equal ease in both developed and developing countries e.g Nigeria. It spreads information to a greater group of population (Uyo City Polytechnic students); thereby saving time, energy, money, and manpower in an effective way.

Radio is an essential mass medium that virtually every member of the society benefit from. kwuwumi (2009) asserts that Radio has radicalized the face of human communication and ultimately become a fixed in the daily lives of humans where by people are informed, taught, nurtured and reformed by way of relaxation. It is a simple and cheap medium readily available as a small means of communication in which the poorest students of Uyo City Polytechnic can have access to. It has a small transistor which can carry the message to any

place on the earth. Kwuewumi (2009) asserted that a world without radio will be like a garden without flowers and trees. AKBC radio speaks to an individual so also to millions at a time. Hence, any listener can think he broadcast is meant for him, whereas listened in group, all think the message is directed toward them. Each student takes the broadcast as very intimate to him. Due to its portability and reliability, accessibility; AKBC radio could found its place everywhere, whether it was a field, a school, a kitchen, or a study room. AKBC radio is a blind man's medium and is meant for ears only.

Egbuchulam (2002) asserts that radio has been a major communication tool for improving the quality of people's lives, bringing to their door step news, entertainment and education through its programmes, despite the world wide enchantment with the internet and web based learning, radio still retains the advantaged communities aspiring to overcome the barriers of illiteracy and physical distance in many countries. Educational radio has been employed within a wide variety of instructional design context. In some cases it is supported by the use of printed materials, by local discussion groups, and by regional study centers. It is sometimes designed so as to permit and encourage listener's reaction and comment. Indeed, in some cases, there is provision for the audience to raise questions and to receive feedback.

The reach and immediacy of AKBC radio provided educators with new potentiality powerful medium through which to support and modify education. While firmly affixed in an oral and aural realm, from the outset; the purpose of educational AKBC radio programmes has been to complement the existing curricula and strong reliance on written text within Western education systems of the twentieth century. Furthermore, AKBC educational radio set the stage for later educational technologies, providing a framework for the adoption and implementation of these technologies that has continued to date.

Prior to the development and widespread of television, radio was the first electronic mass medium.(Lewis,1992,p.26). With it's advent, radio allowed anyone who had one, to listen to news, or other informational broadcast without having to wait for the newspaper, or even listen to live entertainment without having to physically be there.

It has been observed that the application of modern information technologies to educational activities and services in Akwa Ibom State tertiary institutions seems inadequate, probably due to a variety of factors, including: Human factors, and the state of infrastructural development; the quality of instruction, hidden costs, misuse of technology, and the attitude of students and instructors.

Not a few students of Uyo City Polytechnic also believe that there is hardly much benefit that can be derived from the use of AKBC Educational Radio Programmes, thereby giving preferences for the television operations.

The importance of education can never be over emphasized. It is the Taproot of civilization and rural development. Development is achieved, when there is an appreciable level in basic human needs, including high literacy level. Bearing all these in mind, the main aim of this

study is to investigate on the major impacts of educational Programmes of AKBC radio on Uyo City Polytechnic students, based on accessibility, availability, acceptability, affordability, and adaptability, to the services rendered to the students; and to suggest ways of improvement in order to achieve education for all.

This study is guided by necessary bearing in mind, that the world is ever changing and developing. In the Western world, the use of computers to educate the population and give them wider knowledge is very much accessible. This makes them to be scientifically, technologically, educationally developed. This brings about the need for the public to be educated; those who were not, or are not opotuned to enroll into various institutions of learning, listens to AKBC Educational Radio Programmes and benefits from it's academic effort.

2. THE RADIO SERVICES OF AKBC

The radio service, christened, Voice of Promise, Radio Akwa Ibom FM stereo, was officially commissioned on July, 27, 1991, by the Military Governor of the state, Idongesit Nkanga (then a commander). It transmits in frequency modulation of 90.528MHZ. The signal is widely received loud and clear. The radio offer high quality programmes that cater for the needs and interest of their wide and varied audience. Indeed the programmes of Akbc radio have enjoined local, national, and international acclaim, culminating in the winning of prizes during 2004, 2006, and 2008 AFRICAST programmes competition. Today, AKBC Radio transmits 24hrs daily. Programmes of interest therefore have a strong hold on the listener that if there is power failure or unavailability of batteries, the listener's day seems incomplete. Radio for those who love it, is perhaps more than a friend, because the language of radio is many times soft and gentle, appealing, teaching and persuasive (Kuewumi, 2009).

The mission of AKBC Radio on impacting the students of Uyo City Polytechnic

The primary responsibility of the corporation is to provide information, entertainment, and educational services to the public. It strives at all times to render independent and imperial radio broadcasting services that give adequate expression to the culture, characteristics, and students of Akwa Ibom State. The radio also broadcast well researched programmes, documentaries, features, and commentaries; which sensitize and mobilize the students, and public to contribute towards the development of the society. Kuewumi (2009) citing McLeish (2005) referred to radio as a blind medium that paints pictures in the mind of the listener. A blind medium, but one which has capacity to stimulate the imagination such that as soon as a voice comes out of the loud speaker the listener attempts to visualize what he hears and to create in the mind's eye the owner of the voice. In essence, listeners many times detect and create scenarios just by hearing sounds, yet it is a blind medium.

Materials and Methods, Ethical Clearance

In fulfillment of the requirements of the nature of this study, ethical clearance was sought and obtained by the researcher from Akwa Ibom Broadcasting Corporation (AKBC), Akwa Ibom

State. The objectives of the study were explained to the school teachers and students at the time of sample collection. They were also briefed on the impact of educational programmes of AKBC radio, channel of transmission and related issues at the time. Prior to sample collection, informed consent was sought from the school directors.

To ensure a heterogeneous and evenly distributed sample for the study, a total of 300 respondents were selected. Using cluster sampling technique the researcher selected 5 units from each of the administration of Akwa Ibom Broadcasting Corporation (AKBC), (Marketing, Engineering, News, Finance, and Programmes); making a total of 15 sub-units. Twenty (20) respondents were randomly selected from each of the 15 sub-units, making a total of 100 respondents from each administration. Hence a total of 300 respondents were sampled altogether using simple random sampling technique. The researcher used both cluster sampling and simple random sampling technique in this study.

3. INSTRUMENTATION

The instruments used for the collection of data for this study were questionnaire and observation. The questionnaire consists of two sections. The first section (A) was designed to elicit information on the demographic data of the respondents. The second section (B) was designed to obtain response on the:

Radio services of AKBC. Organizational structures of AKBC radio station. Missions of AKBC radio on impacting the students of Uyo City Polytechnic. Students concern and attitude towards listening to AKBC radio educational programmes. Each questionnaire contained 22 items which demanded respondent's opinion.

The researcher also visited Akwa Ibom Broadcasting Corporation (AKBC) to observe the infrastructure available and the services rendered.

The questionnaire was subject to scrutiny of experts in the field of communication. The instrument was presented to my supervisor for content validation. The research instrument was validated by two lecturers in the department of Mass Communication who read and moderated the original version. Their suggestions and that of my supervisor formed the final draft of the instrument.

4. DISCUSSION AND CONCLUSION

A total of 300 copies of questionnaire were produced and personally administered by the researcher to the respondents by balloting. Guidelines for completing the questionnaire was given by the researcher to the respondents for clarification of issues not properly understood. Those who picked 'Yes' were allowed to complete the questionnaire, while those who picked 'No' were denied the opportunity. The subjects were given enough time to complete the questionnaire. On completion, the questionnaires were returned to the researcher on the spot and the total numbers administered were collected. This exercise went on for many days until the entire questionnaire were administered.

The main aim of this study was to determine and validate the likely impacts of AKBC radio education programmes specifically on Uyo City Polytechnic Students. This is done so as to get relevant information on how AKBC radio operates, and also to get government agencies aid and beef up their effort in providing facilities in order to promote AKBC Radio Educational programmes.

The subjects used for the study comprised of youths and adult ranging from 20-50 years, and above numbering 300, cutting across all shades of religious, educational, occupational and gender stratification.

Questionnaire and personal observation were instruments used for data collection. Data collected were analyzed and discussed accordingly on the basis of search questions generated.

Based on the result of the study, it was discovered that Uyo City Polytechnic students don't have interest in educational programmes of AKBC radio. Hence, AKBC radio should continue to play its role well by encouraging its listeners to keep faith. AKBC radio has really served as one of the communication channels in Akwa Ibom State that has encouraged students, target communities to participate in programme activities and to replicate skills acquired.

In conclusion, the terms of ownership community members feel they are part of the ownership because their suggestions or recommendations have been heeded to, by staff of the station. Therefore, it is my belief that if the recommendation in this study is strictly adhered to both AKBC radio staff, government and students of Uyo City Polytechnic, there will be great impartation on the society, if not abated and hence lead to the achievement of education for all students.

REFERENCES

- Academy for educational development(1979). Paraguay using radio for formal education in rural area. Academy news 2(2),4 Washington D.C., Clearing house on development communication.
- Bagley,W.C.,(1930). Radio in the schools. The elementary school journal,31 (4).
- Bianchi,W.,(2002). The Wisconsin school of the Air: Success story with implications. Educational technology and society 5 (1).
- Byram,M., and Kidd,R.,(1983). A hander on-approach to popularizing radio learning group campaigns convergence,16(4),14-22.
- Chaudhary, S.S.,(1996). Current Trends, methods and technologies in distance education for primary school Teachers. Working paper.Vancouver: commonwealth of learning.
- Coleman,W.F.,and Opoku,A.A.,(1968). Rural radio forum project in Ghana. In H.C.Abell,W.F.,Coleman and A.,A.,Opolu(Eds.). An development: Ghana,1964/1965,(pp.7-17).Paris:UNESCO.

- Couch,L.,(1997). Digital and analog communication systems. Upper saddle river, N.,J.,: prentice-hall. Retrieved march 31,2003.
- Cuban, Larry,1986. Teachers and machines. The classroom use of technology since 1920. New York and London: teachers college press.
- Dikshit,H.P.,(2002) preface to study:radio vision (multimedia through Digital Radio), in Sreedher Radio Vision:Multimedia through Digital Radio, UNESCO.
- Egbuchulam, (2002). Broadcasting: Challenges for the Private Media. Vanguard Newspaper.
- Fulder,D.,(1984).Learning on Air,media in education and development 7 (1),36-39.
- Galda,K.,(1984).Learning maths by radio,
- Glaserfeld, Ernst Von(1995). Radical constructivism. A way of knowing and learning.London:Falmer press.
- Goffman,E.,(1956): the presentation of self in everyday life. New York: Double day.
- Higgs,J.,and Mbithi,P.,(eds).1977). Learning and living: education for rural families in developing countries Rome:FAO.
- History of radio.(2009)October 21). In Wikipedia, the free encyclopedia retrieved October 23, 2009.
- History of Radio. (n.d). Retrieved from <http://www.historyofradiowiki.Org>
- Kuewumi, J.B. (2009). Radio: How it Impacts the Listener Personally. Babcock University Mass Communication Journal, 2(1),138-149.
- Look,D.C.,&Nemzek,C.L.,(1939). The effectiveness of teaching by radio. The journal of educational research,33 (2).
- Manovich,Lev (2001). The language of new media.Cambridge/MA:MIT press.
- Muhlamann de Masoner, L.Masoner,P.H.,and Bernal,H.,(1982). An experiment in radiophonic education:Accion cultural popular. Prospects 12(13)365-374.
- Neil,M.,(1981). Education for adults at a distance (a report of the open university tenth anniversary international conference). London;Kogan page.
- Nwaerandu,N.G.,(1994)educational radio: A tool for rural change retrieved October 17,2009.
- Nyirenda,J.E.,(1981) research in developing countries. Educational broadcasting international,14(3),101-104.
- Seidu Al-hassan, Alhassan Andani and Abdulai Abdul-Malik, “The Role of Community Radio in Livelihood Improvement: The Case of Simli Radio”, Field Actions Science Reports [Online], Vol. 5 | 2011, Online since 15 July 2011, connection on 21 September 2024. URL: <http://journals.openedition.org/factsreports/869>
- Shears,A.E.,(1984). Development of management course for the agriculture sector in Nigeria. Programmed learning and educational technology,21 (2);88-94.
- Sweeney,W.O., and Parlato,M.B.,(1982). Using radio:for primary health care. Washington,D.C.American public health association.
- Wainewicz,I.,(1972). Broadcasting for adult education, A guide book to worldwide experience Paris. UNESCO, population.

**EFFECTS OF POLYPROPYLENE AND POLYSTYRENE
MICROPLASTICS ON HEPG2 CELL LINE**

K.R.Padma

Assistant Professor, Department of Biotechnology, Sri Padmavati Mahila Visvavidyalayam (Women's University), Tirupati, AP. email id:

ORCID NO: 0000-0002-6783-3248

K.R.Don

Reader, Department of Oral Pathology and Microbiology, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research (BIHER) Bharath University, Chennai, Tamil Nadu, India.

ORCID NO: 0000-0003-3110-8076

ABSTRACT

Microplastics have garnered significant attention owing to their widespread and copious presence in our daily existence. They have been found in common household commodities like seafood, tap water, water bottles, sugar, salt, honey, and food items packaged in plastic. These microscopic particles can enter the body and go to internal organs like the liver and kidney, which can negatively impact cellular functions. Liver cells (Hep G2) were employed to investigate the possible impact of Polypropylene microplastics (PP-MPs) and Polystyrene microplastics (PS-MPs) on toxicity. When cells were exposed to PP-MPs and PS-MPs, there was a notable decrease in cellular proliferation and also in viability of HepG2 cell line as assessed by MTT assay. The acetone extract of PP-MPs (100µg/mL) shows that the highest effect on viability of cells compared to the other dilutions. This study provides fundamental insights into the co-toxicity of TPHP and PS micro/nanoplastics in HepG2 cells, which is crucial for validating the potential risk of combined toxicity in humans.

Keywords: Microplastics, Nanoplastics, HepG2, MTT assay, Household commodities.

UNIDENTIFIED AERIAL PHENOMENA. OBSERVATIONS OF SPACE EVENTS

Boris Zhilyaev

Main Astronomical Observatory, NAS of Ukraine, Kyiv, Ukraine.

Vladimir Petukhov

Main Astronomical Observatory, NAS of Ukraine, Kyiv, Ukraine.

ABSTRACT

NASA commissioned a research team to study Unidentified Aerial Phenomena (UAP), observations of events that cannot scientifically be identified as known natural phenomena. The Main Astronomical Observatory of NAS of Ukraine conducts an independent study of UAP also. For UAP observations, we used two meteor stations installed in Kyiv and in the Vinarivka village in the south of the Kyiv region. Two-side monitoring of the daytime sky led to the detection of three luminous objects at an altitude of 620, 1130 and 1174 km, moving at a speed of 256, 78 and 282 km/s. We have drawn a meaningful conclusion from observations of space UAPs. They appear and disappear suddenly, and are observed on a time interval in the subsecond range. At the same time, they demonstrate unprecedented high velocities and high-frequency brightness variability. The detection of these objects is an experimental fact. Estimates of their characteristics follow from observational data. The authors do not interpret these objects.

**EFFECT OF FARMERS SELECTED SOCIO-ECONOMIC FACTORS ON
INFORMATION AND COMMUNICATION TECHNOLOGIES UTILIZATION FOR
CASSAVA PRODUCTION IN CROSS RIVER STATE, NIGERIA**

Inyang, J. O.

National Biotechnology Research and Development Agency (NBRDA)

ABSTRACT

This study investigated the Effect of farmers selected socio-economic factors on Information and Communication Technologies utilization for cassava production in Cross River State, Nigeria. The study was designed to describe selected socio-economic characteristics of cassava farmers and to identify the types of ICTs used by the farmers. A multi-stage sampling procedure was used to sample 190 cassava farmers in the study area. Data obtained were analyzed using descriptive statistics. Results from the study revealed that more females (62.6%) were involved in cassava farming. A sizeable proportion (37.4%) of cassava farmers were between the age range of 31-40years. Most (90%) of the respondents had some form of formal education, 50.5% had between 1 and 10 years of cassava farming experience, and most (60%) of the respondents had contact with extension agents. The results also revealed that mobile/cell phone (93.2%), television (80.5%), radio (68.4%), social media (54.2%) and internet (53.2%) were the main types of ICTs frequently used by the farmers for cassava production. The study recommended that farmers be given opportunity through extension agents to learn skills needed on the use of ICT tools for better cassava production. Also, there is need for increase in extension visitation and contact with farmers to bridge knowledge gap on effective utilization of ICTs.

**HAZIRLIK SÜRELERİNİ DİKKATE ALAN HETEROJEN DRONE FİLOLU
DAĞITIM PROBLEMİNE YÖNELİK BİR DOĞRUSAL PROGRAMLAMA MODELİ**
A LINEAR PROGRAMMING MODEL FOR THE HETEROGENEOUS DRONE FLEET
DELIVERY PROBLEM CONSIDERING SETUP TIMES

Murat ŞAHİN

Manisa Celal Bayar Üniversitesi, Mühendislik ve Doğa Bilimleri Fakültesi, Endüstri Mühendisliği Anabilim
Dalı

*Manisa Celal Bayar University, Faculty of Engineering and Natural Sciences, Department of Industrial
Engineering*

ORCID ID: 0000-0003-3173-1749

ÖZET

Son yıllarda insansız hava araçları (dronlar) lojistik ve tedarik zincirlerinde önemli bir rol oynamaya başlamıştır. Özellikle kısa mesafelerde karayolu taşımacılığına kıyasla sundukları hız ve maliyet avantajları, dronların kullanımını arttırmıştır. Bu artış, dronların taşımacılık sektöründeki potansiyelini ve verimliliğini gözler önüne sermekte, dolayısıyla teslimat süreçlerinin daha etkin bir şekilde yönetilmesine olan ihtiyacı artırmaktadır. Bu bağlamda, dron taşımacılığının taşıma kapasiteleri, hızları, batarya ömürleri ve ağırlıkları gibi çeşitli özellikleri göz önüne alındığında, teslimat süreçlerini optimize etmek için birçok araştırma yapılmıştır. Çoğu çalışmada, toplam rota uzunluğunun veya maliyetin minimize edilmesi hedeflenmiştir. Ancak, maliyet avantajının yanı sıra müşteri memnuniyetini artırmak için zamanında teslimat yapmanın da önemi büyüktür. Bu çalışmada, dron taşımacılığı için bir doğrusal programlama modeli önerilmiştir. Modelin amacı, dronları en uygun teslimat rotalarını belirleyerek müşterilerin belirlediği zaman dilimlerinden toplam gecikmeyi minimize etmektir. Model, dronların taşıyacağı paketlerin yükleme sürelerini ve dronların özelliklerini dikkate alarak en iyi rotayı bulmayı hedefler. Modelin temel varsayımlarından biri, dronların batarya kapasitelerinin, taşıdıkları yüklerin ağırlığı ve havada kalma süreleri ile doğru orantılı olduğudur. Yani, daha ağır yükler taşıyan dronların daha uzun süre havada kalabilmesi için batarya kapasiteleri daha yüksek olmalıdır. Ayrıca, doğrusal programlama modelinde, dronların müşterilere uçuş sürelerinin yanı sıra, paketlerin yüklenmesi için gerekli hazırlık süreleri de dikkate alınmaktadır. Yapılan testler sonucunda, önerilen modelin küçük ölçekli örneklerde etkin olduğu, ancak büyük ölçekli örneklerde performansının düştüğü gözlemlenmiştir. Bu sonuçlar, modelin daha geniş ölçekli uygulamalarda iyileştirilmesi gerektiğini göstermektedir. Daha etkili pratik uygulamalar için, kapsamlı algoritmalar veya farklı optimizasyon yöntemleri gerekebilir.

Anahtar Kelimeler: Dron rotalama, matematiksel modelleme, dron teslimat problemi, doğrusal programlama, araç rotalama problemi

ABSTRACT

In recent years, unmanned aerial vehicles (drones) have begun to play a significant role in logistics and supply chains. Their advantages in speed and cost, especially over short distances compared to road transport, have led to an increased use of drones. This rise highlights the potential and efficiency of drones in the transportation sector, thereby increasing the need for more effective management of delivery processes. Given the various features of drone transport, such as payload capacities, speeds, battery life, and weights, many studies have been conducted to optimize delivery processes. Most of these studies aim to minimize the total route length or cost. However, in addition to cost advantages, timely delivery is crucial for enhancing customer satisfaction. This study proposes a linear programming model for drone transportation. The objective of the model is to guide drones to determine the most suitable delivery routes to minimize the total tardiness from the customers' specified time. The model aims to find the optimal route by considering the loading times of the packages to be carried by the drones and the characteristics of the drones themselves. One of the key assumptions of the model is that the battery capacities of drones are proportional to the weight of the loads they carry and their flight duration. In other words, drones carrying heavier loads must have higher battery capacities to stay air for longer periods. Additionally, the linear programming model takes into account not only the flight times of drones to customers but also the preparation times required for loading the packages. Tests have shown that the proposed model is effective in small-scale scenarios but exhibits decreased performance in larger-scale scenarios. These results indicate that the model needs to be improved for larger-scale applications. More effective practical implementations may require comprehensive algorithms or alternative optimization methods.

Keywords: Drone Routing, Mathematical Modeling, Drone Delivery Problem, Linear Programming, Vehicle Routing Problem

**AISI 304 PASLANMAZ ÇELİK MALZEMELERİN ROBOTİK FİBER LAZER
KAYNAĞI YÖNTEMIYLE BİRLEŞTİRİLMESİ**

JOINING AISI 304 STAINLESS STEEL MATERIALS BY ROBOTIC FIBER LASER
WELDING METHOD

Serkan ÖZŞAHİN

Bursa Uludağ Üniversitesi, Fen Bilimleri Enstitüsü, Makine Mühendisliği Bölümü
Bursa Uludağ University, Institute of Science and Technology, Department of Mechanical Engineering

ORCID ID: 0000-0001-9263-8148

Kadir ÇAVDAR

Prof., Dr., Bursa Uludağ Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü
Prof., Dr., Bursa Uludağ University, Engineering Faculty, Department of Mechanical Engineering

ORCID ID: 0000-0001-9126-0315

ÖZET

Bu bildirinin amacı, 1,0 mm kalınlığındaki paslanmaz çelik AISI 304 sacların alın bağlantılarının lazer kaynağının temel parametreleri olan lazer ışını gücü, kaynak hızı, odak çapı, çalışma mesafesi ve frekansın kaynak şekli ve bağlantı kalitesi üzerindeki etkisini analiz etmektir. Deney sırasında, AISI 304 paslanmaz çeliklerin alın bağlantı konfigürasyonunda kaynaklanması için 6 kW CW robotik fiber lazer kullanılmıştır. Lazer gücü, kaynak hızı ve odak mesafesi gibi çeşitli çalışma parametrelerinin etkisi ve bunların kaynak dikişi geometrisi ve mekanik özellikleri üzerindeki etkileşimleri incelenmiştir. Her deneme parametresi için 26 adet 50x50x1mm standart AISI 304 paslanmaz çelik plakaları alın kaynağı ile kaynaklanmıştır. Daha sonra mekanik özellikleri araştırmak için bu numunelere statik çekme testi uygulanmıştır. Sonuçlar, lazer gücü artırılıp diğer değerler sabit tutulduğunda lazer gücünün arttırılmasının maksimum kuvveti ve buna bağlı olarak kopma kuvvetini de arttırdığı görülmüştür. Lazer gücü artırılıp odak çapı 1,2 mm'den 2 mm'ye çıkarıldığında ve diğer değişkenler sabit alındığında 1100W ile aynı lazer gücünde odak çapı 2 mm olan numunede maksimum kuvvet 1,5 kat, kopma kuvvetinin ise 1,2 kat arttığı gözlenmiştir. Diğer değişkenler sabit tutularak lazer gücü artırılıp kaynak hızı 1 m/dk'dan 2 m/dk'ya çıkarıldığında maksimum kuvvet 1,1 kat, kopma kuvveti ise 1,03 kat artmıştır. Lazer gücünün arttırılması ve çalışma mesafesinin +5 mm arttırılmasıyla diğer değişkenler sabit tutularak maksimum kuvvet 1,19 kat, kopma kuvveti ise 1,21 kat artmıştır. Sonuç olarak, lazer gücü parametresi diğer değişkenlere göre daha büyük etkiye sahiptir. Lazer gücü artırılıp diğer değerler sabit tutulduğunda lazer gücünün arttırılması penetrasyonu önemli ölçüde etkilemiştir. 600-1000W arasındaki değerlerde parçanın arka yüzeyinde kaynak nüfuziyet derinliği net olarak görülemez. 1000-1500W arasındaki değerlerde parçanın arka yüzeyinde kaynak dikişi ve nüfuziyet derinliği net bir şekilde görülmüştür. Kaynak ilerleme hızı arttırılıp diğer değişkenler sabit alındığında kaynak nüfuziyeti aynı değerlere göre azalmıştır. Odak çapı

artırılıp diğer değişkenler sabit tutulduğunda dikiş genişliği artmış ve kaynak nüfuziyet derinliği azalmıştır. Çalışma mesafesinin arttırılması kaynak nüfuziyet derinliğini ve yüzey kalitesini arttırmıştır. Mesafenin azaltılması yüksek güçte kaynak dikişinde yırtılmalara neden olmuştur.

Anahtar Kelimeler: Paslanmaz Çelik, Lazer Kaynağı, Lazer Kaynağı Parametreleri.

ABSTRACT

This paper was to analyze the influence of the basic parameters of laser welding which are laser power, welding speed, amplitude spot size, working distance and frequency of butt joints of the 1.0 mm thick stainless steel AISI 304 sheet on the weld shape and joint quality. During the experiment, 6 kW CW robotic fiber laser was used to weld AISI 304 stainless steels in a butt joint configuration. The influence of various operating parameters, such as laser power, welding speed, and focal distance, and their interactions on the weld seam geometry and mechanical properties were studied. For each trial parameter, 26 pieces of 50x50x1mm standard AISI 304 stainless steel plates were butt welded. Static tensile test was then applied to these samples to investigate the mechanical properties. When the laser power is increased and other values are kept constant, it has been observed that increasing the laser power increases the maximum force and, accordingly, the breaking force. When the laser power was increased and the focal diameter increased from 1.2mm to 2mm, and other variables were taken constant, the maximum force increased by 1.5 times and the breaking force increased by 1.2 times in the sample with a focal diameter of 2mm at the same laser power of 1100W. When the laser power was increased and the welding speed was increased from 1m/min to 2m/min, keeping other variables constant, the maximum force increased by 1.1 times and the breaking force increased by 1.03 times. By increasing the laser power and increasing the working distance by +5mm, taking other variables constant, the maximum force increased by 1.19 times and the breaking force by 1.21 times. The laser power parameter has a greater effect than other variables. When the laser power is increased and other values are kept constant, increasing the laser power significantly affects the penetration. At values between 600-1000W, the weld penetration depth could not be clearly seen on the rear surface of the part. At values between 1000-1500W, the weld seam and penetration depth are clearly visible on the rear surface of the part. When the welding progress speed is increased and other variables are taken constant, the weld penetration decreases when compared to the same values. When the focal diameter is increased and other variables are kept constant, the seam width increases and the weld penetration depth decreases. Increasing the working distance increases the weld penetration depth and surface quality. Decreasing the distance causes tears in the welding seam at high power.

Keywords: Stainless Steel, Laser Welding, Laser Welding Parameters.

AÇIK TOPLAYICI KOMPARATÖRLERİN HİSTEREZİS ANALİZİ
HYSTERESIS ANALYSIS OF OPEN COLLECTOR COMPARATORS

Atakan KOÇYİĞİT

MEGE Teknik A.Ş., Elektronik Tasarım Mühendisi
MEGE Teknik A.Ş., Electronic Design Engineer

Rüstem Emre SUNGURBAŞ

MEGE Teknik A.Ş., Elektronik Tasarım Mühendisi
MEGE Teknik A.Ş., Electronic Design Engineer

Caner ARSLAN

MEGE Teknik A.Ş., Elektronik Tasarım Mühendisi
MEGE Teknik A.Ş., Electronic Design Engineer

Hasan Hüseyin DOYĞUN

MEGE Teknik A.Ş., Prototip Üretim ve Test Teknisyeni
MEGE Teknik A.Ş., Prototype Production and Test Technician

ÖZET

Bu bildirinin amacı, açık toplayıcı (open-collector) komparatör entegresinin nasıl çalıştığını, geri besleme (feedback) direncinin neden ve nasıl kullanıldığını ve histeresis aralıklarının komparatör çeşitlerine göre hesaplamalarının nasıl yapıldığını anlatmaktadır. Bildiri için komparatörler ve çalışma prensipleri hakkında makaleler ve kitaplar incelenmiştir. Elektronik devre tasarımı sürecinde yapılan çalışmadan edinilen bilgiler kullanılarak, tasarımcı bünyesinde fayda sağlaması amaçlanmıştır. Çalışma içerisinde histeresis hesaplamaları örneklendirilerek, şemalandırılarak ve grafikler ile gösterimi yapılarak, okuyucu için daha anlaşılır bir hale getirilmiştir. Sonuç olarak, komparatörlerin histeresis etkisi üzerine yapılan hesaplamalar ve incelemeler sonucunda, histeresis mantığının elektronik devrelerdeki kritik rolünü vurgulanmıştır. Elde edilen sonuçların, elektronik sistemlerin güvenilirliği ve performansı üzerinde doğrudan bir etkiye sahip olduğu; tasarım sürecinde histeresisin etkilerinin doğru bir şekilde anlaşılması, istikrarlı ve verimli sistemlerin tasarlanması, gelecek araştırmaların ve geliştirmelerin, elektronik devrelerin histeresis davranışının daha iyi anlaşılması ve kontrol edilmesi üzerinde odaklanmasına yardımcı olmaktadır. Yapılan hesaplamalar ile ölçülen sonuçların birbirleri ile örtüştüğü gözlemlenmiş ve teorik hesaplamaların hazırlanacak olan devre için kullanılabileceği kanıtlanmıştır.

Anahtar Kelimeler: Histeresis, Açık Toplayıcı, Komparatör.

ABSTRACT

The purpose of this paper is to explain how open collector comparators work, why and how feedback resistance is used, and how hysteresis intervals are calculated according to comparator types. For this purpose, articles and books about comparators and their working principles were reviewed. The aim is to provide benefits to the designer by using the information obtained from this study conducted during the electronic circuit design process. In the study, hysteresis calculations are exemplified, schematized and graphically displayed, making them more understandable for the reader. As a result, the calculations and studies conducted on the hysteresis effect of comparators, the critical role of hysteresis logic in electronic circuits is emphasized. The obtained results have a direct effect on the reliability and performance of electronic systems; understanding the effects of hysteresis correctly during the design process helps to design stable and efficient systems, and to focus future research and development on better understanding and controlling the hysteresis behavior of electronic circuits. It has been observed that the calculations and measured results match each other and it has been proven that theoretical calculations can be used for the circuit to be prepared.

Keywords: Hysteresis, Open Collector, Comparator.

**TASARLANAN BİR METAL-POLİMER DOĞRUDAN BİRLEŞTİRME MAKİNESİ
İLE TEK BİNDİRMELİ BAĞLANTI KONFIGÜRASYONUNDA ÜRETİLMİŞ
LAZER TEKSTÜRLÜ Al6063-PA6 HİBRİT ÇUBUKLARIN MEKANİK
ÖZELLİKLERİNİN İNCELENMESİ**

INVESTIGATION OF MECHANICAL PROPERTIES OF LASER TEXTURED Al6063-
PA6 HYBRID BEAMS MANUFACTURED IN SINGLE LAP JOINT CONFIGURATION
THROUGH A DESIGNED METAL-POLYMER DIRECT BONDING MACHINE

Tuğba YÜĞRÜK

Y.L. Öğrencisi, Dokuz Eylül Üniversitesi, Fen Bilimleri Enstitüsü, Makine Mühendisliği Anabilim Dalı
MSc Student, Dokuz Eylul University, The Graduate School of Natural and Applied Sciences, Mechanical
Engineering Department

ORCID ID: 0009-0001-1552-8241

Gökçe Mehmet GENÇER

Dr. Öğr. Üye., Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü
Assist. Prof. Dr., Dokuz Eylul University, Engineering Faculty, Mechanical Engineering Department

ORCID ID: 0000-0003-1084-7240

Mustafa AKARSU

Mak. Müh., Volt Teknoloji, İzmir, Türkiye
Mech. Eng., Volt Technology, Izmir, Turkey

ORCID ID: 0009-0001-6545-8878

ÖZET

Son yıllarda sürdürülebilirliğin sağlanabilmesi için doğal kaynakların daha efektif kullanılması ve çevrenin korunması üzerine gittikçe artan bir önem verilmektedir. Bu kapsamda, özellikle havacılık-uzay ve otomotiv endüstrisinde gerçekleştirilen teknolojik gelişmelerin önemli bir bölümü hafifleştirme uygulamaları üzerine yoğunlaşmıştır. Taşıtlarda gerçekleştirilen hafifleştirme çabaları enerjinin verimli kullanılması ve CO₂ salınımının azaltılmasında önemli bir yaklaşımdır. Hafifleştirme uygulamaları çerçevesinde, geleneksel alaşımlar yerine aynı mekanik değerleri verebilen daha hafif metal matrisli kompozitler ve polimer esaslı kompozitler gibi yenilikçi malzemeler geliştirilmiştir. Ancak geliştirilen metal ve polimer esaslı kompozit malzemelerin kullanım alanlarına göre birbirlerinin yerlerini tümüyle alamadıkları durumlar olabilmektedir. Bu nedenle, fiziksel ve kimyasal özellikleri birbirinden oldukça farklı bu malzemelerin birlikte kullanımları ve birbirlerine güvenli bir şekilde monte edilerek hibrit yapı oluşturma durumları ortaya çıkmıştır.

Endüstride farklı malzemelerin birleştirilmesinde yaygın olarak kullanılan geleneksel yöntemlerinin (mekanik ve kimyasal yöntemler) kendilerine has dezavantajları (ağırlık artışı, delik delme prosesi, çevreye zararlı kimyasal kullanımı vb.) bulunmaktadır. Bu dezavantajları

ortadan kaldırmak için metal alaşımların polimer esaslı malzemeler ile doğrudan birleştirilmesine odaklanılmıştır. Bu çalışmada, polimer matrisli malzemeler ile metal alaşımlarının yapıştırıcı kullanılmadan ve mevcut temel birleştirme tekniklerin dezavantajlarını giderecek şekilde birleştirilmesini daha hızlı ve kolay yolla sağlayan bir makine tasarlanmış ve üretilmiştir. Doğrudan birleşmenin sağlanabilmesi için birleşme bölgesine pnömomatik piston ile kuvvet uygulanmakta ve bu kuvvet yük hücresi ile ölçülebilmektedir. Makinede birleşme için gerekli olan ısı indüksiyon bobini ile metal alaşımı ısıtılarak elde edilmektedir. Tek bindirmeli bağlantı konfigürasyonunda üretilen Al6063-PA6 hibrit çubuklarının birleşme mekanik özellikleri çekme testi ile incelenmiştir. Hibrit yapının birleşme kesiti de optik mikroskop ile incelenmiştir. Doğrudan birleştirilmiş hibrit yapılarda uygun mekanik özelliklerin elde edebilmesi için metalik alaşımların birleşme yüzeyleri lazer tekstürleme ile ızgara dokusu elde edilecek şekilde hazırlanmıştır. Lazer yüzey ön işlemi alüminyum yüzeyine bir ve iki taramalı olacak şekilde uygulanmış ve böylelikle iki farklı deney grubu hazırlanmıştır. Hibrit yapıların birleşme bölgesinde oluşturulan mekanik kilitleme ile iki ve bir taramalı numunelerin ortalama çekme dayanımları sırasıyla 4025,1N ve 3773,5N olarak elde edilmiştir.

Anahtar Kelimeler: Doğrudan birleştirme, hibrit çubuk, tek bindirmeli bağlantı, lazer yüzey ön işlemi, mekanik kilitleme

ABSTRACT

In recent years, increasing importance has been paid to the more effective use of natural resources and environmental protection to ensure sustainability. In this context, a significant portion of the technological developments, especially in the aerospace and automotive industries, have focused on lightweighting applications. Lightweighting efforts in vehicles are a crucial approach to efficient use of energy and reduction of CO₂ emissions. Within the scope of lightweighting applications, innovative materials such as lighter metal matrix composites and polymer-based composites that can ensure the same mechanical values instead of traditional alloys have been developed. However, there are cases where the developed metal and polymer-based composite materials cannot entirely replace each other based on their specific areas of use. Therefore, situations have emerged where these materials, which have distinct physical and chemical characteristics, are used together and assembled safely to form hybrid structures.

Traditional methods (mechanical and chemical methods) widely employed in the industry for joining dissimilar materials have their own disadvantages (increase in weight, hole drilling process, use of environmentally harmful chemicals, etc.). To eliminate these disadvantages, the focus has been given to the direct bonding of metal alloys to polymer-based materials. In this study, a machine was designed and manufactured that enables faster and easier joining of polymer matrix materials to metal alloys without using adhesives and in a way that eliminates

the disadvantages of existing basic joining techniques. To achieve direct joining, force is applied to the joining area with a pneumatic piston and this force can be measured with a load cell. In the machine, the heat required for bonding is obtained by heating the metal alloy with an induction coil. The mechanical properties of Al6063-PA6 hybrid beams fabricated in single lap joint configuration were investigated by tensile shear test. The joint cross-section of hybrid structure were also examined by optical microscope. To obtain favorable mechanical characteristics in directly bonded hybrid structures, the joining surfaces of metallic alloys were prepared to obtain a grid texture by laser texturing. Laser surface pre-treatment was applied to the aluminum surface in one and two scans, thus two different experimental groups were prepared. With the mechanical interlocking created in the joint region of the hybrid structures, the average tensile strengths of the two and one scanned samples were obtained as 4025.1N and 3773.5N, respectively.

Keywords: Direct bonding, hybrid beam, single lap joint, laser surface pre-treatment, mechanical interlocking

**STATISTICAL EVALUATION OF CHEMICAL FERTILIZER RESOURCES IN
TÜRKİYE**

**TÜRKİYE'DEKİ KİMYASAL GÜBRE KAYNAKLARININ İSTATİSTİKSEL
DEĞERLENDİRMESİ**

Ezgi GÜLER

Res. Asst., Bilecik Şeyh Edebali University, Faculty of Engineering, Department of Industrial Engineering

ORCID NO: 0000-0001-8789-8244

ABSTRACT

Fertilization, together with irrigation, is the most important factor that reduces the dependence of agricultural production on natural conditions. Fertilizer production and consumption are indicators of the amount and quality of product obtained from a unit area and symbolize the agricultural development of a country. Statistical evaluation of fertilizer production and consumption provides agricultural added value by providing fertilizer and fertilization control. In this study, nitrogenous (Ammonium Nitrate (26% N)) chemical fertilizer data of Türkiye between 1984-2023 are analyzed. Whether there is a statistically significant difference between the production and consumption data of average nitrogenous chemical fertilizer is examined with Paired Sample T-Test. Regression analysis is a method that allows understanding the relationships between variables based on past period data and obtaining forward-looking forecasting data. In addition, the independent variable "year" and the dependent variable "nitrogenous chemical fertilizer consumption" are determined in the study and cubic regression analysis is applied. The MAPE value is obtained as 0.099. Since this value is below 0.10, the model is classified as "very good forecasting model". The adjusted R^2 value is obtained as 0.857. In this context, 85.7% of the change in nitrogenous chemical fertilizer consumption could be explained by the year variable. The regression model is verified by examining the MAPE and adjusted R^2 values obtained. The amounts of nitrogenous chemical fertilizer consumption between 2024-2028 are estimated with the cubic regression method. The findings obtained from the study are aimed to guide agricultural policies.

Keywords: Chemical Fertilizer, Regression Analysis, Paired Sample T-Test.

ÖZET

Gübreleme, sulama ile birlikte tarımsal üretimin doğa koşullarına bağımlılığını azaltan en önemli faktördür. Gübre üretimi ve tüketimi, birim alandan elde edilen ürün miktarı ve kalitesinin göstergesi olup, bir ülkenin tarımsal gelişimini simgeler. Gübre üretim ve tüketiminin istatistiksel olarak değerlendirilmesi, gübre ve gübreleme kontrolünü sağlayarak tarımsal katma değer sağlar. Bu çalışmada, Türkiye'nin 1984-2023 yılları arasındaki azotlu

(Amonyum Nitrat (%26 N)) kimyasal gübre verileri analiz edilmiştir. Ortalama azotlu kimyasal gübre üretim ve tüketim verileri arasında istatistiksel olarak anlamlı bir fark olup olmadığı Bağımlı Örneklem T-Testi ile incelenmiştir. Regresyon analizi, geçmiş dönem verilerine dayalı değişkenler arasındaki ilişkilerin anlaşılmasını ve ileriye dönük tahmin verilerinin elde edilmesini sağlayan bir yöntemdir. Ayrıca çalışmada bağımsız değişken "yıl" ve bağımlı değişken "azotlu kimyasal gübre tüketimi" belirlenmiş ve kübik regresyon analizi uygulanmıştır. MAPE değeri 0,099 olarak elde edilmiştir. Bu değer 0,10'un altında olduğundan, model "çok iyi tahmin modeli" olarak sınıflandırılmıştır. Ayarlanmış R^2 değeri 0,857 olarak elde edilmiştir. Bu bağlamda, azotlu kimyasal gübre tüketimindeki değişimin %85,7'si yıl değişkeni ile açıklanabilmektedir. Elde edilen MAPE ve ayarlanmış R^2 değerleri incelenerek regresyon modeli doğrulanmıştır. 2024-2028 yılları arasındaki azotlu kimyasal gübre tüketim miktarları kübik regresyon yöntemi ile tahmin edilmiştir. Çalışmadan elde edilen bulguların tarım politikalarına rehberlik etmesi amaçlanmıştır.

Anahtar kelimeler: Kimyasal Gübre, Regresyon Analizi, Bağımlı Örneklem T Testi.

INTRODUCTION

Fertilizers are substances that restore plant nutrients lost from the soil as a result of agricultural production and increase the yield power of the soil (Eraslan et al., 2009). Fertilization, together with irrigation, is the most important factor that reduces the dependence of agricultural production on natural conditions. Therefore, fertilizer production and consumption are one of the best indicators of the agricultural development of a country as well as the quantity and quality of the product obtained from the unit area. It has been proven by research that fertilization, provided that it is balanced and economical, has a higher share in plant production than all other agricultural inputs. The share of fertilizer use in plant production increase varies between 50-75%, and there is a very high relationship between plant yield increase and fertilizer consumption in our country and all over the world (Eyüpoğlu, 2002).

Chemical fertilizers, which were introduced to the use of world countries with the green revolution, are still used today. Chemical fertilizers are artificial substances applied to the soil or plants to provide the nutrition necessary for the growth and development of the plant and to ensure that it can continue its life in a healthy way (Duman et al., 2024). Although the history of using fertilizers to increase efficiency in plant production is quite old, the history of chemical fertilizers that have revolutionized agriculture does not even reach 200 years. There are basically three types of fertilizers in the chemical fertilizer group: nitrogenous fertilizer, phosphorous fertilizer and potassium fertilizer. Of these, nitrogenous fertilizers (N) constitute the group that is consumed the most both worldwide and in Türkiye and has a special place in plant production (Polat, 2020).

There are some statistical studies on chemical fertilizers in the literature.

Zhang and Zhang (2007) aimed to make a review and estimate of fertilizer consumption worldwide. It is seen that fertilizer consumption depends on human population and the increase in fertilizer consumption. It was found that it is mainly caused by the expansion of human population. A univariate linear model was used to fit the historical data of fertilizer consumption, including fertilizer consumption, total human population, annual fertilizer consumption per capita, and the projections for the period 2010-2030 are given in detail.

Rehman et al. (2017) used econometric analysis to investigate the relationship between agricultural gross domestic product and variables such as cultivated area, fertilizer consumption, credit distribution and water availability in Pakistan. The observed data between 1978-2015 are time series data collected from secondary sources. The data was analyzed using Phillips-Perron (P-P) and Augmented Dickey Fuller (ADF) tests and the results were interpreted using cointegration test.

Aryal et al. (2021) analyzed the factors affecting the use of organic and inorganic fertilizers for two important cereal crops, rice and wheat, in Nepal and Bangladesh. Multiple regression models were applied to understand the factors affecting the use of inorganic fertilizers, Heckman models to understand the probability and intensity of organic fertilizer use, and a probit model to examine the overuse of nitrogen fertilizer. The results show that various socioeconomic and geographical factors affect the use of organic and inorganic fertilizers in rice and wheat.

Pisuttinusart et al. (2022) aimed to estimate the import demand for nitrogen fertilizer, potassium fertilizer and compound fertilizer in Thailand. In the study, secondary time series covering the period from January 2008 to December 2021 were analyzed with seasonal autoregressive moving average (SARIMA) or Box-Jenkins methods and the forecast results for the next 12 months were calculated comparatively.

In this study, nitrogenous (Ammonium Nitrate (%26 N)) chemical fertilizer data of Turkey between 1984-2023 are analyzed. Paired Sample T-Test is used to examine whether there is a statistically significant difference between the average nitrogenous chemical fertilizer production and consumption data. In addition, nitrogenous chemical fertilizer consumption is estimated forward using the cubic regression method. The data set and methods used in the second section of the study, the findings obtained in the third section, and the discussion and conclusion in the last section are given.

MATERIAL AND METHODS

Data Set

Nitrogenous (Ammonium Nitrate (%26 N)) chemical fertilizer production and consumption data for Turkey between 1984-2023 are obtained from the Ministry of Agriculture and Forestry of the Republic of Turkey (URL-1). These data are given in Table 1.

Table 1. Nitrogenous chemical fertilizer production and consumption quantities (tons)

Year	Ammonium Nitrate (%26) (Tons)	
	Production	Consumption
1984	1.117.855	1.640.997
1985	1.037.730	1.497.768
1986	998.675	1.388.944
1987	1.038.535	1.721.017
1988	1.160.616	1.682.096
1989	905.461	1.629.808
1990	1.450.419	1.659.556
1991	1.163.125	1.217.719
1992	1.184.887	1.332.290
1993	1.393.350	1.509.566
1994	788.217	1.428.786
1995	1.226.464	1.252.951
1996	1.302.398	1.294.681
1997	1.061.959	1.187.884
1998	1.231.653	1.272.858
1999	1.077.666	1.226.696
2000	1.070.276	1.156.915
2001	866.424	884.989
2002	960.556	957.211
2003	1.021.259	1.072.899
2004	980.607	929.300
2005	821.032	820.827
2006	1.131.072	973.837
2007	942.975	1.005.838
2008	847.074	809.726
2009	898.963	953.613
2010	894.284	736.375
2011	1.028.981	733.193
2012	722.444	883.212
2013	697.714	798.593
2014	749.770	736.495
2015	525.055	607.558
2016	520.884	624.205
2017	783.544	625.090
2018	1.022.715	679.466
2019	1.378.499	918.600
2020	1.509.150	1.042.323
2021	1.588.009	1.090.533
2022	1.355.216	899.974
2023	1.057.135	841.264

In this study, using the data in Table 1, the Paired Sample T-Test is used to examine whether there is a statistically significant difference between chemical fertilizer production and consumption data. In addition, cubic regression method is used on consumption data to obtain estimates for future periods. The methods used are detailed in the next section.

Paired Sample T-Test

One of the methods used to determine the statistical significance levels of hypotheses using sample data in defined clusters is the Paired Sample T-test. The Paired Sample T-test examines the statistical significance of the main mass factor with the value calculated using sample values. If there is a difference, it is checked whether this difference level is sufficient to reject the null hypothesis (Eken, 2021). The Paired Sample T-test can be applied with the SPSS package program.

Cubic Regression Analysis

Regression analysis expresses the equation of the relationship between two dependent (Y) and independent (X) variables (Çelik et al., 2018). The cubic regression model is given in Equation (1) (Rawlings et al., 1998).

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3 + \varepsilon \quad (1)$$

where,

Y represents the dependent variable. The variable X in the equations is the independent variable of the model under consideration. β_0 is a fixed value, β_1 , β_2 and β_3 are the coefficients of the parameters that determine the shaping of the curve in the relevant model.

Some model metrics are used to verify regression models. In this study, MAPE and R^2 values are calculated.

MAPE (Mean Absolute Percentage Error)

Mean absolute percentage error (MAPE) is an error metric that represents the error between the actual values and the predicted values as a percentage. The MAPE formula is given in Equation (2). MAPE is frequently used to measure accuracy in regression and time series models (Özen et al., 2021). A MAPE value of less than 10% is a criterion for the accuracy and usability of the models (Chai & Draxler, 2014).

$$MAPE = \frac{100}{N} \sum_{j=1}^N \left| \frac{(Y_j - Y'_j)}{Y_j} \right| \quad (2)$$

In the Equation (2) Y_j and Y'_j are the actual and estimated values. N is the sample size or number of values.

R^2 (Coefficient of Determination)

R^2 calculated in regression analysis measures how well the relationship between the fit/estimator and real values fits a linear curve. An R^2 value equal to 1 indicates that the model is perfect by providing a linear curve. A high R^2 value is a desired feature for a regression model (Güler and Kandemir, 2022; Çıtakoğlu and Coşkun, 2021). The R^2 formula is given in Equation (3).

$$R^2 = 1 - \frac{\sum_{j=1}^N (Y_j - Y'_j)^2}{\sum_{j=1}^N (Y_j - Y^*_j)^2} \quad (3)$$

In the Equation (3), Y_j and Y'_j are the actual and estimated values, Y^*_j is the mean value of the data set. N is the sample size or number of values.

FINDINGS AND DISCUSSION

In this section, the results of the Paired Sample T-Test and cubic regression analysis are given. The chemical fertilizer production and consumption amounts given in Table 1 are processed in the SPSS package program. The presence of a significant difference between the means of production and consumption amounts is analyzed with the Paired Sample T-Test.

In the Paired Sample T-Test, the dependent variable should be in the interval or ratio scale. In this study, chemical fertilizer consumption and production data are in the interval scale. In addition, these data should be normally distributed. For this, the normality test is applied in SPSS. The obtained result table is given in Table 2. Since the sample size is less than 50, the Shapiro-Wilk column in Table 2 should be checked. Since the Sig. values are greater than 0.05, it is said that the data are normally distributed.

Table 2. Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
consumption_chemical_fertilizer	,117	40	,176	,946	40	,054
production_chemical_fertilizer	,086	40	,200*	,986	40	,905

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The Paired Sample T-Test is applied in SPSS. The obtained results are given in Table 3.

Table 3. Paired Samples Test

		Paired Samples Statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	production_chemical_fertilizer	1037816,20	40	247981,415	39209,304
	consumption_chemical_fertilizer	1093141,33	40	326945,747	51694,662

Paired Samples Correlations

	N	Correlation	Sig.
Pair 1 production_chemical_fertilizer & consumption_chemical_fertilizer	40	,470	,002

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 production_chemical_fertilizer - consumption_chemical_fertilizer	-55325,125	303670,32	48014,493	-152443,605	41793,355	-1,152	39	,256

In the first part of Table 3, some descriptive statistics are given. The correlation coefficient is calculated in the second area. Since the Sig. value (0.002) is less than 0.05, there is a medium level correlation between the consumption and production data. The third part is the main results of the Paired Sample T-Test. Since the Sig. value (0.256) is greater than 0.05, there is no statistically significant difference between the consumption and production data means at the 95% confidence interval.

In the other part of the study, cubic regression analysis is applied to chemical fertilizer consumption data using the SPSS package program. The coefficients results of the cubic regression analysis are given in Table 4.

Table 4. The coefficients results of the cubic regression analysis

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Case Sequence	2185,155	17991,249	,078	,121	,904
Case Sequence ** 2	-2785,554	1012,934	-4,211	-2,750	,009
Case Sequence ** 3	58,779	16,252	3,431	3,617	,001
(Constant)	1602071,978	86236,314		18,578	,000

According to the data in Table 4, cubic regression model is given in Equation (4).

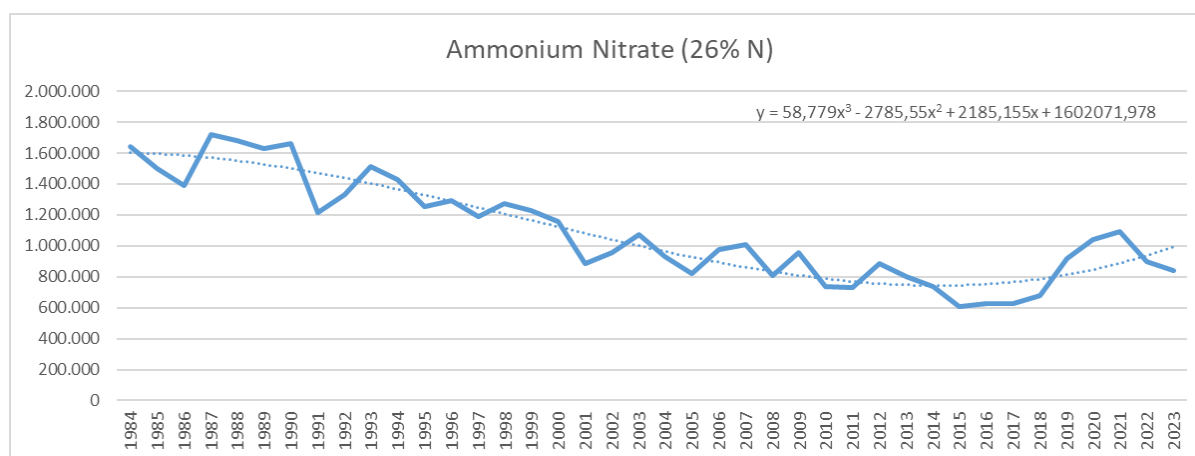
$$y' = 58779x^3 - 2785,55x^2 + 2185,155x + 1602071,378 \quad (4)$$

For the regression model in Equation (4), the nitrogenous chemical fertilizer consumption data in Table 1 are used. The estimated consumption values (y') obtained according to the actual years in the past or observation data are given in Table 5.

Table 5. The estimated nitrogenous chemical fertilizer consumption values for past years (y')

Year	y'	Year	y'
1984	1.601.530	2004	920.182
1985	1.593.585	2005	881.930
1986	1.580.774	2006	845.865
1987	1.563.450	2007	812.341
1988	1.541.966	2008	781.710
1989	1.516.674	2009	754.325
1990	1.487.926	2010	730.538
1991	1.456.077	2011	710.703
1992	1.421.477	2012	695.171
1993	1.384.481	2013	684.295
1994	1.345.440	2014	678.429
1995	1.304.708	2015	677.924
1996	1.262.637	2016	683.134
1997	1.219.579	2017	694.411
1998	1.175.888	2018	712.108
1999	1.131.915	2019	736.577
2000	1.088.014	2020	768.172
2001	1.044.538	2021	807.244
2002	1.001.839	2022	854.147
2003	960.269	2023	909.233

The actual-estimated data and the model equation are given in Figure 1.



Şekil 1. The actual-estimated data and the cubic regression model equation

For the MAPE value, Equation (2) is used for the actual chemical fertilizer consumption data and estimated chemical fertilizer consumption data in Table 1 and Table 5. The MAPE value is obtained as 0.099. Since this value is less than 0.10, the predictive power of the cubic regression model is good. For the R^2 value, Equation (3) is used for the real chemical fertilizer

consumption data and estimated chemical fertilizer consumption data in Table 1 and Table 5. The R^2 value is obtained as 0.8677. Since this value is close to 1, the model has a good representativeness. In this context, 86.77% of the changes in nitrogenous chemical fertilizer consumption data can be explained by the year (time) independent variable.

Based on the cubic regression equation in Equation (4), Türkiye's estimated nitrogenous chemical fertilizer consumption data for the years 2024-2028 are given in Table 6.

Table 6. The estimated nitrogenous chemical fertilizer consumption values for 2024-2028 (y')

Year	y'
2024	972.855
2025	1.045.366
2026	1.127.117
2027	1.218.463
2028	1.319.755

CONCLUSION

In Türkiye, the use of chemical nitrogenous fertilizers continues to increase in general, except for some exceptional years. In Türkiye, since the soils are generally insufficient in terms of organic matter, except for certain regions, there is a large amount of nitrogen (N) needed for plant production. In terms of agricultural policies, analyzing the production and consumption amounts of nitrogenous chemical fertilizers is important in terms of planning the needs. In this context, this study analyzes the nitrogenous chemical fertilizer production and consumption data of Turkey between 1984-2023. No significant difference is found between the means of production and consumption data with the Paired Sample T-test. In addition, a moderate and positive correlation is determined between these data. Since the consumption data are more controllable data, a cubic regression model is created. In the light of the data obtained from the cubic regression model, the MAPE and R^2 values show that the model is a suitable and good estimation model. Therefore, 5-year estimated consumption values between 2024-2028 could be obtained with the cubic regression model. It is thought that all the results obtained will be useful in providing preliminary information in terms of agricultural policies.

REFERENCES

- Aryal, J. P., Sapkota, T. B., Krupnik, T. J., Rahut, D. B., Jat, M. L., Stirling, C. M. 2021. Factors affecting farmers' use of organic and inorganic fertilizers in South Asia. *Environmental Science and Pollution Research*, 28(37): 51480-51496.
- Chai, T., Draxler, R. R. 2014. Root mean square error (RMSE) or mean absolute error (MAE)?. *Geosci. Model Dev.*, 7: 12471250.
- Çelik, Ş., Şengül, T., Söğüt, B., Şengül, A. Y. 2018. Türkiye 'de Organik Bal Üretimine Yıllara Göre Değişiminin Regresyon Analizi ile İncelenmesi Üzerine Bir Çalışma. *Turkish Journal of Agriculture-Food Science and Technology*, 6(11): 1507-1510.

- Duman, R., Bülbül, A. S., Bayram, S. 2024. Kimyasal Fertilizlere Çevre Dostu Bir Alternatif: Biyofertilizerler. International Congress on Multidisciplinary Approaches in Agricultural Sciences (ASMAG), 15-17 Mayıs 2024, Bayburt, Türkiye. Full Text Book, 210.
- Eken, R. 2021. Araçlarda sürücü konforunu ve güvenliğini etkileyen faktörlerin karşılaştırmalı analizi (Master's thesis, Bursa Uludağ University (Turkey)).
- Eraslan, F., İnal, A., Güneş, A., Erdal, İ., Coşkan, A. 2010. Türkiye’de Kimyasal Gübre Üretim ve Tüketim Durumu, Sorunlar, Çözüm Önerileri ve Yenilikler. TMMOB Ziraat Mühendisleri Odası, Ziraat Mühendisliği VII. Teknik Kongresi. 11- 15 Ocak 2010, Ankara, 1-21.
- Eyüpoğlu F. 2002. Türkiye gübre gereksinimi tüketimi ve geleceği. T.C. Tarım ve Köyişleri Bakanlığı. Köy Hizmetleri Genel Müdürlüğü. Toprak ve Gübre Araştırma Enstitüsü İşletme Müdürlüğü Yayınları. Teknik Yayın No: T-2. Genel Yayın No:2. Ankara.
- Güler, E., Kandemir, S. Y. 2022. Lineer ve Kübik Regresyon Analizleri Kullanılarak OECD Ülkelerinin CO₂ Emisyonlarının Tahminlemesi. Avrupa Bilim ve Teknoloji Dergisi, (34): 175-180.
- Özen, N. S., Saraç, S., Koyuncu, M. (2021). COVID-19 vakalarının makine öğrenmesi algoritmaları ile tahmini: Amerika Birleşik Devletleri örneği. Avrupa Bilim ve Teknoloji Dergisi, (22): 134-139.
- Polat, H. 2020. Türkiye’de kimyasal azotlu gübre tüketim durumunun ve toprak analizi zorunluluğunun azotlu gübre kullanımına etkilerinin değerlendirilmesi. Toprak Su Dergisi, 9(2): 60-71.
- Pisuttinusart, C., Jatuporn, C., Suvanvihok, V., Seerasarn, N. 2022. Forecasting the import demand for chemical fertilizer in Thailand. The EUrASEANs: journal on global socio-economic dynamics, 3(34): 61-70.
- Rawlings, J.O., Pantula, S.G., Dickey, D.A. 1998. Applied Regression Analysis: A Research Tool, Second Edition, Springer texts in statistics, USA.,P. 658.
- Rehman, A., Chandio, A. A., Hussain, I., Jingdong, L. 2019. Fertilizer consumption, water availability and credit distribution: Major factors affecting agricultural productivity in Pakistan. Journal of the Saudi Society of Agricultural Sciences, 18(3): 269-274.
- URL-1. <https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Bitki-Besleme-ve-Tarimsal-Teknolojiler/Bitki-Besleme-Istatistikleri> (Accessed Date: 20.09.2024).
- Zhang, W., Zhang, X. 2007. A forecast analysis on fertilizers consumption worldwide. Environmental monitoring and Assessment, 133: 427-434.

**NANOPARTİKÜL KATKILI FAZ DEĞİŞTİREN MALZEMENİN MİKRO
YERÇEKİMİ KOŞULLARINDA TERMAL ENERJİ DEPOLAMA
PERFORMANSININ İNCELENMESİ**

**INVESTIGATION OF THERMAL ENERGY STORAGE PERFORMANCE OF
NANOPARTICLE-ENHANCED PHASE CHANGE MATERIAL UNDER
MICROGRAVITY CONDITIONS**

Burak İZGİ

Yozgat Bozok Üniversitesi, Mühendislik-Mimarlık Fakültesi, Makine Mühendisliği Bölümü
Yozgat Bozok University, Faculty of Engineering and Architecture, Department of Mechanical Engineering

ORCID ID: 0000-0001-9491-8653

ÖZET

Faz Değişiren Malzemeler (FDM), belirli bir sıcaklıkta faz değiştirerek büyük miktarda ısıyı depolar veya serbest bırakır. Bu özellikleri sayesinde, termal enerji depolama ve termal yönetim uygulamalarında sıkça tercih edilmektedirler. FDM'ler, özellikle uydular ve uzay araçları gibi mikro yerçekimi koşullarında çalışan sistemlerde yaygın olarak kullanılmaktadır. Ancak FDM'lerin en büyük dezavantajlarından biri, düşük ısı iletim katsayısına sahip olmalarıdır. Bu durum, erime sürelerinin uzun olmasına neden olmakta ve termal enerji depolama veya termal yönetim verimliliğini olumsuz etkilemektedir. Mikro yerçekimi koşullarında, FDM'nin erimesi sırasında doğal taşınım hareketleri olmadığı için erime süreleri daha da uzamaktadır. Bu nedenle, FDM'lerin ısı iletim performanslarını artırmak için çeşitli yöntemler kullanılmaktadır. Bu yöntemlerden biri, FDM'lere yüksek ısı iletim katsayısına sahip nanopartiküllerin eklenmesidir.

Bu çalışmada, farklı oranlarda bakır (Cu) nanopartiküllerinin FDM'ye eklenmesiyle elde edilen malzemelerin mikro yerçekimi koşullarındaki termal enerji depolama ve güç performansı sayısal olarak incelenmiştir. Çalışmada, bir yüzeyinden sabit sıcaklık ile ısıtılan dikdörtgen kesitli bir kap içerisine yerleştirilen FDM'nin sayısal modeli oluşturularak, %0.5 ile %2 arasında değişen Cu nanopartikül katkısının depolanan enerji miktarına ve güce etkisi değerlendirilmiştir. Yapılan simülasyonlar, nanopartikül oranı arttıkça FDM'nin erime süresinin kısaldığını ancak depolanan enerji miktarının azaldığını göstermiştir. Bu durum, nanopartiküllerin ısı iletim katsayısını artırması, ancak faz değiştirme gizli ısısını azaltması ile açıklanmaktadır. Ayrıca, genetik algoritma kullanılarak yapılan optimizasyon sonucunda, enerji depolama kapasitesi ve güç performansı açısından en uygun nanopartikül katkı oranı belirlenmiştir.

Anahtar Kelimeler: Faz Değişiren Malzemeler, Nanopartiküller, Isı İletim Katsayısı, Mikro yerçekimi, Termal Enerji Depolama

ABSTRACT

Phase Change Materials (PCMs) store or release large amounts of heat by changing phase at a specific temperature. Due to these characteristics, they are widely used in thermal energy storage and thermal management applications. PCMs are especially utilized in systems operating under microgravity conditions, such as satellites and spacecraft. However, one of the major drawbacks of PCMs is their low thermal conductivity. This results in long melting durations, negatively impacting the efficiency of thermal energy storage or thermal management. In microgravity conditions, the absence of natural convection during the melting of PCMs further prolongs the melting process. Therefore, various methods are employed to improve the thermal conductivity of PCMs. One such method is the addition of nanoparticles with high thermal conductivity to PCMs.

In this study, the thermal energy storage and power performance of a PCM with varying concentrations of copper (Cu) nanoparticles was numerically investigated under microgravity conditions. A numerical model was created for the PCM, housed in a rectangular container and heated from one side at a constant temperature. The impact of Cu nanoparticle additions, ranging from 0.5% to 2%, on energy storage and power was assessed. Simulations showed that as the nanoparticle concentration increased, the melting time of the PCM decreased, but the amount of stored energy was reduced. This can be explained by the fact that nanoparticles increase thermal conductivity but reduce the latent heat of phase change. Additionally, optimization using a genetic algorithm was performed to determine the optimal nanoparticle concentration in terms of energy storage capacity and power performance.

Keywords: Phase Change Materials, Nanoparticles, Thermal Conductivity, Microgravity, Thermal Energy Storage

GİRİŞ

Faz Değiřtiren Malzemeler (FDM) enerji depolama sistemlerinde önemli bir rol oynamakta olup, faz deęiřimi sırasında büyük miktarda gizli ısıyı depolama veya serbest bırakma kapasiteleri sayesinde termal yönetim uygulamalarında yaygın bir kullanım alanı bulmuşlardır. Bu malzemeler, uydular ve uzay araçları gibi mikro yerçekimi koşullarında çalışan sistemlerde de yaygın olarak kullanılmaktadır (Diaconu et al., 2024). Ancak, FDM'lerin en önemli dezavantajlarından biri düşük ısı iletim katsayısına sahip olmalarıdır (Wu et al., 2020). Bu, özellikle mikro yerçekimi koşullarında doğal taşınım hareketlerinin eksikliğiyle birleřtiğinde, erime sürelerinin uzamasına ve dolayısıyla termal enerji depolama verimliliğinin azalmasına neden olmaktadır (Chen et al., 2019; Kansara et al., 2024).

Literatürde FDM'lerin ısı iletim özelliklerini iyileřtirmek için kanatçıklar, iğne kanatçıklar, metal veya karbon köpükler, nanopartiküller ve ısı boruları gibi çeřitli yöntemler önerilmektedir (Choure et al., 2023). Tüm bu teknikler ısı transferini önemli ölçüde iyileřtirse

de sistemde depolanan enerjiyi azaltma, sistemin kütlesini ve hacmini artırma gibi dezavantajları beraberinde getirmektedir. Bu dezavantajlar, özellikle kütle ve hacim, uzay uygulamalarında kritik öneme sahiptir. Bu noktada, yüksek ısı iletim katsayısına sahip nanopartiküllerin FDM'lere eklenmesi, kanatçık gibi diğer yöntemlere kıyasla sistemin kütlesini önemli seviyede artırmadan ısı transferini iyileştirmesi ile öne çıkmaktadır.

Yapılan çalışmalar, nanopartikül katkısının, FDM'nin ısı iletim performansını önemli ölçüde artırdığını göstermektedir (Sathishkumar et al., 2024). Karbon temelli nanomalzemeler, özellikle karmaşık yapıları sayesinde, FDM'lerin ısı iletim performansını önemli ölçüde artırmaktadır. Bu malzemeler, sürekli bir ısı iletim ağı oluşturarak termal iletkenliği artırırken, faz değiştirme gizli ısı üzerindeki etkileri ise nano katkı oranına bağlı olarak değişmektedir. Bakır gibi nanometaller, elektron ve fononların ısı transferinde rol oynaması nedeniyle FDM'lerin ısı özelliklerini iyileştirmede sıklıkla tercih edilmektedir (Han et al., 2022). Ayrıca, grafen ve genişletilmiş grafit gibi malzemeler hem mekanik kararlılığı artırmakta hem de nano ölçekli iyileştirme yöntemleriyle FDM'lerin termal performansını geliştirmektedir (Teggar et al., 2022). Nourani et al., (2016) FDM olarak parafin kullandıkları çalışmada, nanopartikül oranına ve sıcaklığa bağlı olarak ısı iletim katsayısının %1-43 oranında artırılabilirliğini bildirmişlerdir. Sharma et al., (2016) palmitik asit FDM içerisine TiO₂ nanopartikül eklendiğinde ısı iletim katsayısının %80 iyileştiğini aktarmışlardır. (Lin & Al-Kayiem, 2016) yaptıkları çalışmada %2 oranında bakır (Cu) nanopartiküllerinin FDM'ye eklenmesinin ısı iletim katsayısını %46 artırdığını ancak FDM'nin faz değiştirme gizli ısını %15 azalttığını rapor etmişlerdir. Ayrıca, Zhou et al., (2022) mikro yerçekimi koşullarında termokapiler hareketlerin etkisini incelemiş ve nanopartikül katkısının bu koşullarda FDM erime süresini kısalttığını vurgulamışlardır.

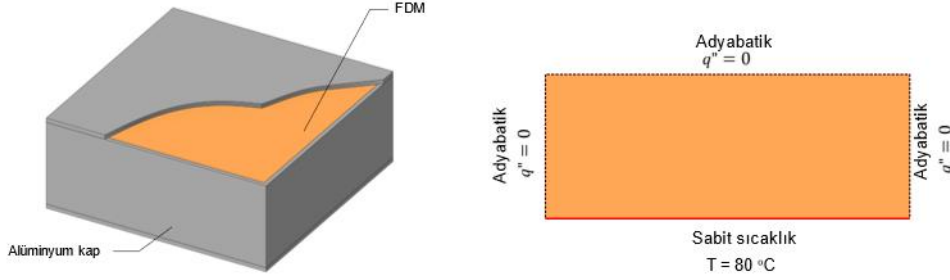
Bu bağlamda, nanopartiküllerin farklı oranlarda FDM'ye eklenmesiyle elde edilen malzemelerin termal enerji depolama ve güç performansının optimize edilmesi önem taşımaktadır. Bu çalışmada, farklı oranlarda bakır nanopartikül katkısının FDM'lerin mikro yerçekimi koşullarındaki termal enerji depolama ve güç performansına etkisi sayısal olarak incelenmiştir. Ayrıca, genetik algoritma ile nanopartikül oranlarının optimize edilmesi üzerine bir araştırma gerçekleştirilmiştir.

YÖNTEM

Sayısal çalışma için ele alınan sistemin şematik görünümü Şekil 12'de verilmiştir. Sistem 52 x 52 x 20 mm boyutlarında, alt yüzeyinden ısıtılan, diğer yüzeyleri yalıtılmış alüminyum bir kap içerisine doldurulmuş FDM'den oluşmaktadır. Faz değişimini simüle etmek için hesaplamalı akışkanlar mekaniği modeli iki boyutlu olarak Ansys-Fluent yazılımında oluşturulmuştur. Sistem başlangıçta 25 °C sıcaklıktadır. Alt yüzeyine 80 °C sabit sıcaklık uygulanan sistemin yan ve üst yüzeyleri adyabatiktir. Model oluşturulurken şu kabuller yapılmıştır:

- FDM'nin termofiziksel özellikleri sabit kabul edilmiştir.

- Faz değişimi sırasındaki hacim değişimi ihmal edilmiştir.
- Mikro yerçekimi nedeni ile sıvı fazdaki doğal taşınım etkileri ihmal edilmiştir.



Şekil 12 FDM'li termal enerji depolama sisteminin şematik görünümü

Kullanılan FDM'nin, bakır nanopartikülün ve farklı oranlarda nanopartikül katkısı FDM'nin termofiziksel özellikleri Tablo 7'de verilmiştir. Nanopartikül katkılı FDM'nin yoğunluğu ve özgül ısı, nanopartikül kaykısı yüzdesine (Φ) göre aşağıdaki formüller ile hesaplanmıştır (Mebarek-Oudina & Chabani, 2023). Diğer termofiziksel özellikler (Lin & Al-Kayiem, 2016) tarafından yapılan çalışmadan alınmıştır.

$$\rho_{npPCM} = (1 - \Phi)\rho_{PCM} + \Phi\rho_{np} \quad (1)$$

$$(\rho C_p)_{npPCM} = (1 - \Phi)(\rho C_p)_{PCM} + \Phi(\rho C_p)_{np} \quad (2)$$

Oluşturulan modelde faz değişimi entalpi-gözeneklilik metoduna (Voller & Prakash, 1987; Brent et al., 1988) dayanan “solidification/melting” modülü ile çözülmüştür. Erime tamamlanıp sistem alt yüzeyden uygulanan sıcaklığa ulaştığında depolanan toplam enerji miktarı, faz değiştirme gizli ısı ve duyulur ısıların toplamı olarak aşağıdaki gibi yazılabilir:

$$E = m(L + C_p(T_y - T_0)) \quad (3)$$

Kütle başına depolana enerji ise aşağıdaki gibi ifade edilebilir:

$$e = L + C_p(T_y - T_0) \quad (4)$$

Bu enerjinin depolanması için geçen süreye (t) bağlı olarak güç aşağıdaki gibi yazılabilir:

$$P = E/t \quad (5)$$

Tablo 7 FDM, bakır nanopartikül ve farklı oranlarda nanopartikül katkılı FDM'nin termofiziksel özellikleri (Lin & Al-Kayiem, 2016)

Özellik	FDM (Parafin wax)	Cu	FDM +%0.5 Cu	FDM + %1 Cu	FDM +%1.5 Cu	FDM +%2 Cu
ρ [kg/m ³]	825	8933	865.54	906.08	945.62	987.16
C_p [kJ/kg°C]	2.5	0.385	2.39	2.29	2.2	2.12
k [W/m°C]	0.172	401	0.2	0.226	0.299	0.32

T_k [°C]	55.2	58.62	57.37	56.35	56.49
T_e [°C]	60.42	59.57	58.97	58.15	57.81
L [kJ/kg]	184.2	172.2	166.7	160.3	157.3

Optimum nanopartikül katkı oranının sistematik olarak belirlenebilmesi için öncelikle, nanopartikül katkı oranına bağlı olarak depolanan enerji miktarını ve gücü veren basit bir makine öğrenmesi modeli oluşturulmuştur. Bunun için %0.5 - %2 oranında nanopartikül katkılı FDM'ler için simülasyonlar yapılarak her bir oran için güç ve enerji miktarları hesaplanmıştır. Hesaplanan değerler Tablo 8'de sunulmuştur. Bu değerler modelde giriş ve çıkış parametreleri olarak kullanılmıştır.

Oluşturulan modeller pymoo (Blank & Deb, 2020) optimizasyon kütüphanesi kullanılarak NSGA-II algoritmasına girdi olarak verilmiş ve iki amacı da maksimum yapacak nanopartikül katkı oranı (n) belirlenmiştir.

$$\text{Maximize: } e = f_1(n)$$

$$\text{Maximize: } P = f_2(n)$$

$$0.5 < n < 2$$

BULGULAR

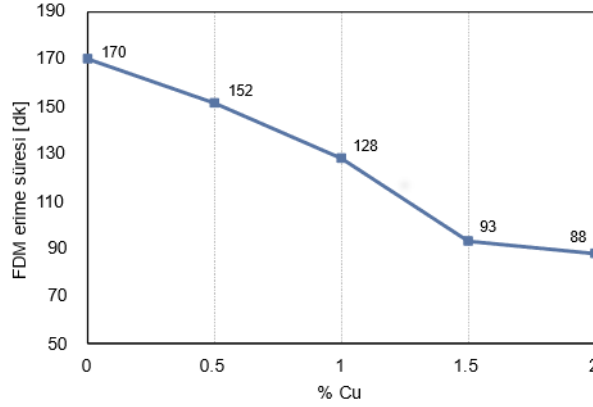
Farklı oranlarda bakır nanopartikül katkılarının FDM'nin termal enerji depolama performansına etkileri sistemin gücü ve depolanan enerji miktarı açısından sayısal olarak analiz edilmiştir. Nanopartikül katkısı bulunmayan FDM ve %0.5-%2 oranlarında nanopartikül eklenmiş FDM'lerin güç ve depolanan enerji miktarı Tablo 8'de sunulmuştur.

Tablo 8 Farklı nanopartikül katkı oranlarına göre hesaplanana güç ve enerji değerleri

% Cu	P [W]	e [kJ/kg]
0	0.1407	321.7
0.5	0.1575	306.2
1	0.1859	292.1
1.5	0.2552	279.2
2	0.2693	267.3

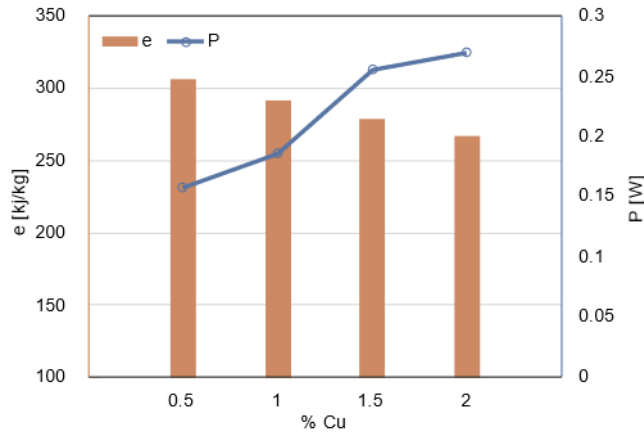
Şekil 13'de, FDM içerisine eklenen bakır nanopartiküllerinin erime süresine olan etkisi ayrıntılı olarak gösterilmiştir. Grafik incelendiğinde, bakır katkı oranının artışıyla birlikte FDM'nin erime süresinde belirgin bir azalma gözlenmektedir. Nanopartikül katkısı olmayan FDM'nin erime süresi 170 dakika iken, %2 oranında bakır içeren FDM'nin erime süresi 88 dakikaya düşmüştür. Bu da erime süresinde %48.2 oranında bir azalmaya işaret etmektedir. Bununla birlikte, bakır katkı oranındaki artışın erime süresini kısaltıcı etkisi %1.5 seviyesine kadar sürekli ve belirgin bir şekilde devam etmekte; ancak bu oranı aştıktan sonra azalma daha sınırlı kalmaktadır. %1.5 bakır içeren FDM'de erime süresi 93 dakika iken, %2 bakır içeren FDM'de bu süre yalnızca 5 dakika daha kısalarak 88 dakikaya düşmüştür. Bu durum, belirli bir katkı oranının ötesinde bakır nanopartiküllerinin ısı transferini artırıcı etkisinin

giderek daha az hissedildiğini ve erime süresini kısaltmada sınırlı bir etkiye sahip olduğunu göstermektedir.



Şekil 13 Nanopartikül katkı oranına göre FDM erime süresinin değişimi.

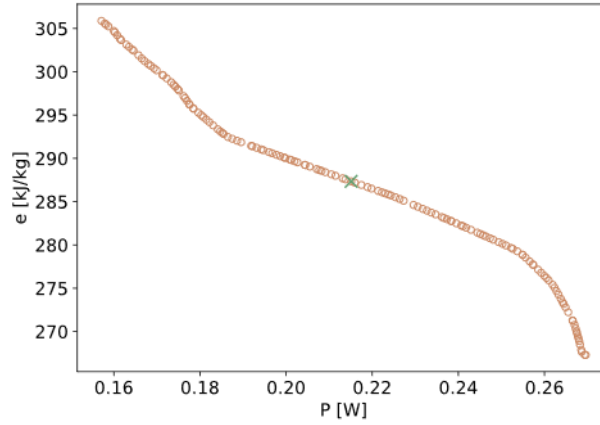
Bakır nanopartikül katkısının termal enerji depolama kapasitesi ve güç performansı üzerindeki etkisi Şekil 14’te sunulmuştur. Grafik incelendiğinde, bakır katkı oranı arttıkça kütle başına depolanan enerji miktarının azaldığı, gücün ise arttığı görülmektedir. %0.5 oranında bakır katkısı içeren FDM'nin enerji depolama kapasitesi yaklaşık 306.2 kJ/kg iken, %2 bakır katkısında bu değer yaklaşık 267.3 kJ/kg’ye düşmüştür. Güç performansına bakıldığında ise bakır katkı oranındaki artışın %1.5 oranına kadar gücü önemli ölçüde artırdığı, bu orandan sonra ise güç performansını iyileştirme etkisinin azaldığı dikkat çekmektedir. %0.5 bakır katkısı ile güç performansı 0.1575 W seviyesindeyken, %2 bakır katkısı ile bu değer 0.2693 W’ya yükselmiştir.



Şekil 14 Farklı nanopartikül katkı oranları için sistemde depolanan enerji ve güç performansı değerleri.

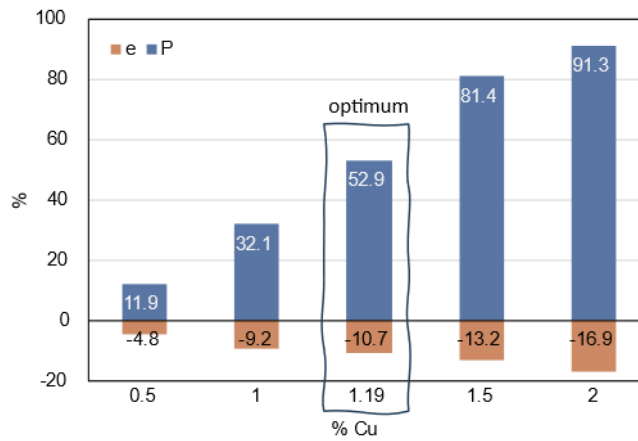
Şekil 15'te, enerji depolama kapasitesi (e) ile güç performansı (P) arasındaki Pareto optimal ilişki sunulmuştur. Grafikte, güç performansı arttıkça enerji depolama kapasitesinin azaldığı görülmektedir. Bu durum, FDM'nin güç performansını artırmaya yönelik yapılan nanopartikül katkısının, malzemenin enerji depolama kapasitesi üzerinde olumsuz bir etkiye neden olduğunu göstermektedir. Bu eğilim, sistemde hem enerji depolama hem de güç

performansını optimize etmenin zor olduğunu ve belirli bir denge sağlanması gerektiğini işaret etmektedir. Pareto optimal grafiği, bu iki parametre arasında en uygun dengeyi sağlamak için hangi kombinasyonların tercih edilmesi gerektiğini göstermektedir. Bu bağlamda, daha yüksek güç performansı hedeflendiğinde enerji depolama kapasitesinden ödün verilmesi gerektiği, daha yüksek enerji depolama kapasitesi istendiğinde ise güç performansının sınırlandırılması gerektiği sonucuna varılmaktadır.



Şekil 15 Güç ve depolanana enerji için Pareto optimal çözümler.

Güç ve enerji depolama kapasitesi arasında dengeli bir performans hedeflenen bir senaryoda, Pareto optimal çözüm kapsamında %50 güç ve %50 depolanan enerji ağırlığı seçildiğinde, optimum nanopartikül katkı oranı %1.19 olarak hesaplanmıştır. Bulunan bu optimum durum ve diğer katkı oranlarının katkısız FDM ile enerji ve güç karşılaştırması Şekil 16’te gösterilmiştir. Nanopartikül katkı oranı %1.19 olduğunda, güç performansı katkısız FDM’ye göre %52.9 artarken, depolanan enerji miktarında %10.7 oranında bir azalma meydana gelmiştir.



Şekil 16 Nanopartikül katkılı FDM’lerin katkısız FDM’ye göre güç ve depolanan enerji değerlerindeki değişimin karşılaştırılması.

SONUÇ

Bu çalışma, bakır (Cu) nanopartikül katkılarının FDM’nin termal enerji depolama kapasitesi ve güç performansı üzerindeki etkilerini mikro yerçekimi koşulları altında sayısal olarak

incelemiştir. Sonuçlar, nanopartikül konsantrasyonunun artmasıyla erime süresi, enerji depolama ve güç çıkışı arasında belirgin bir dengenin oluştuğunu göstermiştir. Özellikle, Cu nanopartiküllerinin FDM'lerin erime süresini önemli ölçüde azalttığı görülmüştür; %2 nanopartikül katkısıyla erime süresi %48.2 oranında azalmıştır. Bununla birlikte, erime süresindeki bu iyileşme, depolanan enerji miktarında bir azalmaya neden olmuştur. Örneğin, %0.5 Cu katkısında enerji depolama kapasitesi 306.2 kJ/kg iken, %2 Cu katkısında bu değer 267.3 kJ/kg'ye düşmüştür. Bu durumun önemli bir sebebi, nanopartiküllerin ısı iletim katsayısını artırmasına karşın faz değiştirme gizli ısısını azaltmasıdır.

Güç performansı ise nanopartikül konsantrasyonunun artmasıyla artış göstermiştir; %0.5 Cu katkısında 0.1575 W olan güç, %2 Cu katkısında 0.2693 W'a yükselmiştir. Ancak, %1.5'in üzerindeki nanopartikül oranlarında güç artışı sınırlı kalmıştır. Pareto çözümü, enerji depolama kapasitesi ve güç performansı arasında bir denge sağlanması gerektiğini göstermiştir. Genetik algoritma ile yapılan optimizasyon sonucunda, %1.19 Cu katkısında güç performansı %52.9 artarken, enerji depolama kapasitesinde %10.7 oranında bir azalma meydana gelmiştir. Bu bulgular, nanopartikül katkılı FDM'lerin hızlı termal yanıt ve optimize güç çıkışı gerektiren uygulamalarda büyük bir potansiyele sahip olduğunu göstermekte; ancak enerji ve güç ihtiyaçları arasında dikkatli bir dengeleme yapılması gerektiğini ortaya koymaktadır.

KAYNAKLAR

- Blank, J., & Deb, K. (2020). Pymoo: Multi-Objective Optimization in Python. *IEEE Access*, 8, 89497–89509. <https://doi.org/10.1109/ACCESS.2020.2990567>
- Brent, A. D., Voller, V. R., & Reid, K. J. (1988). Enthalpy-Porosity Technique For Modeling Convection-Diffusion Phase Change: Application To The Melting Of A Pure Metal. *Numerical Heat Transfer*, 13(3), 297–318. <https://doi.org/10.1080/10407788808913615>
- Chen, X., Hao, G., Yao, F., & Zhang, C. (2019). Numerical study on melting phase change under microgravity. *Microgravity Science and Technology*, 31, 793–803.
- Choure, B. K., Alam, T., & Kumar, R. (2023). A review on heat transfer enhancement techniques for PCM based thermal energy storage system. *Journal of Energy Storage*, 72, 108161. <https://doi.org/10.1016/j.est.2023.108161>
- Diaconu, B. M., Cruceru, M., & Anghelescu, L. (2024). Phase change materials in space systems. Fundamental applications, materials and special requirements—A review. *Acta Astronautica*, 216, 163–213.
- Han, L., Zhang, X., Ji, J., & Ma, K. (2022). Research progress on the influence of nano-additives on phase change materials. *Journal of Energy Storage*, 55, 105807.
- Kansara, K., Singh, S., Dwivedi, N. K., & Khodachenko, M. L. (2024). Investigating combined effects of varying gravity and heat flux direction on the melting dynamics of phase change material in space. *Acta Astronautica*, 220, 427–448.

- Lin, S. C., & Al-Kayiem, H. H. (2016). Evaluation of copper nanoparticles–Paraffin wax compositions for solar thermal energy storage. *Solar Energy*, *132*, 267–278.
- Mebarek-Oudina, F., & Chabani, I. (2023). Review on nano enhanced PCMs: Insight on nePCM application in thermal management/storage systems. *Energies*, *16*(3), 1066.
- Nourani, M., Hamdami, N., Keramat, J., Moheb, A., & Shahedi, M. (2016). Thermal behavior of paraffin-nano-Al₂O₃ stabilized by sodium stearyl lactylate as a stable phase change material with high thermal conductivity. *Renewable Energy*, *88*, 474–482.
- Sathishkumar, A., Sundaram, P., Cheralathan, M., & Kumar, P. G. (2024). Effect of nano-enhanced phase change materials on performance of cool thermal energy storage system: A review. *Journal of Energy Storage*, *78*, 110079. <https://doi.org/10.1016/j.est.2023.110079>
- Sharma, R., Ganesan, P., Tyagi, V., Metselaar, H., & Sandaran, S. (2016). Thermal properties and heat storage analysis of palmitic acid-TiO₂ composite as nano-enhanced organic phase change material (NEOPCM). *Applied Thermal Engineering*, *99*, 1254–1262.
- Teggar, M., Arıcı, M., Mert, M. S., Mousavi Ajarostaghi, S. S., Niyas, H., Tunçbilek, E., Ismail, K. A. R., Younsi, Z., Benhouia, A. T., & Mezaache, E. H. (2022). A comprehensive review of micro/nano enhanced phase change materials. *Journal of Thermal Analysis and Calorimetry*, *147*(6), 3989–4016. <https://doi.org/10.1007/s10973-021-10808-0>
- Voller, V. R., & Prakash, C. (1987). A fixed grid numerical modelling methodology for convection-diffusion mushy region phase-change problems. *International Journal of Heat and Mass Transfer*, *30*(8), 1709–1719.
- Wu, S., Yan, T., Kuai, Z., & Pan, W. (2020). Thermal conductivity enhancement on phase change materials for thermal energy storage: A review. *Energy Storage Materials*, *25*, 251–295.
- Zhou, X., Duan, W., Chi, F., & Jiang, Y. (2022). Numerical Investigation of nano-PCM Melting Enhanced by Thermocapillary Convection under Microgravity Condition. *Microgravity Science and Technology*, *34*(3), 41. <https://doi.org/10.1007/s12217-022-09953-4>

**OTOMOTİV SEKTÖRÜNDE İÇ VE DIŞ APLİKASYONLARDA KULLANILMAK
ÜZERE ISIL YAŞLANDIRMA VE DARBE DAYANIMLI POLİAMİD BAZLI
KOMPOZİTLERİN GELİŞTİRİLMESİ**

DEVELOPMENT OF HEAT AGING AND IMPACT RESISTANT POLYAMIDE
COMPOSITES FOR USE IN INTERNAL AND EXTERNAL APPLICATIONS IN THE
AUTOMOTIVE SECTOR

Zeynep ÇOKKIR

Technology&Innovation Engineer, Epsan Plastik

ÖZET

Plastik malzemeler hafiflik, maliyet, işleme kolaylığı gibi farklı ve önemli avantajları sebebiyle otomotiv sektöründe çoğunlukla tercih edilmektedirler. Bu sektörde, üretilen araçlar için en önemli özellik kullanılan malzemelerin olabildiğince hafif olmasıdır. Bu durumun sonucunda metalin yerini alabilecek plastikler daha da önem kazanmaktadır. Bu taleplere yerli ürün seçeneği sunabilmek için yüksek ısıda sürekli çalışabilen plastik ürünlerin geliştirilmesi ihtiyacı duyulmuştur. Bu çalışmada otomotiv sektöründe iç ve dış aplikasyonlarında kullanılmak üzere yüksek darbe ve ısı yaşlandırma dayanımlı poliamid bazlı kompozitlerin geliştirilmesi, yüksek ısı ortaya çıkaran örneğin motorun etrafında bulunan polimerik kompozitlerin yüksek sıcaklıklarda dahi yüksek mekanik özellikler gösterip, sürekli kullanım sonrasında da özelliklerini koruması veya kabul edilebilir bir oranda düşmesi hedeflenmektedir. Bu kapsamda polimerlerin zamana bağlı olarak ısı yaşlanma ve ısı dayanım özelliklerinin test edilip nihai sonuçlarının yeterliliği kontrol edilmiştir.

Ulusal platformda 200-240 °C aralığındaki sıcaklıklarda mekanik özelliklerinin %30-35 düşmesi kabul edilebilir bir aralıktır. Bu gibi yüksek sıcaklıklara dayanıklı Poliamid bazlı kompozitleri geliştirmek ana hedefdir. Bu çalışmada literatür çalışmaları incelenerek, belirlenen altı farklı formülasyon, farklı darbe dayanımı katkılarının ve ısı yaşlandırma dayanımı sunan farklı katkıların kullanımı ile tek yönlü çift vidalı ekstrüder kullanılarak eriyikten karıştırma yöntemi ile hazırlanmış ve granül haline getirilmiştir. Elde edilen granüller enjeksiyon kalıplama makinası ile test plakaları formuna getirilmiştir. Sonrasında üretilen malzemelerin fiziksel, mekanik, ısı yaşlandırma testleri yapılmıştır. Yapılan testler sonucunda üretilen poliamid bazlı kompozitlerden bir formülasyon otomotiv sektöründe araç iç ve dış aksamda kullanılacak yüksek darbe ve ısı yaşlandırma dayanımı sunduğu gözlenmiştir. Geliştirilen yüksek ısı dayanımlı malzemede 230°C'de 3000 saat sonrasında mekanik özelliklerini minimum %70 oranında korunduğu belirlenmiştir.

Anahtar kelimeler: Poliamid 6, Mekanik özellikler, Darbe dayanımı, Isı dayanım

ABSTRACT

Plastic materials are frequently preferred in the automotive industry due to their various and significant advantages, such as lightness, cost-effectiveness, and ease of processing. In this sector, the most critical feature for manufactured vehicles is the lightweight nature of the materials used. Consequently, plastics that can replace metal have gained more importance. To meet these demands with local product options, there has been a need to develop plastic products that can continuously operate at high temperatures. In this study, the aim is to develop polyamide-based composites with high impact resistance and thermal aging resistance for use in both interior and exterior applications in the automotive industry. The goal is for the polymeric composites, which are exposed to high heat, such as those surrounding the engine, to exhibit high mechanical properties even at elevated temperatures and to maintain their properties, or experience an acceptable level of degradation, after prolonged use. In this context, the thermal aging and thermal resistance properties of the polymers over time have been tested, and the final results have been evaluated for adequacy.

On the national platform, a 30-35% reduction in mechanical properties at temperatures ranging from 200-240°C is considered an acceptable range. The primary goal is to develop polyamide-based composites that can withstand such high temperatures. In this study, after examining literature studies, six different formulations were identified and prepared using melt blending with a single-screw extruder, incorporating various impact resistance additives and additives that provide thermal aging resistance. The resulting granules were formed into test plates using an injection molding machine. Subsequently, the produced materials underwent physical, mechanical, and thermal aging tests. As a result of these tests, one of the polyamide-based composite formulations was found to provide high impact and thermal aging resistance, making it suitable for use in automotive interior and exterior components. It was determined that the developed high thermal-resistant material retained at least 70% of its mechanical properties after 3000 hours at 230°C.

Keywords: Polyamide 6, Mechanical, Impact, Thermal Resistance

ROLE OF PROTEIN-RICH DIETS IN PROMOTING A HEALTHY LIFE: BENEFITS, SOURCES, AND CONSIDERATIONS

Akanksha Gautam

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

Mahendra Kumar Savita

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

ABSTRACT

A protein-rich diet has long been associated with numerous health benefits, including improved muscle mass, weight management, enhanced metabolic function, and better overall health. Proteins play a crucial role in tissue repair, enzyme production, and immune system function. This article reviews the importance of dietary protein for a healthy life, the benefits of high-protein diets, and the best dietary sources of protein. It also highlights potential risks associated with excessive protein intake and provides recommendations for optimal consumption based on age, activity level, and health status.

Keywords: protein-rich diet, muscle health, metabolic function, dietary protein, weight management, protein sources, amino acids, healthy aging, nutrition, high-protein diets

1. Introduction

Proteins are essential macronutrients required for various biological functions, including the repair and growth of tissues, enzyme synthesis, and immune responses. A protein-rich diet is widely recommended for individuals across all age groups to promote muscle health, improve metabolic function, and support overall well-being. While the Recommended Dietary Allowance (RDA) for protein is 0.8 grams per kilogram of body weight for the average adult, certain populations—such as athletes, older adults, and those recovering from illness—may benefit from higher protein intake. This article explores the role of protein in maintaining a healthy life and evaluates the best protein sources for different dietary preferences.

2. Importance of Protein in the Diet

Protein serves several critical functions in the body, including:

Muscle Maintenance and Repair: Protein provides the building blocks (amino acids) necessary for muscle growth and repair, especially after exercise. High-protein diets help prevent muscle loss, particularly in older adults, where sarcopenia (muscle loss due to aging) is a concern.

Metabolism and Weight Management: Proteins increase satiety, reduce hunger, and promote thermogenesis, making them beneficial for weight management and metabolic health. High-protein diets have been shown to reduce body fat, improve muscle-to-fat ratios, and increase energy expenditure.

Immune Function and Healing: Proteins are essential for the production of antibodies, enzymes, and other immune cells, supporting the body's defense mechanisms. They also facilitate wound healing and recovery from injuries or surgeries.

3. Health Benefits of a Protein-Rich Diet

3.1 Muscle Mass and Strength

One of the most well-established benefits of a protein-rich diet is its ability to preserve and enhance muscle mass and strength. Dietary protein is crucial for muscle protein synthesis, especially after resistance training. Studies have shown that consuming adequate protein in combination with exercise can significantly enhance muscle hypertrophy and strength gains.

3.2 Weight Management and Satiety

Protein plays a key role in regulating hunger hormones such as ghrelin and peptide YY. High-protein meals lead to greater feelings of fullness compared to meals high in carbohydrates or fats. This satiety effect helps with calorie control and supports long-term weight loss or maintenance. In several studies, individuals on high-protein diets lost more weight and fat mass compared to those on lower-protein diets.

3.3 Bone Health

Contrary to the misconception that high-protein diets may cause bone loss, research indicates that dietary protein supports bone health by increasing calcium absorption and promoting bone density. High-protein diets, especially those rich in dairy proteins, have been associated with a reduced risk of osteoporosis and bone fractures in older adults.

3.4 Improved Cardiometabolic Health

Dietary protein, particularly from plant-based sources, can improve markers of cardiometabolic health. Higher protein intake is linked to lower blood pressure, improved lipid profiles, and enhanced insulin sensitivity. Plant proteins, such as those from legumes, nuts, and seeds, are especially beneficial in reducing the risk of cardiovascular disease due to their lower levels of saturated fats.

4. Protein Sources: Animal vs. Plant-Based

Proteins are available from both animal and plant sources, each with its advantages and nutritional profiles.

4.1 Animal-Based Protein Sources

Animal-based proteins are considered "complete" proteins, containing all nine essential amino acids. Some common animal protein sources include:

Meat and Poultry: Beef, chicken, turkey, and pork are rich sources of high-quality protein and essential micronutrients like iron and zinc.

Fish and Seafood: Salmon, tuna, and shrimp are excellent sources of lean protein and contain heart-healthy omega-3 fatty acids.

Dairy Products: Milk, cheese, and yogurt provide both protein and calcium, important for bone health.

Eggs: One of the most versatile and bioavailable sources of protein, eggs contain all essential amino acids and several important vitamins and minerals.

4.2 Plant-Based Protein Sources

Plant-based proteins are gaining popularity due to their health benefits and sustainability. While some plant proteins are incomplete, combining different plant sources can provide all essential amino acids. Common plant-based protein sources include:

Legumes: Beans, lentils, and chickpeas are rich in protein and fiber, making them excellent choices for vegetarians and vegans.

Nuts and Seeds: Almonds, chia seeds, flaxseeds, and sunflower seeds are nutrient-dense and provide good amounts of protein and healthy fats.

Whole Grains: Quinoa, brown rice, and oats offer both protein and complex carbohydrates, making them good choices for energy and muscle recovery.

Soy Products: Tofu, tempeh, and edamame are complete protein sources derived from soybeans and are widely used in plant-based diets.

5. Considerations for a Protein-Rich Diet

While protein is essential for health, excessive intake can pose risks, especially in individuals with pre-existing kidney conditions. It is important to balance protein intake with other macronutrients to avoid potential health issues.

5.1 Protein and Kidney Health

Excessive protein intake, particularly from animal sources, can strain the kidneys, leading to potential damage in individuals with pre-existing kidney conditions. However, for healthy individuals, there is little evidence to suggest that a high-protein diet causes kidney problems. Adequate hydration and balanced nutrient intake are key to preventing any negative effects.

5.2 Timing of Protein Intake

Research suggests that distributing protein intake evenly throughout the day maximizes muscle protein synthesis. Instead of consuming large amounts of protein in one meal, it is beneficial to include protein-rich foods in every meal and snack. This approach can help sustain muscle mass and improve overall health.

6. Protein Intake Recommendations

Protein needs vary based on age, activity level, and individual health goals. General recommendations for protein intake are as follows:

Adults: 0.8–1.2 grams of protein per kilogram of body weight per day, depending on physical activity levels.

Athletes and Active Individuals: 1.2–2.0 grams of protein per kilogram of body weight per day to support muscle growth and recovery.

Older Adults: Increased protein intake (1.2–1.5 grams per kilogram of body weight) is recommended to counteract age-related muscle loss and support bone health.

7. Conclusion

A protein-rich diet is essential for maintaining muscle mass, supporting metabolic health, promoting weight management, and enhancing overall well-being. Both animal and plant-based protein sources offer unique benefits, and a balanced intake from varied sources is recommended for optimal health. While high-protein diets are generally safe for most individuals, those with specific health conditions should consult healthcare professionals before increasing protein intake. Further research into the long-term effects of high-protein diets is necessary to fully understand their role in preventing chronic diseases and promoting healthy aging.

References

- Phillips, S. M., et al. "Dietary Protein for Athletes: From Requirements to Optimum Adaptation." *Journal of Sports Sciences*, vol. 29, no. 1, 2011, pp. 29-38.
- Paddon-Jones, D., et al. "Protein, Weight Management, and Satiety." *American Journal of Clinical Nutrition*, vol. 87, no. 5, 2008, pp. 1558-1561.
- Campbell, W. W., & Leidy, H. J. "Dietary Protein and Resistance Training Effects on Muscle and Body Composition in Older Adults: A Review." *Journal of the American College of Nutrition*, vol. 26, no. 6, 2007, pp. 696-703.
- Leidy, H. J., et al. "The Role of Protein in Weight Loss and Maintenance." *American Journal of Clinical Nutrition*, vol. 101, no. 6, 2015, pp. 1320S-1329S.
- Kerstetter, J. E., et al. "The Impact of Dietary Protein on Calcium Absorption and Bone Health." *Current Opinion in Lipidology*, vol. 14, no. 1, 2003, pp. 55-58.

- Fulgoni, V. L. "Current Protein Intake in America: Analysis of the National Health and Nutrition Examination Survey, 2003-2004." *American Journal of Clinical Nutrition*, vol. 87, no. 5, 2008, pp. 1554S-1557S.
- Hu, F. B. "Plant-Based Foods and Prevention of Cardiovascular Disease: An Overview." *American Journal of Clinical Nutrition*, vol. 78, no. 3, 2003, pp. 544S-551S.
- Layman, D. K., et al. "Protein in Optimal Health: Heart Disease and Cancer." *American Journal of Clinical Nutrition*, vol. 80

HOME REMEDIES FOR MANAGING SEPTICEMIA IN FISH: A REVIEW OF TRADITIONAL AND NATURAL TREATMENTS

Akanksha, Mahendra Kumar Savita

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

ABSTRACT

Septicemia, a systemic bacterial infection in fish, can cause significant health and economic challenges in aquaculture. While antibiotics are commonly used to treat septicemia, the rise of antibiotic resistance has led to increased interest in natural remedies. This article explores various home remedies and traditional fish septicemia treatments, including herbal extracts, probiotics, and water management strategies. It reviews the efficacy of these treatments and highlights the need for further research to confirm their effectiveness and safety in aquaculture practices.

Keywords: septicemia in fish, home remedies, herbal treatments, aquaculture, antibiotic resistance, natural fish treatments, probiotics, water quality, fish health, bacterial infections

1. Introduction

Septicemia, a serious bacterial infection in fish, is characterized by the invasion of bacteria into the bloodstream, leading to widespread infection of organs and tissues. It often results from stress, poor water quality, and injuries that compromise the fish's immune system. The most common pathogens causing septicemia include *Aeromonas*, *Vibrio*, and *Pseudomonas* species. Traditionally, antibiotics are used for treatment, but concerns about antibiotic resistance have spurred interest in alternative, natural remedies. This review aims to explore home remedies for managing septicemia in fish, focusing on natural treatments and their potential efficacy.

2. Septicemia in Fish: Causes and Symptoms

Septicemia in fish is primarily caused by bacterial infections that enter through wounds or damaged skin. Factors contributing to septicemia include:

Poor water quality (e.g., high ammonia, nitrite, or nitrate levels)

Overcrowding and inadequate oxygen supply

Stress from transport or changes in water temperature

Symptoms of septicemia include reddening of the skin, hemorrhaging, swollen abdomen, lethargy, loss of appetite, and erratic swimming behavior. Early detection is crucial for effective treatment.

3. Herbal Remedies for Septicemia

Several herbs have antimicrobial properties and are used in traditional medicine to manage bacterial infections in fish. These include:

3.1 Garlic (*Allium sativum*)

Garlic is known for its potent antimicrobial properties, effective against various bacterial strains. It contains allicin, a compound that inhibits bacterial growth and boosts immune function in fish. Crushed garlic can be added to fish food to help improve their resistance to bacterial infections such as septicemia. Studies have shown that garlic enhances the overall health and disease resistance in fish when used as a dietary supplement.

3.2 Turmeric (*Curcuma longa*)

Turmeric is widely recognized for its anti-inflammatory and antimicrobial properties. Curcumin, the active component in turmeric, has shown efficacy against several bacterial strains that cause septicemia in fish. Adding small amounts of turmeric to the fish feed can help reduce infection symptoms and strengthen immune responses.

3.3 Neem (*Azadirachta indica*)

Neem leaves and oil are traditionally used for their antiseptic and antimicrobial properties. Neem extracts can be added to the fish tank as a natural remedy to combat bacterial infections. Its bioactive compounds, such as nimbidin, have been shown to inhibit bacterial growth and enhance immune responses in fish.

4. Probiotics and Septicemia Control

Probiotics, or beneficial bacteria, play a vital role in enhancing the gut health of fish, promoting nutrient absorption, and boosting the immune system. Probiotic supplements, such as *Lactobacillus* and *Bacillus* species, are commonly used to prevent and manage septicemia. They compete with pathogenic bacteria, reduce intestinal inflammation, and improve the fish's ability to resist infection.

Studies have demonstrated that probiotic-treated fish have lower mortality rates when exposed to septicemia-causing bacteria. These beneficial bacteria can be added to fish feed or directly into the water as a preventative measure.

5. Water Management Strategies

Maintaining optimal water quality is one of the most effective ways to prevent septicemia in fish. Proper water management includes the following:

5.1 Salt Baths

Salt (sodium chloride) is a commonly used remedy in aquaculture for treating external infections and reducing osmotic stress. Salt baths help improve the osmotic balance of fish and enhance the excretion of excess water, which is beneficial in cases of septicemia with

symptoms such as dropsy (swollen abdomen). A salt concentration of 0.5–3% is typically used in a temporary bath to reduce bacterial load and promote healing.

5.2 Aloe Vera (*Aloe barbadensis*)

Aloe vera is known for its wound-healing and antimicrobial properties. Aloe vera extracts can be applied topically to injured or infected areas of the fish or added to the water to promote skin healing and prevent bacterial infections. Its use in septicemia cases may reduce external symptoms like fin and skin lesions.

5.3 Potassium Permanganate

Potassium permanganate is a traditional treatment used in aquaculture to control external bacterial and fungal infections. A diluted solution of potassium permanganate can be applied to fish tanks to reduce bacterial loads in the water, promoting faster recovery from septicemia. However, care should be taken to avoid overdosing, as it can be harmful to both fish and beneficial microorganisms.

6. Challenges and Considerations

While home remedies offer potential benefits for managing septicemia in fish, they are not without limitations. The effectiveness of these treatments can vary based on the fish species, the severity of the infection, and environmental conditions. Furthermore, overdosing or improper application of certain remedies (e.g., salt or potassium permanganate) can harm the fish and disrupt the water quality. It is crucial to monitor water parameters and fish behavior closely during treatment.

There is also a need for more scientific research to evaluate the efficacy and safety of these natural treatments in controlled settings. While anecdotal evidence suggests the potential benefits of herbal remedies and probiotics, standardized guidelines for their use in aquaculture are lacking.

7. Conclusion

The use of natural and home remedies for treating septicemia in fish offers an alternative to antibiotics, which are associated with the risk of resistance development. Herbal treatments such as garlic, turmeric, and neem, as well as probiotics and proper water management strategies like salt baths, show promise in managing septicemia in fish. Further research is needed to optimize the use of these remedies in aquaculture, ensuring both efficacy and safety. Integrating these treatments into fish health management could contribute to more sustainable aquaculture practices.

References

- Reverter, M., et al. "Use of Plant Extracts in Fish Aquaculture as an Alternative to Chemotherapy: Current Status and Future Perspectives." *Aquaculture*, vol. 433, 2014, pp. 50-61.
- Nya, E. J., & Austin, B. "Use of Garlic, *Allium sativum*, to Control *Aeromonas hydrophila* Infections in Rainbow Trout (*Oncorhynchus mykiss*)." *Journal of Fish Diseases*, vol. 32, no. 11, 2009, pp. 963-970.
- Hussain, Z., et al. "Curcumin as an Antimicrobial and Immunomodulatory Agent for Fish: A Review." *Aquaculture Reports*, vol. 17, 2020, pp. 100345.
- Ghaffar, A., et al. "The Potential Role of Neem (*Azadirachta indica*) in Aquaculture: A Review." *Journal of Entomology and Zoology Studies*, vol. 6, no. 3, 2018, pp. 1205-1210.
- Pandiyam, P., et al. "Probiotics in Aquaculture." *Drug Invention Today*, vol. 5, no. 1, 2013, pp. 55-59.
- Merrifield, D. L., et al. "The Future of Probiotics and Prebiotics in Aquaculture." *Aquaculture*, vol. 445, 2015, pp. 36-41.
- Martinez Cruz, P., et al. "Salt Baths in Aquaculture: The Therapeutic Potential for Fish Health." *Aquaculture Research*, vol. 51, no. 7, 2020, pp. 2882-2891.
- Sivaram, V., et al. "Inclusion of Aloe Vera as Immunostimulant in Feed on Growth Performance and Immune Response of Common Carp (*Cyprinus carpio*)." *Fish & Shellfish Immunology*, vol. 36, no. 1, 2014, pp. 80-86.
- Ali, S. M., et al. "Application of Potassium Permanganate in Aquaculture: A Review." *International Journal of Research Studies in Biosciences*, vol. 4, no. 7, 2016, pp. 16-23.
- Rahman, M. M., et al. "Antibacterial Efficacy of Probiotics and Herbal Extracts in Preventing Septicemia in Tilapia (*Oreochromis niloticus*)." *Aquaculture International*, vol. 28, no. 4, 2020, pp. 1541-1550

MALARIA: EPIDEMIOLOGY, PATHOGENESIS, AND CONTROL STRATEGIES

Abhinesh Pal

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

Mahendra Kumar Savita

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

ABSTRACT

Malaria is a life-threatening disease caused by Plasmodium parasites transmitted through the bites of infected female Anopheles mosquitoes. Despite considerable efforts, malaria remains a significant public health issue, particularly in tropical and subtropical regions. This review explores the epidemiology, pathogenesis, clinical manifestations, diagnostic methods, and control strategies for malaria, with an emphasis on the most affected regions. It also examines the current challenges in the development of vaccines, drug resistance, and the role of climate change in altering malaria transmission patterns.

Keywords: Malaria, Plasmodium, Anopheles mosquitoes, drug resistance, pathogenesis, malaria control, vaccine development, climate change, epidemiology, malaria diagnosis

1. Introduction

Malaria is a parasitic disease primarily affecting low-income tropical and subtropical regions. Caused by five Plasmodium species (*P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi*), it remains a major global health problem. According to the World Health Organization (WHO), there were approximately 247 million cases of malaria worldwide in 2022, with Africa accounting for 95% of these cases. This review provides a comprehensive overview of the key aspects of malaria, including its epidemiology, pathogenesis, diagnosis, and control.

2. Epidemiology

The global distribution of malaria is largely concentrated in Africa, Southeast Asia, and Latin America, with Africa bearing the highest burden. *P. falciparum* is responsible for the majority of malaria-related deaths, while *P. vivax* dominates in some parts of Asia and Latin America. The disease predominantly affects children under five and pregnant women due to their compromised immunity.

Risk Factors include poverty, lack of access to healthcare, and environmental factors that promote mosquito breeding. In recent years, the risk of malaria transmission has also been linked to climate change. Rising temperatures and altered precipitation patterns have expanded the geographical range of malaria vectors into previously unaffected areas.

3. Pathogenesis

The malaria parasite's life cycle is complex, involving both the mosquito vector and human host. After an infectious mosquito bite, sporozoites enter the bloodstream and travel to the liver, where they multiply and mature into merozoites. These merozoites re-enter the bloodstream, invade red blood cells, and initiate the symptomatic phase of malaria.

Immune Response: The immune system responds to malaria infection by producing antibodies and activating macrophages, but the parasite's ability to sequester in the microvasculature and evade immune detection makes it difficult to eliminate. *P. falciparum* is especially notorious for causing severe forms of the disease, such as cerebral malaria, through the sequestration of infected red blood cells in vital organs.

4. Clinical Manifestations

The clinical presentation of malaria varies depending on the species of *Plasmodium*. Common symptoms include fever, chills, headache, nausea, vomiting, and muscle pain. Severe malaria, particularly due to *P. falciparum*, can lead to complications such as anemia, metabolic acidosis, respiratory distress, and organ failure. Cerebral malaria, a severe manifestation of *P. falciparum* infection, can cause seizures, coma, and death.

5. Diagnosis

Microscopic Examination: The gold standard for malaria diagnosis remains microscopic examination of blood smears stained with Giemsa. This method allows for species identification and parasite quantification.

Rapid Diagnostic Tests (RDTs): These immunochromatographic tests detect specific malaria antigens in the blood and provide results within 15–30 minutes. While highly useful in remote areas without laboratory facilities, RDTs may miss low-density infections.

Molecular Diagnostics: Polymerase chain reaction (PCR) is used for detecting low-level parasitemia and species differentiation in research settings but is not yet widely available in low-resource areas.

6. Treatment

The treatment of malaria depends on the *Plasmodium* species, severity of the disease, and the geographical location, due to varying patterns of drug resistance. Artemisinin-based combination therapies (ACTs) are the first-line treatment for uncomplicated *P. falciparum* malaria. For *P. vivax* infections, chloroquine is still effective in some regions, but resistance has emerged in parts of Southeast Asia.

Drug Resistance: The emergence of artemisinin-resistant *P. falciparum* in Southeast Asia poses a major threat to malaria control. Resistance results from mutations in the parasite's *kelch13* gene, which reduces the efficacy of artemisinin derivatives.

7. Prevention and Control

Vector Control: Preventing mosquito bites is crucial for malaria control. The most effective vector control measures include insecticide-treated bed nets (ITNs) and indoor residual spraying (IRS). Long-lasting insecticidal nets (LLINs) have proven to reduce malaria morbidity and mortality significantly.

Chemoprophylaxis: Preventive antimalarial drugs are recommended for travelers and individuals living in endemic areas. Sulfadoxine-pyrimethamine is used in intermittent preventive treatment in pregnancy (IPTp), while atovaquone-proguanil and mefloquine are common choices for travelers.

Vaccine Development: The development of an effective malaria vaccine has been a long-standing challenge. The RTS, S/AS01 vaccine, the first malaria vaccine approved for use, provides partial protection against *P. falciparum* in children. Efforts to develop more effective vaccines are ongoing, focusing on inducing stronger immune responses and broader protection.

8. Climate Change and Malaria

Global warming can potentially exacerbate malaria transmission by expanding the habitats of *Anopheles* mosquitoes into new regions. Changes in temperature and rainfall can increase mosquito population density, reduce the parasite's extrinsic incubation period, and prolong transmission seasons. Efforts to mitigate climate change and strengthen health systems in vulnerable areas are essential for malaria control in the future.

9. Conclusion

Despite significant advances in reducing malaria-related morbidity and mortality, the disease remains a public health challenge in many parts of the world. Current control strategies, including vector control and chemotherapy, have progressed but are threatened by drug and insecticide resistance. Continuous efforts to develop new vaccines, improve diagnostic tools, and address the impact of climate change will be critical for achieving the global goal of malaria elimination.

References

- World Health Organization. "World Malaria Report 2022." WHO, 2022.
- Bhatt, S. et al. "The Global Distribution and Burden of Malaria." *Nature*, vol. 526, no. 7572, 2015, pp. 207-211.
- Caminade, C. et al. "Impact of Climate Change on Global Malaria Distribution." *Proceedings of the National Academy of Sciences*, vol. 111, no. 9, 2014, pp. 3286-3291.
- Cowman, A. F., et al. "The Pathogenesis of *Plasmodium Falciparum* Malaria." *Cell Host & Microbe*, vol. 12, no. 1, 2012, pp. 5-18.

- Miller, L. H., et al. "The Pathogenesis of Severe Malaria." *Nature Reviews Microbiology*, vol. 11, no. 10, 2013, pp. 683-696.
- White, N. J. et al. "Malaria." *The Lancet*, vol. 383, no. 9918, 2014, pp. 723-735.
- Moody, A. "Rapid Diagnostic Tests for Malaria Parasites." *Clinical Microbiology Reviews*, vol. 15, no. 1, 2002, pp. 66-78.
- Wongsrichanalai, C., et al. "Rapid Diagnostic Tests for Malaria." *The Lancet Infectious Diseases*, vol. 7, no. 9, 2007, pp. 576-588.
- Snounou, G. et al. "The Use of PCR for Malaria Diagnosis." *Annals of Tropical Medicine & Parasitology*, vol. 87, no. 4, 1993, pp. 367-373.
- Dondorp, A. M., et al. "Artemisinin Resistance in *Plasmodium Falciparum* Malaria." *New England Journal of Medicine*, vol. 361, no. 5, 2009, pp. 455-467.
- Fairhurst, R. M., & Dondorp, A. M. "Artemisinin-Resistant *Plasmodium Falciparum* Malaria." *Microbiology Spectrum*, vol. 4, no. 3, 2016, pp. 1-25.
- Lengeler, C. "Insecticide-Treated Bed Nets and Curtains for Preventing Malaria." *Cochrane Database of Systematic Reviews*, 2004, CD000363.
- Gosling, R. D., et al. "Chemoprevention of Malaria." *PLoS Medicine*, vol. 7, no. 3,

**HOME REMEDIES FOR HIGH BLOOD PRESSURE: EXPLORING NATURAL
APPROACHES TO HYPERTENSION MANAGEMENT**

Archit Kumar

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

Mahendra Kumar Savita

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

ABSTRACT

Hypertension, or high blood pressure, is a prevalent condition that significantly increases the risk of cardiovascular diseases, stroke, and kidney damage. While pharmacological treatments are essential for controlling blood pressure, home remedies have gained attention for their potential role in supporting hypertension management. This article reviews various home remedies for high blood pressure, evaluating their efficacy, scientific basis, and practical applications. The discussion includes dietary modifications, herbal treatments, and lifestyle changes, providing a comprehensive overview of natural approaches to managing hypertension.

Keywords: Hypertension, high blood pressure, home remedies, dietary interventions, herbal treatments, lifestyle modifications, blood pressure management, natural approaches, cardiovascular health, hypertension support.

Introduction

Hypertension is a chronic condition characterized by persistently elevated blood pressure, which can lead to severe health complications, including heart disease, stroke, and kidney failure [1]. Effective management of hypertension typically involves lifestyle modifications, pharmacological treatments, and regular monitoring [2]. In addition to conventional methods, various home remedies are used to support blood pressure control. This article examines the potential benefits and scientific support for these remedies.

1. Overview of Hypertension Management

Hypertension management strategies include reducing sodium intake, increasing physical activity, and using antihypertensive medications [3]. Home remedies can complement these approaches by providing additional methods to support cardiovascular health and manage blood pressure [4].

2. Dietary Interventions

Dietary changes can have a significant impact on blood pressure levels. Several home remedies focus on dietary approaches:

Garlic: Garlic is known for its potential to lower blood pressure due to its ability to enhance nitric oxide production and improve endothelial function [5]. Studies suggest that garlic supplements may contribute to modest reductions in blood pressure.

Beet Juice: Beet juice is high in nitrates, which can be converted into nitric oxide in the body, leading to vasodilation and reduced blood pressure [6]. Consuming beet juice regularly may help lower blood pressure in some individuals.

Hibiscus Tea: Hibiscus tea has been shown to have antihypertensive effects. It is believed to help relax blood vessels and reduce blood pressure levels [7].

Omega-3 Fatty Acids: Found in fish oil and certain plant sources, omega-3 fatty acids can help lower blood pressure by reducing inflammation and improving blood vessel function [8].

3. Herbal Remedies

Herbal treatments have been traditionally used to support cardiovascular health:

Hawthorn: Hawthorn extract is used to improve heart function and reduce blood pressure. It has been shown to enhance blood flow and reduce arterial stiffness [9].

Coenzyme Q10 (CoQ10): CoQ10 is an antioxidant that can help improve endothelial function and reduce blood pressure [10].

Olive Leaf Extract: Olive leaf extract has been reported to have antihypertensive effects due to its ability to improve blood vessel function and reduce oxidative stress [11].

4. Lifestyle Modifications

Lifestyle changes are essential for managing high blood pressure:

Regular Exercise: Engaging in physical activities such as walking, swimming, or cycling can help lower blood pressure by improving cardiovascular health and reducing weight [12].

Stress Management: Chronic stress can contribute to high blood pressure. Techniques such as mindfulness, meditation, and deep breathing exercises can help reduce stress and support overall blood pressure control [13].

Reducing Alcohol Intake: Excessive alcohol consumption can raise blood pressure. Moderating alcohol intake can contribute to better blood pressure management [14].

5. Scientific Evidence and Efficacy

The scientific evidence supporting many home remedies for hypertension varies. Remedies such as garlic and beet juice have demonstrated potential benefits in clinical studies [15] [16]. However, other remedies, such as olive leaf extract and CoQ10, require more research to establish their effectiveness and safety [17] [18]. It is important to consider these remedies as complementary to conventional treatments and to consult healthcare professionals before incorporating them into a hypertension management plan [19] [20].

6. Safety and Considerations

While home remedies can offer benefits, they should not replace medical treatments. It is essential to monitor blood pressure regularly and consult with healthcare providers to ensure that these remedies do not interact with prescribed medications or underlying health conditions [21]. Personalization of treatment and cautious integration of home remedies are key to effective hypertension management.

7. Future Research Directions

Further research is needed to evaluate the long-term efficacy and safety of various home remedies for high blood pressure. Clinical trials and studies focusing on the mechanisms of action and potential interactions with conventional treatments will provide valuable insights for integrating these remedies into hypertension care strategies [22].

Conclusion

Home remedies can complement conventional treatments for high blood pressure, offering potential benefits through dietary interventions, herbal treatments, and lifestyle modifications. While some remedies have scientific support, others require further investigation to confirm their effectiveness and safety. Combining home remedies with standard medical care can enhance overall hypertension management and improve cardiovascular health [23].

References

- Whelton, P.K., et al. (2018). 2017 High Blood Pressure Clinical Practice Guidelines. *Journal of the American College of Cardiology*, 71(19), 127-248.
- Mills, K.T., et al. (2020). Global Disparities of Hypertension Prevalence and Control: A Systematic Review. *Circulation*, 142(4), 442-450.
- Lawes, C.M.M., et al. (2008). Blood Pressure and Risk of Cardiovascular Diseases: A Review. *Journal of Hypertension*, 26(10), 1867-1876.
- Muntner, P., et al. (2019). The Role of Lifestyle Modifications in Blood Pressure Control. *Hypertension*, 73(1), 21-31.

- Ried, K., et al. (2016). Garlic Lowers Blood Pressure in Hypertensive Adults. *Journal of Nutrition*, 146(3), 489-496.
- sieminska, S., et al. (2017). Beetroot Juice and Its Effect on Blood Pressure: A Review. *Nutrition Reviews*, 75(6), 478-490.
- Budzynska, A., et al. (2013). Hibiscus Tea Consumption and Its Effect on Blood Pressure: A Systematic Review. *American Journal of Hypertension*, 26(6), 821-827.
- Harris, W.S., et al. (2009). Omega-3 Fatty Acids and Cardiovascular Outcomes: A Systematic Review. *Journal of the American College of Cardiology*, 54(6), 550-560.
- Tsi, D., et al. (2014). Hawthorn Extracts and Their Effect on Blood Pressure: A Systematic Review. *Phytotherapy Research*, 28(8), 1159-1168.
- Rosenfeldt, F.L., et al. (2007). Coenzyme Q10 in the Treatment of Hypertension: A Systematic Review. *Journal of Human Hypertension*, 21(9), 702-709.
- Rizzo, M., et al. (2013). Olive Leaf Extract and Its Effect on Blood Pressure and Lipid Profile: A Review. *Phytotherapy Research*, 27(2), 160-167.
- Cornelissen, V.A., et al. (2013). Exercise Training for Hypertension: A Systematic Review and Meta-Analysis. *Journal of Hypertension*, 31(2), 256-270.
- Choi, T.S., et al. (2018). Stress Reduction Techniques and Their Impact on Blood Pressure: A Meta-Analysis. *Journal of Behavioral Medicine*, 41(5), 688-698.
- Roerecke, M., et al. (2018). Alcohol Consumption and Hypertension: A Review of the Evidence. *Hypertension*, 72(6), 1132-1142.
- Sobenin, I.A., et al. (2017). Garlic and Its Effect on Blood Pressure: A Comprehensive Review. *Journal of Clinical Medicine*, 6(9), 91.
- McCall, M.R., et al. (2014). Beet Juice and Blood Pressure: A Meta-Analysis of Clinical Trials. *American Journal of Clinical Nutrition*, 100(2), 246-254.
- Cicero, A.F., et al. (2011). Olive Leaf Extract and Hypertension: A Clinical Review. *Phytotherapy Research*, 25(5), 727-732.
- Rizzo, M., et al. (2013). Coenzyme Q10 and Blood Pressure: A Review. *Journal of Clinical Medicine*, 2(4), 432-441.
- Silagy, C.A., & Neil, H.A. (1994). Garlic as a Treatment for Hypertension: A Systematic Review. *Journal of Hypertension*, 12(7), 877-883.
- Zeng, X., et al. (2020). Effect of Garlic on Blood Pressure: A Meta-Analysis of Randomized Controlled Trials. *Journal of Hypertension*, 38(4), 654-660.
- Moser, M., et al. (2019). Integrating Home Remedies with Conventional Hypertension Treatments: Safety Considerations. *Hypertension Research*, 42(9), 1361-1367.

**THE IMPACT OF SOCIAL MEDIA INFLUENCERS ON FINANCIAL DECISION-
MAKING AMONG MALAYSIAN YOUTH: A CONCEPTUAL FRAMEWORK**

Ong Hock Siong

Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, 31900
Kampar, Perak, Malaysia

KongYin Mei

Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, 31900
Kampar, Perak, Malaysia

Cheah Chee Keong

Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, 31900
Kampar, Perak, Malaysia

Adam Arif Lee Aik Keang

Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, 31900
Kampar, Perak, Malaysia

Wong Kok Yaw

Faculty of Accountancy, Finance & Business, Tunku Abdul Rahman University of Management and
Technology, Malaysia

Nakesvari A/P Shanmugam

Faculty of Accountancy, Finance & Business, Tunku Abdul Rahman University of Management and
Technology, Malaysia

ABSTRACT

The rapid growth of social media influencers has significantly shaped the behaviour and attitude towards decision-making of the young generation, especially in financial decision-making. In the Malaysian context, due to the high usage of social media, youths' attitudes and behaviours in making financial decisions such as spending, investing, and saving are significantly influenced by these influencers. This study will investigate the influence of social media influencers on financial decision-making among Malaysian youth. The study will investigate how perceived trust in influencers, perceived expertise, and the engagement of financial content influence youth financial decision-making. This study will explore influencers' engagement in promoting various financial products and services, investment strategies, and spending habits toward shaping their financial attitude and behaviours. This study utilizes a quantitative survey method to collect data from Malaysian youth on their experience with financial advice from social media influencers and the results from these advices. This study analyzed several key variables in financial literacy and financial behavior,

such as trust, influencer credibility, and content relevance. The objective of this study is to identify how social media influencers affect both positive and negative financial practices among Malaysian youth. Policymakers, educators, and financial services providers would have a better understanding of these dynamics when developing strategies to promote responsible financial decision-making in the digital era and enhance financial literacy among the younger population.

Keywords: Social media influencers, financial decision-making, Malaysian youth

INVESTIGATING HOW SULTANA RAZIA CAME TO POWER

Nasrin Rezai

ABSTRACT

Sultana Razia, was the first Muslim female ruler. In 634 AH, with Delhi as her capital in India, she ascended to power. She was appointed as the successor by her father, Shamsuddin Iltutmish. However, due to being A woman, she faced opposition from the court ministers and officials. Instead of her, her brother, Ruknuddin Firuz Shah ascended to the throne with the support of the nobles and Shah Turkan in 634 AH. However, Ruknuddin`s incompetence in governance and Shah Turkan`s cruelty led to public discontent and rebellions against his rule. As a result of these rebellions, Ruknuddin and his mother were arrested and imprisoned. In this manner, Sultana Razia assumed power in 634 AH, taking control of the Delhi government. The present article uses library research to describe and analyze how Sultana Razia came to power, the challenges and difficulties she faced before and after ascending to power, her actions, and the problems that led to her decline and the fall of her rule.

Keywords: Sultana Razia, Iltutmish, Delhi, Ruknuddin Shah, India

HOME REMEDIES FOR TUBERCULOSIS: AN OVERVIEW OF TRADITIONAL AND NATURAL APPROACHES TO COMPLEMENT MODERN TREATMENT

Disha, Mahendra Kumar Savita

Naraina Vidyapeeth Engineering and Management Institute, Kanpur, UP, India -208020

ABSTRACT

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains a significant global health threat, particularly in low- and middle-income countries. While modern medicine has led to the development of effective antibiotic treatments, the rise of drug-resistant TB strains has rekindled interest in complementary therapies, including home remedies and traditional practices. This article reviews various natural remedies that have historically been used alongside medical treatments for TB. It explores the potential benefits and limitations of remedies like garlic, ginger, honey, herbs, and nutritional strategies, emphasizing the need for scientific research to confirm their efficacy.

Keywords: tuberculosis, home remedies, herbal medicine, natural treatments, antimicrobial herbs, TB management, drug-resistant TB, immune support, traditional remedies, nutrition in TB

1. Introduction

Tuberculosis (TB) remains one of the world's most lethal infectious diseases, affecting millions annually. Although modern treatment regimens consisting of antibiotics like rifampicin, isoniazid, ethambutol, and pyrazinamide are effective, challenges such as drug resistance, side effects, and long treatment durations have led many to explore natural remedies as adjunct therapies. This article reviews home remedies that have been traditionally used to complement modern TB treatment, including herbal medicine, dietary interventions, and other natural approaches that aim to boost immunity, reduce symptoms, and enhance overall recovery.

2. The Role of Home Remedies in TB Management

While home remedies cannot replace standard antibiotic therapy, they may play a supportive role by strengthening the immune system, alleviating symptoms, and reducing inflammation. In many traditional healing systems, herbs, foods, and lifestyle practices are used to enhance the body's resistance to infection and promote healing. Below, we review some commonly used remedies for tuberculosis.

3. Garlic (*Allium sativum*)

Garlic has long been recognized for its antimicrobial and immune-boosting properties. Allicin, a sulfur compound found in garlic, exhibits strong antibacterial activity against a wide range of pathogens, including *Mycobacterium tuberculosis*. Studies have demonstrated that garlic can enhance the immune response by stimulating the activity of macrophages and lymphocytes, key components of the body's defense against TB.

Garlic can be consumed raw, added to meals, or taken as a supplement. Regular consumption may help in supporting lung health and reducing TB symptoms such as coughing and chest pain.

4. Ginger (*Zingiber officinale*)

Ginger is another potent anti-inflammatory and antimicrobial herb commonly used in traditional medicine to alleviate respiratory issues. Its active compounds, such as gingerol, have been shown to have inhibitory effects on several bacterial strains, including *Mycobacterium tuberculosis*. In addition to its antimicrobial properties, ginger is known for its ability to reduce nausea, a common side effect of TB medications.

Ginger can be consumed as a tea, added to food, or taken in supplement form to help manage the symptoms of TB and support overall immune function.

5. Honey

Honey, particularly raw and unpasteurized varieties, is well-known for its antimicrobial and anti-inflammatory properties. It has been used in traditional medicine to soothe respiratory symptoms and promote healing in TB patients. Honey's high sugar content creates an inhospitable environment for bacterial growth, and its antioxidants can help reduce lung inflammation and promote tissue repair.

Honey can be consumed directly, mixed into warm water or herbal teas, or applied topically to support wound healing and tissue regeneration in cases where TB has caused skin infections.

6. Indian Gooseberry (*Emblica officinalis*, Amla)

Indian gooseberry, or amla, is widely used in Ayurvedic medicine for its immune-boosting properties. It is rich in vitamin C, a powerful antioxidant that helps the body fight infections by enhancing the function of immune cells. Amla also contains tannins and flavonoids, which contribute to its antimicrobial effects.

Incorporating amla into the diet, either fresh or in the form of supplements, may help TB patients improve their immune responses, reduce oxidative stress, and enhance recovery.

7. Black Pepper (*Piper nigrum*)

Black pepper has been used for centuries in traditional medicine for its antimicrobial properties and its ability to improve digestion and bioavailability of other therapeutic

substances. Piperine, the active component in black pepper, enhances the absorption of curcumin and other anti-inflammatory compounds, making it a valuable addition to herbal remedies for TB .

Black pepper can be added to food or consumed with herbal teas or turmeric-based preparations to enhance their therapeutic effects.

8. Turmeric (*Curcuma longa*)

Turmeric is a powerful anti-inflammatory herb widely used in traditional medicine systems like Ayurveda. Curcumin, its active compound, has been shown to inhibit the growth of *Mycobacterium tuberculosis* in vitro, and its anti-inflammatory properties can help reduce lung inflammation and improve respiratory function in TB patients .

Turmeric can be consumed as part of the diet or taken as a supplement. When combined with black pepper, its bioavailability is significantly increased, enhancing its potential therapeutic effects.

9. Nutritional Support in TB Management

Good nutrition is critical for TB patients, as the disease often leads to malnutrition and weight loss. Adequate intake of protein, vitamins (especially vitamin D and C), and minerals (such as zinc) can support the immune system and accelerate recovery. Foods rich in these nutrients include:

Eggs and Lean Meats: Provide high-quality protein essential for tissue repair.

Fruits and Vegetables: Offer a variety of vitamins, minerals, and antioxidants to boost the immune system.

Whole Grains: Provide energy and support overall health.

Milk and Dairy Products: Rich in calcium and vitamin D, important for lung health.

Improving nutritional intake can help TB patients maintain weight, support immune function, and improve treatment outcomes.

10. Eucalyptus Oil

Eucalyptus oil is often used in traditional medicine to relieve respiratory symptoms. Its antibacterial properties, along with its ability to act as a decongestant, make it useful in managing TB symptoms such as cough and chest congestion. Inhalation of eucalyptus oil steam can help clear the respiratory tract, reduce mucus buildup, and ease breathing difficulties.

Eucalyptus oil should be used with caution, as it can be irritating if used in high concentrations or ingested. It is most effective when used as part of steam therapy or applied topically in diluted form.

11. Limitations and Risks of Home Remedies for TB

While home remedies may offer supportive benefits for TB patients, they should never replace conventional antibiotic treatment. Failure to complete prescribed antibiotics can lead to drug resistance, prolonged illness, and transmission of the disease. Additionally, some natural remedies may interact with TB medications or cause allergic reactions in some individuals. Therefore, it is essential to consult healthcare professionals before using any home remedy as part of a TB treatment plan.

12. Conclusion

Home remedies, including herbal treatments, nutritional support, and natural therapies, can play a complementary role in managing tuberculosis. Remedies like garlic, ginger, honey, turmeric, and nutritional strategies offer potential benefits for immune support and symptom relief. However, it is important to emphasize that these remedies should only be used alongside, not as a substitute for, conventional medical treatment. More research is needed to scientifically validate the efficacy of these natural therapies and to determine safe and effective dosages for TB management.

References

- Banerjee, A., et al. "Antimicrobial Activity of Allicin from Garlic: Its Role in Tuberculosis Treatment." *Journal of Antimicrobial Chemotherapy*, vol. 68, no. 1, 2013, pp. 128-135.
- Prasad, S., & Tyagi, A. K. "Ginger and Its Constituents: Role in Prevention and Treatment of Tuberculosis." *Phytotherapy Research*, vol. 29, no. 12, 2015, pp. 1859-1867.
- Molan, P. C. "Potential of Honey in the Treatment of Tuberculosis." *International Journal of Clinical Medicine*, vol. 4, no. 9, 2013, pp. 91-95.
- Singh, R., et al. "Phytotherapeutic Role of Indian Gooseberry in Pulmonary Tuberculosis." *Journal of Herbal Medicine*, vol. 6, no. 2, 2014, pp. 65-73.
- Suresh, D., & Srinivasan, K. "Black Pepper (*Piper nigrum*) and Its Biologically Active Compound Piperine: A Review." *Journal of Food Biochemistry*, vol. 34, no. 6, 2010, pp. 1231-1245.
- Tóth, P., et al. "Antimycobacterial Activity of Curcumin Against *Mycobacterium Tuberculosis*." *Fitoterapia*, vol. 92, no. 1, 2014, pp. 55-62.
- Cegielski, J. P., et al. "The Role of Nutrition in Tuberculosis Management." *The American Journal of Clinical Nutrition*, vol. 80, no. 2, 2012, pp. 321-329.
- Trillini, M., et al. "Eucalyptus Oil and Respiratory Relief: A Natural Complement to TB Treatment." *Respiratory Medicine*, vol. 10, no. 3, 2017, pp. 156-162.
- Horne, D. J., et al. "Treatment of Drug-Resistant Tuberculosis: Home Remedies and Challenges." *Infectious Disease Clinics of North America*, vol. 30, no. 2, 2016, pp. 325-

**EVALUATION OF FUEL CELL TECHNOLOGIES AS A CLEAN ENERGY
ALTERNATIVE IN MARITIME INDUSTRY**

Sertaç BULUT

Assist. Prof. Dr., İzmir Kâtip Çelebi University, Faculty of Naval Architecture and Maritime, Department of
Naval Architecture and Marine Engineering

ORCID NO: 0000-0002-4994-8148

ABSTRACT

Fuel cells are innovative energy production technologies that offer high efficiency and low emissions. In the maritime industry, the potential of these systems serves as an important bridge between clean energy solutions and environmental sustainability. These technologies not only offer a cleaner alternative but also provide reliable and efficient power, which is crucial for the maritime sector. This study provides a comparative evaluation of different fuel cell systems used in maritime applications and examines the advantages these technologies offer. Proton exchange membrane fuel cells (PEMFC), solid oxide fuel cells (SOFC), and molten carbonate fuel cells (MCFC) are investigated, along with their diverse applications in the maritime sector. The general operating principles, efficiency, fuel tolerances, and innovations of these fuel cell systems in maritime applications are evaluated. Furthermore, the ability of fuel cells to reduce environmental impacts makes them an appealing solution for the industry's growing need for sustainability. Compared to conventional systems, fuel cells represent a promising alternative for sustainable ship energy systems, with lower emissions, improved energy efficiency, and reduced environmental impact. In conclusion, the widespread use of these technologies is expected to play a crucial role in reducing the maritime industry's carbon footprint, making them an essential component of future clean energy solutions.

Keywords: Fuel Cell, Energy Efficiency, Clean Energy, Maritime Industry, Environmental Sustainability.

INTRODUCTION

The maritime industry is increasingly focusing on sustainable energy solutions, and fuel cell technologies have emerged as a promising alternative due to their high efficiency and low environmental impact. As the shipping sector produces a significant part of global emissions, there is a pressing need to explore clean energy options to reduce pollutants such as CO₂, NO_x, and SO_x. Fuel cells offer an innovative approach by converting chemical energy directly into electrical energy without the combustion process, making them suitable for maritime applications where noise reduction, lower emissions, and fuel flexibility are essential.

Consequently, fuel cells represent a crucial step towards achieving greener maritime operations and meeting stringent international regulations.

Regulations on carbon emissions and pollutants are becoming increasingly stringent for the maritime sector. International shipping activities emitted approximately 800 million tons of CO₂ in 2012, accounting for about 2.2% of total global carbon emissions (Third IMO GHG Study 2014). In the same year, NO_x and SO_x emissions from ships made up 15% and 13% of the global totals, respectively. (Fan et al., 2018). These high emission levels have encouraged the maritime industry to adopt cleaner energy alternatives. The International Maritime Organization (IMO) has introduced new regulations under MARPOL Annex VI, imposing strict limits on NO_x and SO_x emissions (Ling-Chin and Roskilly, 2016; Moreno-Gutiérrez et al., 2019). As it becomes challenging for conventional diesel engines to comply with these regulations, the industry is considering alternative energy sources like fuel cells, which have the potential to reduce emissions and improve energy efficiency.

Among fuel cell technologies, Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC), and Molten Carbonate Fuel Cells (MCFC) are the most widely used in the maritime sector. PEMFCs are known for their low operating temperatures and high power density, making them particularly efficient when using hydrogen as fuel. SOFCs, on the other hand, operate at high temperatures, allowing them to directly utilize a variety of fuels such as ammonia and low-sulfur diesel. MCFCs stand out for their ability to efficiently convert carbon-based fuels at high temperatures, making them effective in reducing CO₂ emissions (Yan et al., 2020; Sohani et al., 2020). When there is a high power requirement and hydrogen storage onboard becomes challenging, SOFC and MCFC are the preferred choices (Inal, 2022).

PEMFC applications in the maritime sector have shown a wide range of successful implementations. In the ZEMSHIP project, a zero-emission passenger vessel was constructed in Hamburg, featuring two PEM fuel cells with 48 kW power each and a total battery capacity of 560V (Schneider et al., 2010; Vogler and Würsig, 2011). As a result, the vessel operated for over 2,500 hours, achieving a yearly reduction of 47,000 kg in CO₂ emissions compared to diesel-electric ships. The MARANDA project demonstrated a 165 kW PEMFC system on a research vessel under Arctic conditions, proving the technology's robustness and adaptability. The DESIRE project focused on developing hydrogen production using a diesel reformer for PEMFCs, which was successfully implemented on a naval ship (Krummrich et al., 2006). Additionally, projects such as the Ship Hybridisation (ISHY) and H2SHIPS have further explored the integration and viability of PEMFCs in maritime applications. The SF-BREEZE project developed a concept for an aluminum ferry powered by 41 PEM fuel cell units of 120 kW each, demonstrating the potential for large-scale PEMFC use in marine applications (Pratt and Klebanoff, 2016). Similarly, the Pa-X-ell project utilized high-temperature PEM fuel cells in combination with a methanol reformer to reduce emissions on a passenger ship, demonstrating effective heat and power generation (Tronstad et al., 2017).

SOFC applications have also shown promising results in maritime projects. The METHAPU project investigated the feasibility of using a 20 kW SOFC unit with methanol as fuel on a RoRo vessel, successfully demonstrating over 700 hours of continuous operation (Tronstad et al., 2017). The SchIBZ project evaluated the application of SOFCs in commercial vessels, developing a system capable of generating 50 to 500 kW of power using low-sulfur diesel, with an electrical efficiency of 50% (Leites et al., 2012; e4ships, 2022). Furthermore, the PACBOAT and Nautical Integrated Hybrid Energy System for Long-haul Cruise Ships (NAUTILUS) projects have developed SOFC systems powered by LNG, demonstrating their potential for use on large cruise ships. The FELICITAS project aimed to maximize efficiency and minimize hazardous emissions with a 250 kW SOFC system, achieving high efficiency levels of over 60%, thereby proving the feasibility of SOFCs for maritime applications (FELICITAS, 2009).

MCFC applications have also been tested in maritime settings. The FellowSHIP project, which implemented a 320 kW LNG-powered MCFC system on the Viking Lady, demonstrated over 18,500 hours of continuous operation with no NO_x, SO_x, or particulate matter emissions (Inal and Deniz, 2018; McConnell, 2010; Tronstad et al., 2017). The MC-WAP project further explored the use of a 150 kW MCFC system fueled by diesel, showing that the high-temperature operation of MCFCs could efficiently utilize exhaust gases for additional power generation. Additionally, the ship service fuel cell (SSFC) and fuel cell technology for ships (FCSHIP) projects investigated the use of MCFCs in ship services, revealing the system's efficiency and environmental advantages (Allen et al., 1998; Privette et al., 2002; Bourne et al., 2001; Alkaner and Zhou, 2006).

This study aims to evaluate the potential of Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC), and Molten Carbonate Fuel Cells (MCFC) within the maritime industry. The evaluation includes key performance parameters such as efficiency, operating temperature, fuel flexibility, power density, power capacity, physical size, environmental impact, cost, and lifetime. This research provides a comprehensive assessment of the applicability and feasibility of these fuel cell technologies for various types of ships. By highlighting the advantages and potential challenges associated with each fuel cell type, this evaluation aims to inform future strategies for integrating fuel cell technology into marine applications, ultimately supporting the industry's transition towards more sustainable and energy-efficient solutions.

RESEARCH AND FINDINGS

Overview of PEMFC, SOFC, and MCFC Fuel Cell Systems

This section presents detailed information on the general characteristics and technical specifications of PEMFC, SOFC, and MCFC systems. Proton Exchange Membrane Fuel Cells (PEMFCs) are known for their versatility and broad range of applications, making them one of the most promising fuel cell types for widespread implementation (Sharaf and Orhan,

2014). PEMFCs typically operate at low temperatures, between 60-180°C (Tronstad et al., 2017), utilizing an ion-exchange membrane as the electrolyte, which conducts protons while acting as an electrical insulator. The membrane's functionality is dependent on maintaining humidity, as this allows for effective proton transfer. PEMFCs primarily use hydrogen as fuel, which reacts with oxygen to produce water, electricity, and heat in an exothermic reaction. This system's efficiency generally ranges between 40-60%, with advantages like flexible operation, relatively simple water management, and less stringent material requirements. However, platinum-based catalysts are required, making PEMFCs sensitive to impurities like carbon monoxide, which can poison the catalyst (Baschuk and Li, 2001). The electrochemical reactions in PEMFC are shown in Equations 1, 2, and 3 (Mench, 2008). Table 1 presents an overview of the key features of PEMFC (Ebrahimi et al., 2021; Inal and Deniz, 2018; Sharaf and Orhan, 2014; Tronstad et al., 2017). Figur 1 presents a schematic representation of Proton Exchange Membrane Fuel Cell.

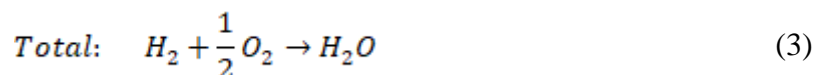
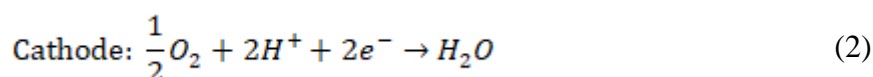


Table 1. Characteristics of PEMFC (Ebrahimi et al., 2021; Inal and Deniz, 2018; Sharaf and Orhan, 2014; Tronstad et al., 2017)

Parameter	Electrolyte	Fuel Options	Emissions	Efficiency	Temperatures
Value	Proton Exchange Membrane	Hydrogen	Water	%40-60	60 – 180 °C

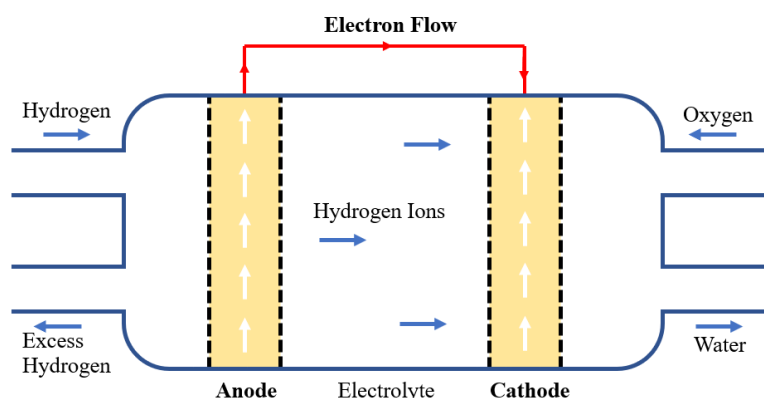


Figure 1. Schematic representation of PEMFC.

Solid Oxide Fuel Cells (SOFCs) are high-temperature fuel cells that typically operate between 800-1000°C (Marefati and Mehrpooya, 2019; Mench, 2008). SOFCs use a solid-state electrolyte made of yttrium-stabilized zirconia, enabling the conduction of oxygen ions at

these high temperatures (Tronstad et al., 2017). The high operating temperature of SOFCs facilitates faster electrochemical reaction kinetics, allowing them to achieve electrical efficiencies ranging from 40-70%. Furthermore, due to their high operating temperature, SOFCs are well-suited for combined heat and power (CHP) systems, where total efficiency can reach 75-80% (Tronstad et al., 2017). SOFCs can accommodate a variety of fuels, such as LNG, methanol, and hydrogen, without requiring an external reforming unit since fuel reforming occurs directly within the fuel cell. This flexibility in fuel usage is a significant advantage of SOFCs in maritime applications. However, the high temperatures required for SOFC operation result in certain disadvantages, such as slow startup times, the need for robust thermal insulation, and potential challenges with material degradation due to thermal cycling. The electrochemical reactions for SOFC are detailed in Equations 4, 5, and 6 (Mench, 2008). Table 2 summarizes the key features of SOFC (Sharaf and Orhan, 2014; Tronstad et al., 2017). Figure 2 presents a schematic representation of Solid Oxide Fuel Cell.

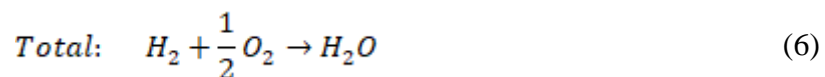
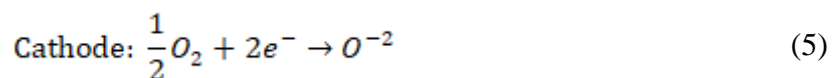
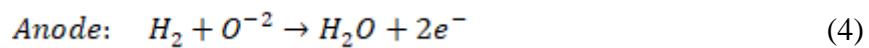


Table 2. Characteristics of SOFC (Sharaf and Orhan, 2014; Tronstad et al., 2017)

Parameter	Electrolyte	Fuel Options	Emissions	Efficiency	Temperatures
Value	Ceramic that conducts oxide ion	Natural Gas, Diesel, Hydrogen	CO ₂ (with carbon included fuel)	%40-70	800 – 1000 °C

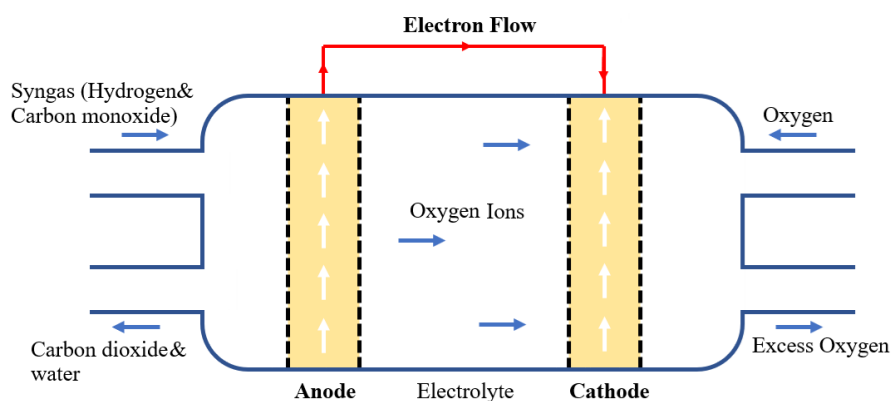


Figure 2. Schematic representation of SOFC.

Molten Carbonate Fuel Cells (MCFCs) operate at temperatures ranging from 600-700°C, which enhances ion conductivity and eliminates the need for costly catalysts like platinum (Marefati and Mehrpooya, 2019). MCFCs use a molten carbonate electrolyte composed of

alkali metal carbonates, and the fuel cell's electrodes are typically made of nickel at the anode and nickel oxide at the cathode (Mench, 2008). Due to their high operating temperatures, MCFCs achieve electrical efficiencies of 50-60%, which can be increased to around 85% when used in cogeneration systems (Tronstad et al., 2017). With the ability to reform hydrocarbon fuels such as natural gas, diesel, and hydrogen directly within the cell, MCFCs do not require an external reformer and increases their fuel flexibility. Despite their advantages, MCFCs have some drawbacks, including a slow startup process, low power density, and challenges with high-temperature corrosion and material cracking (Inal, 2022). MCFCs are typically used in applications requiring high energy demand, such as industrial power generation and large-scale marine applications, where their fuel flexibility and high efficiency offer substantial benefits. The electrochemical reactions for Molten Carbonate Fuel Cells are presented in Equations 7, 8, and 9 (Mench, 2008). Table 3 provides a summary of the key features of MCFC (Sharaf and Orhan, 2014; Tronstad et al., 2017). Figure 3 presents a schematic representation of Molten Carbonate Fuel Cell.

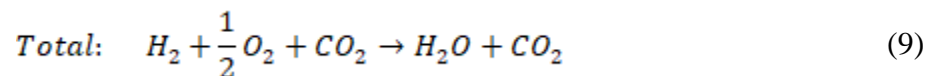
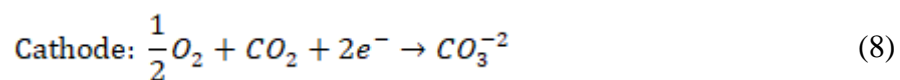
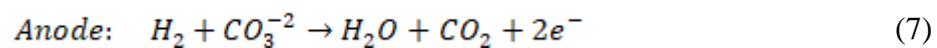


Table 3. Characteristics of MCFC (Sharaf and Orhan, 2014; Tronstad et al., 2017)

Parameter	Electrolyte	Fuel Options	Emissions	Efficiency	Temperatures
Value	Molten mixture of alkali metal carbonates	Natural Gas, Diesel, Hydrogen	CO ₂ (with carbon included fuel)	%50-60	600 – 700 °C

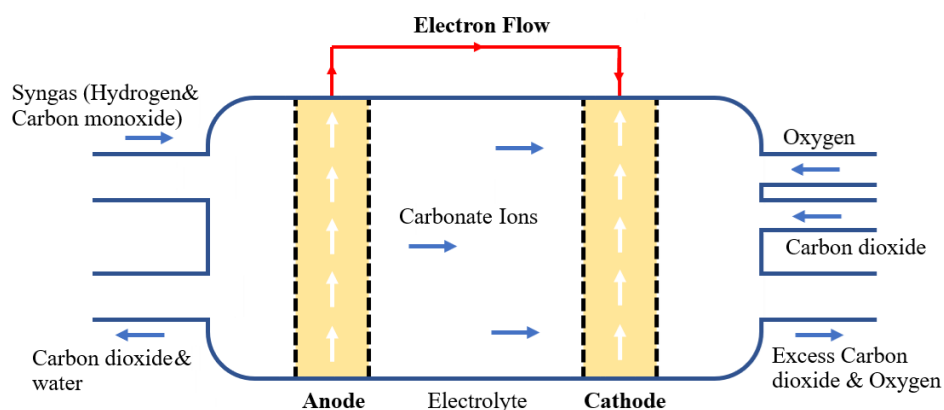


Figure 3. Schematic representation of MCFC.

Comparative Analysis of Fuel Cell Systems for Maritime Applications

In this section, PEMFC, SOFC, and MCFC systems have been comparatively evaluated by considering performance parameters. Efficiency, operating temperature, fuel flexibility, physical size, environmental impact, power density, power capacity, cost and lifetime are considered as performance parameter. Based on the capabilities of the fuel cell systems according to performance parameters, their availability for different types of ships has been comprehensively investigated.

Fuel cell systems offer varying efficiencies depending on their type and operating conditions. PEMFCs typically achieve electrical efficiencies ranging from 50-60%, making them effective for the direct conversion of hydrogen into electricity (Tronstad et al., 2017). However, due to their lower operating temperature (50-100°C), they have limited potential for combined heat and power (CHP) applications, as there isn't sufficient waste heat for additional power generation (Dai et al., 2009). In contrast, SOFCs and MCFCs operate at much higher temperatures, around 500-1000 °C and 600-800 °C respectively, allowing them to utilize waste heat effectively (Mench, 2008). This ability to integrate with CHP systems results in total efficiencies reaching 70-80% for SOFCs and up to 85% for MCFCs, making them more advantageous in applications where both electricity and heat are needed (Tronstad et al., 2017; De-Troya et al., 2016).

The operating temperature is a crucial factor influencing the performance and adaptability of each fuel cell type. PEMFCs operate at relatively low temperatures, ensuring quick start-up and simplified thermal management, which makes them suitable for applications requiring rapid responses. However, their low temperature also means they are more sensitive to fuel impurities and require high-purity hydrogen (Baschuk and Li, 2001). On the other hand, SOFCs and MCFCs, with their high operating temperatures, can directly use a wide range of hydrocarbon fuels without needing external reformers (Tronstad et al., 2017; Marefati and Mehrpooya, 2019). This enhances their fuel flexibility but results in longer start-up times and requires robust thermal management systems to handle the high heat (Tronstad et al., 2017). Table 4 presents an overview of efficiency, operating temperature, and fuel flexibility for PEMFC, SOFC, and MCFC systems (Tronstad et al., 2017).

Table 4. Overview of efficiency, operating temperature, and fuel flexibility for PEMFC, SOFC, and MCFC systems (Tronstad et al., 2017).

Fuel Cell	Efficiency	Operating Temperature	Fuel Flexibility
PEMFC	%50-60 (electrical)	50-100 °C	Hydrogen
SOFC	%60 (electrical) %70-80 (with heat recovery)	500-1000 °C	LNG, Methanol, Diesel, Hydrogen
MCFC	%50 (electrical) %85 (with heat recovery)	600-800 °C	LNG, Methanol, Diesel, Hydrogen

Fuel flexibility is a significant advantage for SOFCs and MCFCs, as they can operate using a variety of fuels, including hydrogen, LNG, diesel, and ammonia (van Biert et al., 2016; De-Troya et al., 2016). This versatility makes them more adaptable for maritime applications where different fuel types may be required based on availability and cost. In contrast, PEMFCs predominantly rely on high-purity hydrogen, limiting their adaptability (Baschuk and Li, 2001). When hydrocarbons are used, PEMFCs need an external reforming process to purify hydrogen, which adds complexity and cost, making them less practical in environments where multiple fuel sources are needed (Sasank et al., 2016).

The size and power density of these fuel cell systems also vary considerably. PEMFCs are known for their high power density, with specific power values ranging from 125 to 750 W/kg and power density from 50 to 400 W/L (van Biert et al., 2016). This makes them highly suitable for applications with limited space, such as smaller vessels or as auxiliary power sources on larger ships. For example, a PEMFC model like “FCe 150” can produce 150 kW of power while occupying just 0.66 m³ of space, underscoring its compactness and effectiveness for transport applications (Minnehan and Pratt, 2017). In contrast, SOFCs and MCFCs have lower power densities, primarily due to their high-temperature components and the need for insulation (Mench, 2008). Furthermore, high-temperature systems like MCFC and SOFC also require additional fuel processing equipment when using fuels such as diesel or LNG, which increases both volume and mass (Inal, 2022). For instance, the SureSource 3000 (MCFC) model can generate 2800 kW of power but requires a volume of 252 m³ (Minnehan and Pratt, 2017). As a result, these fuel cells are more suitable for larger vessels, such as cargo or special-purpose ships, where space constraints are less critical.

In terms of environmental impact, PEMFCs produce only water as a byproduct when using hydrogen, making them the cleanest option among the three systems (Tronstad et al., 2017). SOFCs and MCFCs emit CO₂ when operating with carbon-based fuels, but their overall emissions are still significantly lower than conventional diesel engines (Bourne et al., 2001). SOFCs produce minimal NO_x emissions due to their high operating temperatures, but small amounts of NO_x may form in auxiliary equipment or side processes, such as externally heated fuel reformers or burners. MCFCs can capture and reuse carbon dioxide from the fuel stream, providing a significant opportunity for integrating carbon capture technologies (Tronstad et al., 2017). Table 5 presents an overview of size, emissions, relative cost and power density for PEMFC, SOFC, and MCFC systems.

Table 5. Overview of size, emissions, relative cost and power density for PEMFC, SOFC, and MCFC systems (Tronstad et al., 2017).

Fuel Cell	Physical size	Environmental impact	Cost	Power Capacity
PEMFC	Small	No	Low	Up to 120 kW
SOFC	Medium	CO ₂ and low levels of NO _x (with carbon fuel)	High	20-60 kW
MCFC	Large	CO ₂ and low levels of NO _x (with carbon fuel)	High	Up to 500 kW

The cost of fuel cells is a critical factor in determining their viability for large-scale use. PEMFCs are currently more expensive due to the use of platinum catalysts, which increase both material and production costs. Furthermore, PEMFCs require high-purity hydrogen and complex storage and handling systems, adding to the overall expense. However, advancements in technology and economies of scale are expected to reduce the cost of PEMFCs as production increases (Tronstad et al., 2017). On the other hand, SOFCs and MCFCs also have high initial capital costs due to their use of complex, high-temperature materials and components, but they offer significant long-term advantages. These systems can utilize a wider variety of fuels, including natural gas and biogas, which can lead to potential fuel savings. Moreover, their higher efficiency and potential for combined heat and power (CHP) applications may result in long-term cost advantages as operating expenses are lowered through fuel efficiency (van Biert et al., 2016).

The lifetime of fuel cells is strongly influenced by their operating temperatures, with higher temperatures causing thermal stresses that limit durability (Dodds et al., 2015). SOFCs have shown significant improvements, now achieving lifespans of 40,000 to 80,000 hours, and some even up to 90,000 hours in specific cases (Ellamla et al., 2015). MCFCs, however, typically last between 15,000 to 30,000 hours due to their high-temperature operation and corrosive electrolytes (Elkafas et al., 2022). PEMFCs offer lifetimes of 60,000 to 80,000 hours in stationary applications, with stack replacements needed every 20,000 to 30,000 hours. In transport applications, they typically exceed 25,000 hours (Ellamla et al., 2015; Staffell, 2015). For shipping, where vessels run 4,000 to 6,500 hours annually, stack replacements are the most significant maintenance event, directly affecting long-term cost efficiency

CONCLUSION

In this study, Proton Exchange Membrane Fuel Cells, Molten Carbonate Fuel Cells, and Solid Oxide Fuel Cells, which are the most commonly used in the maritime industry, have been comprehensively evaluated based on specific performance parameters. The performance parameters include efficiency, operating temperature, fuel flexibility, power density, power capacity, physical size, environmental impact, cost, and lifetime. Based on the results of these evaluations, recommendations have been made regarding which types of ships are more

suitable for PEMFC, SOFC, and MCFC systems, according to their characteristics in terms of performance parameters.

Proton Exchange Membrane Fuel Cells (PEMFCs) are characterized by their low operating temperature and high efficiency, achieving electrical efficiencies between 50-60%. Their fast start-up times and high power density make them particularly suitable for short-range vessels and smaller ships, such as ferries, passenger vessels, RO-RO ships, and small craft, where weight and space are crucial considerations. PEMFCs' ability to operate efficiently at low power output also makes them well-suited for auxiliary power units (APUs) and distributed generation in maritime applications. However, their lower operating temperature limits the amount of waste heat produced, making integration with combined heat and power (CHP) systems less effective. Additionally, PEMFC systems are highly dependent on high-purity hydrogen, which can increase complexity and cost when hydrocarbons are used, as external reformers are required to purify the hydrogen. These characteristics make PEMFCs an ideal choice for vessels operating over short distances or those not requiring continuous high power output, particularly in scenarios where hydrogen storage infrastructure is available.

Molten Carbonate Fuel Cells (MCFCs) and Solid Oxide Fuel Cells (SOFCs) are both highly suitable for large-scale maritime operations, but their specific applications vary depending on their technical characteristics and operational requirements. MCFCs, operating at temperatures around 600-800°C, offer flexibility in fuel usage, utilizing hydrogen, methanol, and hydrocarbons, making them particularly advantageous for long-distance commercial operations. Their ability to efficiently use hydrocarbon fuels without extensive hydrogen storage infrastructure makes them ideal for large cargo ships, container vessels, and tankers, where fuel availability and efficiency over long distances are essential. Additionally, MCFCs have the potential for carbon capture and reuse from the fuel stream, providing an environmental benefit that aligns with stricter maritime emissions regulations. However, due to the corrosive nature of the molten electrolyte, MCFCs have a shorter operational lifespan compared to SOFCs, leading to faster degradation and higher maintenance costs.

SOFCs operate at even higher temperatures (500-1000°C) and are known for their remarkable fuel flexibility, allowing them to utilize a range of fuels such as hydrogen, methanol, and natural gas without the need for external reformers. This makes them particularly suitable for long-range vessels that require continuous power over extended periods. SOFCs' high operating temperature also allows for efficient waste heat recovery, which can be integrated into combined heat and power (CHP) systems, resulting in total efficiencies of up to 70-80%. This efficiency, combined with the ability to meet both electricity and heat demands, makes SOFCs ideal for cruise ships, large cargo ships, and offshore support ships, where continuous high power is required. While SOFC systems have slower start-up times and more complex thermal management, their long operational lifetime, up to 80,000 hours, makes them a reliable long-term solution for large vessels engaged in long-distance operations.

This study presents a comprehensive evaluation of Proton Exchange Membrane Fuel Cells, Molten Carbonate Fuel Cells and Solid Oxide Fuel Cells which are commonly used in the maritime industry. This research offers guidance, particularly for researchers focusing on fuel cell system applications for specific types of ships. In the future, this study can be expanded by examining different performance parameters, modeling the applications of fuel cell systems for various ship designs in more detail, and conducting engineering calculations.

Acknowledgement

*This research is supported by Izmir Katip Çelebi University Scientific Research Projects Commission (BAP) under Project Number 2024-GAP-GİDF-0010 within the framework of the project titled “Green Transition in Blue Voyage: Eco-Friendly Tırhandil Design with Fuel Cell Technology”.

REFERENCES

- Alkaner, S., & Zhou, P. (2006). A comparative study on life cycle analysis of Molten carbon fuel cells and diesel engines for marine application. *Journal of Power Sources*, 158, 188–199.
- Allen, S., Ashe, E., Gore, D., & Woerner, J. (1998). Marine applications of fuel cells: a multi-agency research program. *Naval Engineers Journal*, 110, 93–106.
- Baschuk, J. J., & Li, X. (2001). Carbon monoxide poisoning of proton exchange membrane fuel cells. *International Journal of Energy Research*, 25(8),
- Bourne, C., Nietsch, T., Griffiths, D., & Morley, J. (2001). Application of Fuel Cells in Surface Ships. *Harwell Laboratory*.
- Dai, W., Wang, H., Yuan, X. Z., Martin, J. J., Yang, D., Qiao, J., & Ma, J. (2009). A review on water balance in the membrane electrode assembly of proton exchange membrane fuel cells. *International Journal of Hydrogen Energy*, 34(23), 9461–9478.
- De-Troya, J. J., Álvarez, C., Fernández-Garrido, C., & Carral, L. (2016). Analysing the possibilities of using fuel cells in ships. *International Journal of Hydrogen Energy*, 41(4), 2853–2866.
- e4ships – brennstoffzellen im maritimen einsatz. <http://www.e4ships.de>. (Accessed 15 March 2022).
- Ebrahimi, M., Kujawski, W., Fatyeyeva, K. & Kujawa, J. A. (2021). Review on Ionic Liquids-Based Membranes for Middle and High Temperature Polymer Electrolyte Membrane Fuel Cells (PEM FCs). *International Journal of Molecular Sciences*, 22, 5430.
- Ellamla, H. R., Staffell, I., Bujlo, P., Pollet, B. G., & Pasupathi, S. (2015). Current status of fuel cell based combined heat and power systems for residential sector. *Journal of Power Sources*, 293, 312–328.

- Elkafas, A. G., Rivarolo, M., Gadducci, E., Magistri, L., & Massardo, A. F. (2022). Fuel cell systems for maritime: a review of research development, commercial products, applications, and perspectives. *Processes*, 11(1), 97.
- Fan, Y. Van, Perry, S., Klemeš, J. J., & Lee, C. T. (2018). A review on air emissions assessment: Transportation. *Journal of Cleaner Production*, 194, 673–684.
- FELICITAS (2009). Fuel cell power trains and clustering in heavy-duty transports. Project Proposal No: 516270. Coordinator: Matthias Klingner.
- Inal, Ö. B. (2022). *Dynamic modelling, simulation based analysis and optimization of hybrid ship propulsion systems*. M. Sc. Thesis. Istanbul Technical University.
- Inal, O.B. and Deniz, C., (2018). *Fuel Cell Availability for Merchant Ships, Proceeding of the Third International Naval Architecture and Maritime Conference*, 907-916, Turkey: Yıldız Technical University, April 24-25.
- Krummrich, S., Tuinstra, B., Kraaij, G., Roes, J., & Olgun, H. (2006). Diesel fuel processing for fuel cells—DESIRE. *Journal of Power Sources*, 160, 500–504.
- Leites, K., Bauschulte, A., Dragon, M., Krummrich, S., & Nehter, P. (2012). SchIBZ-design of different diesel based fuel cell systems for seagoing vessels and their evaluation. *ECS Transactions*, 42, 49–58.
- Ling-Chin, J., & Roskilly, A. P. (2016). A comparative life cycle assessment of marine power systems. *Energy Conversion and Management*, 127, 477-493.
- Marefati, M., & Mehrpooya, M. (2019). Introducing and investigation of a combined molten carbonate fuel cell, thermoelectric generator, linear fresnel solar reflector and power turbine combined heating and power process. *Journal of Cleaner Production*, 240, 118247.
- McConnell, V. P. (2010). Now, voyager? The increasing marine use of fuel cells. *Fuel Cells Bulletin*, (5), 12-17.
- Mench, M.M., (2008) Fuel Cell Engines. Hoboken, NJ: John Wiley & Sons Inc.
- Minnehan, J.J., & Pratt, J.W., (2017) Practical application limits of fuel cells and batteries for zero emissions vessels, Sandia Reports, SAND2017-12665, California.
- Moreno-Gutiérrez, J., Pájaro-Velázquez, E., Amado-Sánchez, Y., Rodríguez-Moreno, R., Calderay-Cayetano, F., & Durán-Grados, V. (2019). Comparative analysis between different methods for calculating on-board ship's emissions and energy consumption based on operational data. *Science of the Total Environment*, 650, 575-584.
- Pratt, J. W., & Klebanoff, L. E. (2016). Feasibility of the SF-BREEZE: A Zero-Emission, Hydrogen Fuel Cell, High-Speed Passenger Ferry. *California*
- Privette, R. M., Flynn, T. A., Perna, M. A., Holland, R., Rahmani, S., Wood-burn, C., Scoles, S. W., & Watson R. C. (2002). 2.5 MW PEM fuel cell system for navy ship service power.
- Sasank, B. V., Rajalakshmi, N., & Dhathathreyan, K. S. (2016). Performance analysis of polymer electrolyte membrane (PEM) fuel cell stack operated under marine environmental conditions. *Journal of Marine Science and Technology*, 21(3), 471–478.

- Schneider, J., Dirk, S., Stolten, D., Grube, T. (2010). ZEMShip. *18th World Hydrogen Energy Conference*, 16–21.
- Sharaf, O. Z., & Orhan, M. F. (2014). An overview of fuel cell technology: Fundamentals and applications. *Renewable and Sustainable Energy Reviews*, 32, 810–853.
- Sohani, A., Naderi, S., Torabi, F., Sayyaadi, H., Golizadeh Akhlaghi, Y., Zhao, X., ... Said, Z. (2020). Application based multi-objective performance optimization of a proton exchange membrane fuel cell. *Journal of Cleaner Production*, 252, 119567.
- Staffell, I. (2015). Zero carbon infinite COP heat from fuel cell CHP. *Applied Energy*, 147, 373–385.
- Tronstad, T., Åstrand, H. H., Haugom, G. P., & Langfeldt, L. (2017). Study on the use of Fuel Cells in Shipping. EMSA European Maritime Safety Agency.
- Van Biert, L., Godjevac, M., Visser, K., & Aravind, P. V. (2016). A review of fuel cell systems for maritime applications. *Journal of Power Sources*, 327(X), 345–364.
- Vogler, F., & Würsig, G. (2011). Fuel Cells in Maritime Applications Challenges , Chances and Experiences. *4th International Conference on Hydrogen Safety*, 1–13.
- Yan, H., Wang, G., Lu, Z., Tan, P., Kwan, T. H., Xu, H., Chen, B., Ni, M., & Wu, Z. (2020). Techno-economic evaluation and technology roadmap of the MWe-scale SOFC-PEMFC hybrid fuel cell system for clean power generation. *Journal of Cleaner Production*, 255, 120225.

MUĞLA TARİHİ KENT MERKEZİ HANLAR BÖLGESİ'NİN MEKÂNSAL
DEĞİŞİMİNİN İNCELENMESİ

ANALYSIS OF THE SPATIAL CHANGES OF THE HANS DISTRICT IN THE HISTORIC
CITY CENTER OF MUĞLA

Funda GENÇER

Dr. Öğretim Üyesi, Manisa Celal Bayar Üniversitesi, Güzel Sanatlar Tasarım ve Mimarlık Fakültesi, Mimarlık
Bölümü

*Assist. Prof. Dr., Manisa Celal Bayar University, Faculty of Fine Arts, Design and Architecture, Department of
Architecture*

ORCID ID: 0000-0003-4628-6596

ÖZET

Muğla'nın tarihi kent merkezinde bulunan Hanlar Bölgesi, şehrin ticaret ve sosyal yaşamının önemli bir merkezi olarak bilinir. Han, arasta gibi ticari yapıların ve esnaf çarşılarının yer aldığı bu bölge, Osmanlı döneminden 19.yy sonuna kadar kentin ticaret merkezi olmuştur. Hanlar Bölgesi zaman içinde değişime uğramıştır. Bazı hanlar yok olurken bazıları ise bütünlüğünü kaybetmiştir. Tarihi bölgenin mekânsal değişiminin tespiti bölge ile ilgili alınacak koruma kararları açısından önemlidir. Bu amaçla çalışma kapsamında hanlar bölgesinin mekânsal değişiminin analizi yapılacaktır. Çalışmanın amacı, Hanlar Bölgesi'nin özgün ve günümüz mekânsal kullanımını tespit ederek, bölgenin mekânsal değişiminin belirlenmesidir. Bu sayede tarihi ticaret bölgesinin değişimi tespit edilerek, koruma sorunları tartışılacaktır.

Çalışmanın yöntemi iki aşamadan oluşmaktadır. Birinci aşamada değişmişlik analizi yapılarak bölgede kaldırılmış, yokolmuş ve değişmiş kütle ve elemanlar tespit edilecektir. İkinci aşamada ise Görüş Grafiği Analizi (VGA) yapılarak alanın görünür alan bütünleşme haritaları üzerinden özgün ve mevcut durumu karşılaştırılacaktır.

Çalışma sonucunda hanlar bölgesinin değişimleri tespit edilerek, bu değişimlerin bölgenin dolaşım rotasını ve görünür alanları nasıl etkilediği tartışılmıştır. Tarihi alanın özgün durum kullanımının tanıtılması ve yaşatılması için ticari bir dolaşım rotası önerilmiştir. Rotanın dolaşım güzergahı ve kaybolmuş ya da mevcut önemli tarihi yapılar bilgilendirici tabelalar ile tanıtılmıştır. Çalışmada tespit edilen değişimler ve öneriler dikkate alınarak bölgenin koruma çalışmalarının belirlenmesi, alanın özgün kullanımının ve kaybolmuş elemanlarının tanıtılması açısından önemlidir.

Anahtar Kelimeler: Han, Muğla, Görüş Grafiği Analizi, Koruma.

ABSTRACT

The *Hans* District, situated in the historical city center of Muğla, is known for its significant role in the city's social and commercial activities. This district, consisting of trade buildings such as *han* and *arasta* and craftsmen shops, was a city trade center from the Ottoman period to the end of the 19th century. The *Hans* District has undergone significant changes over time. Although certain *hans* have vanished, others have lost their integrity. It is crucial to ascertain the form and evolution of the historic district to make informed decisions regarding its protection. The spatial evolution of the *Hans* District over time will be examined within the context of this study. By examining the *Hans* District's original and current use, the objective is to decipher altered or missing elements of the district. Thus, the district's historical circulation route will be reconfigured, and its conservation issues will be addressed.

The research methodology comprises two phases. The initial stage will involve alteration analysis to ascertain the masses and elements removed, missing, or altered in the district. The original and current state of the area will be compared in the second stage by conducting a Visibility Graph Analysis (VGA) using the visible area integration maps.

The study determined the changes in the *Hans* District and discussed the impact of these changes on the circulation route and visible areas of the district. A commercial circulation route has been suggested to maintain and promote the original use of the historic area. Informing signs have been installed along this route to track critical existing and missing historical buildings and the route's navigation. It is crucial to ascertain the conservation efforts of the area to commemorate both the lost elements and their original usage, considering the changes and suggestions identified in the study.

Keywords: Han, Muğla, Visibility Graph Analysis, Conservation.

**IMPACT OF MATRIC SUCTION ON THE UNCONFINED COMPRESSIVE
STRENGTH OF A BENTONITE SAND MIXTURE**

Seda DURUKAN

Asist. Prof. Dr., Manisa Celal Bayar University, Manisa Vocational School of Technical Sciences, Department
of Construction

Abdülşamet GÜVEN

MSc., Diy-Mar Construction Industry and Trade Ltd. Co. and Formerly Manisa Celal Bayar University,
Graduate School, Civil Eng.

ABSTRACT

Classical soil mechanics performs analyses based on criteria for saturated conditions. However, in many cases soils are far from being saturated. A soil that is stable under unsaturated conditions may collapse due to decreasing strength as the saturation degree increases. Therefore, especially when evaluating natural or built slopes, the unsaturated conditions of the soils should also be taken into consideration because under rain or snowfall, the saturation degree of the soil will increase, and its strength will decrease. It is known that this expected decrease in the strength of soils is due to the decrease in the matric suction. Therefore, it is important to determine the suction of soils and determine their strength values under different saturation degree conditions. In this study, a mixture of bentonite-sand, which is used for many purposes that are likely to have slope stability problems, was prepared with 10% of bentonite of dry weight. The matric suction pressures at different water contents on this mixture with the same dry unit volume weight were measured in the laboratory using the filter paper method and the soil water characteristics curve was constructed. From this curve, van-Genuchten parameters were determined. Then, unconfined compression tests were carried out in the laboratory using mixtures prepared at different water contents. The matric suction and unconfined compressive strengths corresponding to each saturation degree were evaluated and the effect of matric suction on the strength was determined. As a practical result, in 10% bentonite sand mixture, when the measured matric suction pressure value was decreased by 5.6 times, the unconfined compressive strength decreased by 1.8 times; when the matric suction pressure value was decreased by 16 times, the unconfined compressive strength was decreased by 2.2 times.

Keywords: Matric Suction, Unconfined Compressive Strength, Filter Paper, Bentonite Sand Mixtures.

INTRODUCTION

Fills or embankments are naturally in an unsaturated condition, controlled at around 60% to 70% for maximum dry density (Lambe, 1951). Similarly, However, generally due to the weather change, the degree of saturation can be changed. The variation in the saturation degree causes a change in the undrained shear strength of the compacted soils which is an important issue to address in various geotechnical engineering problems (Fredlund & Raharjo, 1993). When the natural or handmade slopes exposed to rainfall, it is evident that the strength of unsaturated soils would decrease. Therefore, if the strength of unsaturated soils a given saturation can be estimated more efficiently, the stability problems during rainy weathers would be more reliable. This analysis is necessary due to the presence of unsaturated soil conditions in these depths called vadose zone. A variety of engineering projects entail the analysis of soil characteristics in vadose zones.

Matric suction is defined as the difference between pore air pressure and pore water pressure. According to the unsaturated soil mechanics principles, matric suction plays a critical role in influencing the unconfined compressive strength (UCS) of unsaturated soils. Thus, a correlation between matric suction and strength as measured by simple laboratory test, such as an unconfined compression test, is a practical tool for evaluation of the aforementioned problems. The relationship between matric suction and strength is not constant and includes the variation in soil types and moisture conditions (Fredlund & Rahardjo, 1993; Lu & Liko, 2004). Yet, matric suction is known to affect both the cohesion and internal friction angle of soils, which are key parameters in determining shear strength.

Abd et al. (2020) concluded that the relationship between the shear strength and the matric suction had two different behaviors. The first part was found to be linear where the second was non-linear. The point between the two parts represented a reversal point and defined as the peak point. The study revealed that a rapid increase in both cohesion and angle of friction was observed and, then further increase in matric suction resulted in a decrease in cohesion and stabled the angle of friction. The shear strength of unsaturated soils can be determined via several testing methods such as consolidated drained, constant water content, unconsolidated undrained, and unconfined compression tests (Chae et al. 2010; Hossain & Yin, 2010; Zhou & Xu, 2014; Chen et al., 2024). Among these tests, the UC test can be the most reasonable choice for it is the simplest and the most economical (Oh & Vanapalli, 2018).

The transition between the matric suction and strength is established using a soil water characteristics curve (SWCC) (Ng & Pang, 2000; Kim & Borden, 2011). The SWCC shows the relationship between the suction values and water content or volumetric water content or saturation degree values of soils. This curve allows us to obtain any suction value for a given water content. Zhou et al. (2016) performed Consolidated drained direct shear tests and unconfined compressive strength tests to determine shear strength of unsaturated completely decomposed granite (CDG) soil. The study also included a series of SWCC of CDG soil

under different net normal stresses. Their study one more exhibited that the unsaturated shear strength significantly increased with an increase in net normal stress and matric suction. They proposed a new model for prediction of UCS from shear strength and initial suction.

The aim of this study is to determine the matric suction of a clayey mixture and to provide an approach to its relationship with the UCS of the mixture for a specific water content. For this approach, a clayey mixture was prepared. This study is a part of a broader study (Güven, 2024) and includes one of the soil mixture results. It presents a series of unconfined compression tests at different water contents in relation with matric suction values. The tests were performed to investigate the effect of matric suction on the unconfined compressive strength.

MATERIALS AND METHOD

The bentonite sand mixtures (BSMs) are frequently used for compacted fills, hydraulic barriers on slopes, as barriers for waste repositories or thermohydraulic backfills. In addition, the BSMs can also be used in civil engineering works such as roads, dams and any types of embankments as in their unsaturated compacted forms (Whenham et al., 2007; Li & Zhang, 2015). Thus, to investigate the suction-UCS relation a BSM was selected. The proportion the materials in the mixture was 10% of bentonite by dry weight to the total dry weight and presented as 10% BSM throughout the study. Sand was obtained from Aydınlar quarry Turgutlu Manisa and bentonite was obtained from Ankara Karakaya Bentonite company. Bentonite was used in powder form and sand was sieved through No.40 sieve. Some geotechnical parameters of the materials used are presented in Table 1.

Table 1. Some geotechnical parameters of the materials.

Properties	Bentonite	Sand
Mineralogy	Smektit Kristabolit Kuvars	Quartz
Liquid limit	%405	NP*
Plastic limit	%57	
Plasticity Index	%348	
Specific Gravity	2.71	2.65

*NP:Non-plastic.

Both filter paper tests and unconfined compression tests were performed for different water contents on samples prepared with 10% BSM. The filters used in the filter paper experiments were Whatman No.42 type filter papers and were used directly without any pre-treatment. In the filter paper experiment, each sample was prepared in a controlled manner at different water contents. Filter paper test is described as an inexpensive and relatively simple laboratory test method that can be used to measure both total and matric suctions. The test can reliably measure suction pressures between 0.01-100 MPa. The total suction pressure is measured with the help of two pieces of filter paper placed on top on a thin ring placed on the

upper surface of the soil sample. It is essential that the filter papers do not contact the soil sample. If the matric suction pressure is to be measured, the contact filter paper set as in a sandwich form of one relatively small filter paper in between two bigger filter papers.

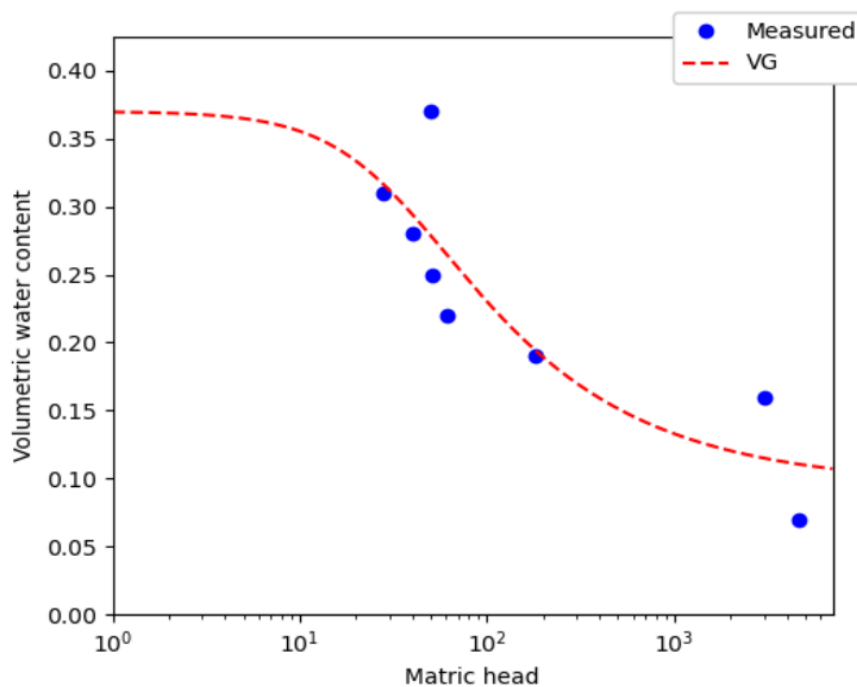
Soil samples had a diameter of 4 cm in diameter and 2 cm in height and compressed as two pieces of cylinders. The filter papers were placed and sealed in glass bottles and kept in the incubator at 20 C° for 1 week. At the end of 1 week, the filter papers were measured to obtain the water content where to be used the amount of suction through the calibration curve given in ASTM D5298. Consequently, the results obtained from the filter paper experiments were plotted on the SWCC. Matric suction and volumetric water content values were used. The SWRC Fit program (Seki, 2007; Seki et al., 2022), which allows the input of data obtained in the laboratory and fits curves to these data, was used to generate the curves.

In the unconfined compression tests, a different path was followed, and all samples were first compressed in accordance with the selected compression criteria and the experiment was carried out immediately with 1 of them and the others were left to air dry. The aim here was to try to create the natural drying cycle as much as possible in the laboratory environment. The water content of the dried samples was controlled both before and after the test. For the unconfined compression tests the samples had a diameter of 5 cm and a length of 10 cm. Sample mixture is compressed into the sample container in 3 stages and with a total of 25 free-falling special rammers. During the unconfined compression tests the ASTM D2166 standart was followed.

RESULTS AND DISCUSSION

Soil samples with such water contents and saturation degrees were matched against the matric suction values found by the filter paper method and the SWCC of 10% BSM was constructed and presented in Figure 1. With the help of this curve, the matric suction value at any desired water content or saturation degree value can be determined. The blue dots in the figure represents the experimental data whereas the red dashed line represents the van-Genuchten model (Van Genuchten, 1980; Vanapalli et al., 1996) prediction line. The van-genuchten parameters are also presented at the bottom of the graph in Figure 1. A good agreement between the measured data and the van-Genuchten model was observed. Once this curve was constructed it means one can easily obtain any suction value for a given water content by using the curve itself and/or with the curve model parameters. Thus, when the water content of any UCS sample is known then, the suction pressure for that specific water content value can be found.

Subsequently, the UCS values of the soil samples having such water content or saturation degree values were determined and the matric suction values at these water contents were read from the SWCC curve of 10% BSM. Finally, the relationship between matric suction and free pressure values is analyzed and the findings are presented. The relation between the UCS and matric suction values was presented in Figure 2.



Model	Equation	Parameters	R ²	AIC
van Genuchten	$S_e = \left[\frac{1}{1 + (\alpha h)^n} \right]^m \quad (m = 1 - 1/n)$	$\theta_s = 0.37012$ $\theta_r = 0.094434$ $\alpha = 0.031338$ $n = 1.5718$	0.7543	-42.23

Figure 1. The SWCC of the 10% BSM.

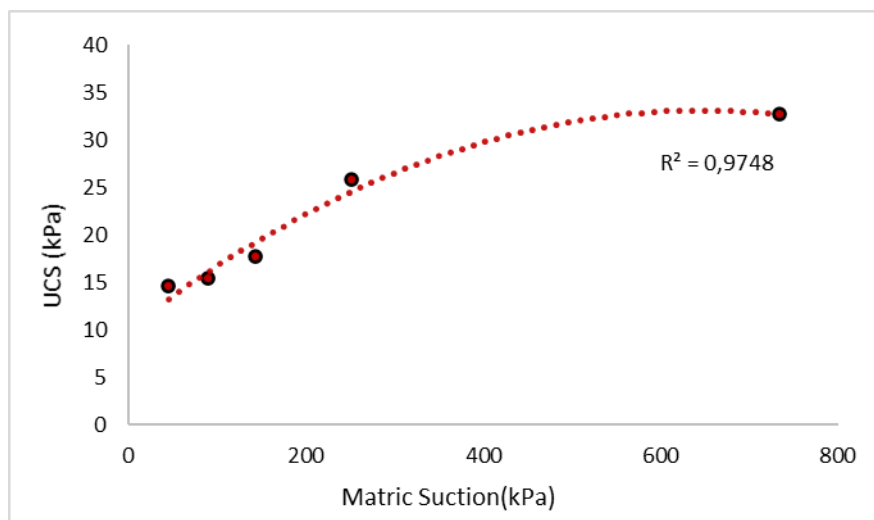


Figure 2. The relation between UCS and water content.

The preliminary test results revealed that with an increase in the matric suction a notable increase in UCS was determined in 10% BSM samples. In other words, the increase in the water content in the soil caused the strength in the soil to decrease. As a practical result, in 10% bentonite sand mixture, when the measured matric suction pressure value was decreased by 5.6 times, the unconfined compressive strength decreased by 1.8 times; when the matric

suction pressure value was decreased by 16 times, the unconfined compressive strength was decreased by 2.2 times.

CONCLUSION

This study aimed to determine the matric suction of a clayey soil and to provide an approach to its relationship with the UCS of the mixture for a specific water content. For this approach, a 10% BSM was prepared at different water contents and subjected to matric suction and strength tests. The matric suction pressures at different water contents with the same dry unit volume weight were measured using the filter paper method. The SWCC was constructed and van-Genuchten parameters were determined. Unconfined compression tests were carried out using mixtures prepared at varying water contents. The corresponding matric suction and UCS values were evaluated. The preliminary results give hope for a good relation between the suction and UCS values. However, it is obvious that a general relation cannot be established with one soil sample. Thus, for future studies, it is strongly recommended to extend the study to different mixtures in order to obtain a model for the prediction of the unsaturated soil strength.

REFERENCES

- Abd, I.A., Fattah, M.Y. & Mekkiyah, H. (2020). Relationship between the matric suction and the shear strength in unsaturated soil. *Case Studies in Construction Materials*, 13, e00441, <https://doi.org/10.1016/j.cscm.2020.e00441>.
- ASTM D5298. (2016). Standard Test Methods for Measurement of Soil Potential (Suction) Using Filter Paper. West Conshohocken, PA, United States.
- ASTM D2166. (2016). Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. West Conshohocken, PA, United States.
- Chae, J.G., Kim, B.S., Park, S.W. & Kato, S. (2010). Effect of suction on unconfined strength in partly saturated soils. *KSCE J. Civil Eng.*, 14(3), 281–290.
- Chen, Y., Xu, Y., Wang, L. et al. (2024). Study on the relationship between matric suction, unconfined compressive strength, and uniaxial tensile strength for compacted expansive soils. *Environ Earth Sci*, 83, 165. <https://doi.org/10.1007/s12665-024-11470-z>
- Fredlund, D.G. & H. Rahardjo. (1993). *Soil mechanics for unsaturated soils*. John Wiley & Sons, New York. doi:10.1002/9780470172759
- Güven, A. (2024). Serbest basınç mukavemetinin matrik emme ile değişiminin incelenmesi. Manisa Celal Bayar University, Graduate School, Department of Civil Engineering, Master Thesis, p. 84.
- Hossain, M.A. & Yin, J.H. (2010). Behavior of a compacted completely decomposed granite soil from suction controlled direct shear tests. *J. Geotech. Geoenviron. Eng.*, 136(1), 189–198.

- Kim, W.S. & Borden, R.H. (2011). Influence of soil type and stress state on predicting shear strength of unsaturated soils using the soil-water characteristic curve. *Can. Geotech. J.*, 48(12), 1886–1900.
- Lambe, T.W. (1951). *Soil testing for engineers*, John Wiley and Sons, New York.
- Li, L., & Zhang., X. (2015). Modified unconfined compression testing system to characterize stress-strain behavior of unsaturated soils at low confining stresses. *Transp. Res. Rec.*, 2510:54–64. doi:10.3141/2510-07
- Lu, N. & Liko, W.J. (2004). *Unsaturated Soil Mechanics*, John Wiley and Sons, New York.
- Ng, C.W.W. & Pang, Y.W. (2000). Influence of stress state soil-water characteristics and slope stability. *J. Geotech. Geoenviron. Eng.*, 126(2), 157–166.
- Oh, W.T., & S. Vanapalli. (2018). Undrained shear strength of unsaturated soils under zero or low confining pressures in the vadose zone. *Vadose Zone J.*, 17:180024.
- Seki, K. (2007). SWRC fit - a nonlinear fitting program with a water retention curve for soils having unimodal and bimodal pore structure. *Hydrol. Earth Syst. Sci. Discuss.*, 4, 407-437.
- Seki, K., Toride, N. & Th. van Genuchten, M. (2022). Closed-form hydraulic conductivity equations for multimodal unsaturated soil hydraulic properties. *Vadose Zone J.*, 21, e20168.
- van Genuchten, M.T. (1980). A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Science Society of America Journal*, 44, 892-898.
- Vanapalli, S.K., Fredlund, D.G., Pufahl, M.D. & Clifton, A.W. (1996). Model for prediction of shear strength with respect to soil suction. *Canadian Geotechnical Journal*, 33(3), 379-392.
- Whenham, V., De Vos, M., Legrand, C., Charlier, R., Maertens, J. & Verbrugge, J.-C. (2007). Influence of soil suction on trench stability. *Springer Proc. Phys.*, 112:495-501. doi:10.1007/3-540-69873-6_49
- Zhou, W.H. & Xu, X. (2014). Unconfined compression strength of unsaturated completely decomposed granite soil with different clay mixing ratios, *Geomechanics from Micro to Macro*, in: Soga et al. (Eds.), *Proceedings of IS-Cambridge 2014*, Cambridge, UK, Taylor & Francis Group, London, pp. 1341–1346. ISBN 978-1-138-02707-7.
- Zhou, W.H., Xu, X. & Garg, A. (2016). Measurement of unsaturated shear strength parameters of silty sand and its correlation with unconfined compressive strength. *Measurement*, 93, 351-358, <https://doi.org/10.1016/j.measurement.2016.07.049>.

**ESTIMATION OF EARTHQUAKE RISK LEVELS OF RC STRUCTURES WITH
ARTIFICIAL INTELLIGENCE METHODS**

Mertcan YILMAZ

Res. Assist., Erciyes University, Engineering Faculty, Department of Civil Engineering

ORCID ID: 0000-0001-9868-2991

Tamer DIRIKGIL

Assoc. Prof., Erciyes University, Engineering Faculty, Department of Civil Engineering

ORCID ID: 0000-0001-5640-2883

ABSTRACT

Turkiye is one of the countries with the most intense seismic activity. Past earthquakes have caused casualties and various levels of damage to structures. To prevent similar situations in the future or minimize losses, it is necessary to determine the earthquake safety of existing structures and their earthquake risk levels to take precautions in advance. The earthquake performance of reinforced concrete (RC) structures can be determined according to earthquake codes. However, since earthquake codes are developed to determine the detailed earthquake performance of individual structures, determining the earthquake performance of a certain building stock is costly in terms of labor, time, and money. Therefore, rapid assessment systems that are as reliable as earthquake codes and less costly are needed. In this paper, the usability of artificial intelligence methods has been investigated for rapid determination of the earthquake risk levels of low-rise RC frame structures in Turkey's building stock before an earthquake. In this context, building plans in the SERU (Structural Engineering Database) database were used, and the effects of the changes in parameters that can directly affect the structural performance (concrete strength, reinforcement strength, longitudinal reinforcement ratio, transverse reinforcement ratio, corrosion presence, location, soil class) over the years on the earthquake performance were examined and subjected to nonlinear analysis. The obtained performance levels were estimated with different machine-learning models. As a result of the training, more than eighty percent of the test data were estimated correctly. It was evaluated that the performance could be increased by diversifying the number of data and considering different parameters, and the risk levels of the structures before the earthquake could be estimated quickly and accurately with artificial intelligence algorithms.

Keywords: Earthquake Performance, Artificial Intelligence, Rapid Seismic Risk Assessment, Machine-learning

INTRODUCTION

In the last 100 years, 963 earthquakes of magnitude 5 and above on the Richter scale have occurred in Turkey, which is located in the Alpine-Himalayan earthquake zone. [1]. As a result of these earthquakes, many people lost their lives and thousands of buildings were damaged or destroyed to various degrees. In Turkey, many earthquake codes were published in order to design earthquake-resistant structures, the first of which was in 1940 and the latest version was obtained in 2018. However, recent earthquakes have shown that a significant portion of the building stock is not at a level that can provide life safety against earthquakes due to reasons such as not checking compliance with the earthquake regulation, being constructed with insufficiently durable materials, being constructed with detail errors or having load-bearing system elements removed during use. Such structures pose a risk in terms of ensuring life safety in possible earthquakes and these structures need to be identified and made earthquake resistant. The rules for determining the seismic performance of buildings were first defined in the 2007 Turkish Earthquake Code (TEC 2007) [2] and were finalized in the 2018 Turkish Building Earthquake Code (TBEC 2018) [3]. With these codes, it is possible to determine the performance level of buildings under a certain earthquake effect (Limited Damage -LD, Controlled Damage -CD Collapse Prevention-CP, Collapse-CO). However, since earthquake codes are developed for the design and evaluation of individual buildings and require detailed examination, determining the earthquake performance of a particular building stock according to these codes is costly in terms of time, labor and money. Therefore, in order to determine the risky structures in a certain building stock, methods that are as accurate as the earthquake codes and can be evaluated quickly are needed. In addition to earthquake codes, the Principles for the Detection of Risky Structures (PDRS 2013) [4] were published in 2013 to determine risky structures and were updated in 2019 (PDRS 2019) [5]. However, in these codes, buildings are classified as risky or non-risk, and the level of risk is not determined. In the literature, it is seen that some methods have been developed for the detection of risky structures, and these methods can be generally divided into two as 1st Stage methods [6-8] and 2nd Stage methods [9-12] according to the examination details of the structures. In the 1st stage methods, structures are generally examined observationally. With these observations, parameters such as the appearance quality of the structure, number of floors, presence of overhang, soft story, etc. are scored according to a score table. The aim is to quickly estimate the risk levels of structures according to the order of scores. In the 2nd stage methods, in addition to the observational examination of the structures, some mechanical properties of the load-bearing elements are also evaluated and the risk levels are aimed to be estimated using some assumptions and statistical approaches. Since both methods are based on some assumptions, they may cause some subjective and erroneous decisions to emerge during the evaluation[13]. At this point, the ability of artificial intelligence algorithms to predict the result by establishing a relationship between parameters can be used. In the literature, artificial intelligence algorithms have been used in similar tasks in the field of

structural engineering. [14-19]. However, there is no sufficiently reliable method that can estimate the risk level of the existing building stock. With this motivation, in this study, the feasibility of the performance levels of the structures whose performance levels were determined according to TBEC 2018 was investigated by using artificial intelligence algorithms.

MATERIALS AND METHOD

This study aims to predict risky structures before an earthquake using artificial intelligence methods. In this context, the parameters that may affect the earthquake performance of structures were determined by taking into account the findings obtained as a result of earthquakes experienced in recent years and the changes in codes that occurred in the past years. [20-25] (Table 1). Performance analysis of these parameters was carried out in three locations with different seismicity and according to four different soil classes.

Table 1. Changes in parameters depending on the years

Years	Location	Soil Class	Concrete Strength (MPa)	Yield Strength of Reinforcement (Mpa)	Longitudinal Reinforcement Ratio	Stirrup Spacing (cm)	Corrosion (Yes:1, No:0)
Before 2000	Bingöl Afyon Kayseri	ZA	8	220	0.006	25	1
		ZB					
		ZC					
		ZD					
2000-2007	Bingöl Afyon Kayseri	ZA	12	220	0.008	25	1
		ZB					
		ZC					
		ZD					
2007-2011	Bingöl Afyon Kayseri	ZA	16	420	0.01	10	1
		ZB					
		ZC					
		ZD					
2011-2018	Bingöl Afyon Kayseri	ZA	20	420	0.013	10	0
		ZB					
		ZC					
		ZD					

Within the scope of the study, in order to determine the risk levels of low-rise reinforced concrete frame residential buildings in the Turkish building stock, the BNG-6-3-12 and AFY-CO-04 building plans in the Structural Engineering Research Unit (SERU) [26] database, which were obtained as a result of field studies conducted after the 2003 Bingöl (6.4 M_w) and 2002 Afyonkarahisar (6.0 M_w) [27] earthquakes, were used. The plans were modeled in three dimensions in the Sap 2000 v20.2 program, taking into account the parameters specified in Table 1, and performance analysis was performed using the nonlinear single-mode static pushover analysis method included in TBEC 2018. As a result of the analysis, a total of 144 different performance results were obtained. The risk levels of the structures were determined according to the earthquake performance results as 1st Degree risk if the structure performance is CO, 2nd Degree risk if CP, 3rd Degree risk if CD and 4th Degree risk if LD. In machine learning algorithms, some of the data obtained is used for training, while some is

used for testing according to the weights learned as a result of training, and usually 10% to 20% of the data is separated as test data. In this study, 80% of the data is separated as training and 20% as test data. The obtained data was trained and tested in Support Vector Machine (SVM), Random Forest (RF), Decision Tree (DT) and GradientBoosting machine learning algorithms, which are frequently used in similar classification problems in the literature. In order to examine the prediction performance of machine learning algorithms in more detail, the performances of the models were evaluated according to different performance metrics (F1 score, recall, precision) obtained from this matrix using the created confusing matrices.

RESULTS AND DISCUSSION

As a result of the performance analysis of the buildings according to TBEC 2018 using the determined parameters, the damage distributions according to the plans are shown in Figure 1 and Figure 2. As a result of analyzing all the parameters in different locations and ground classes in both plans, it is understood that more than 50 percent are in the state of collapse. In addition, it is seen that approximately 5 percent in both plans are in the state of damage to prevent collapse, and the remaining percentages are in limited damage and controlled damage.

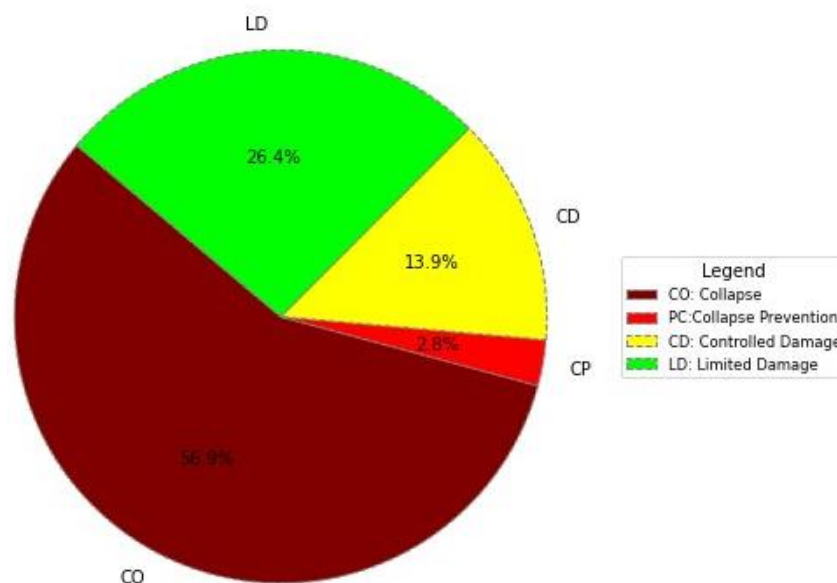


Figure 1. BNG-6-3-12 performance level percentage

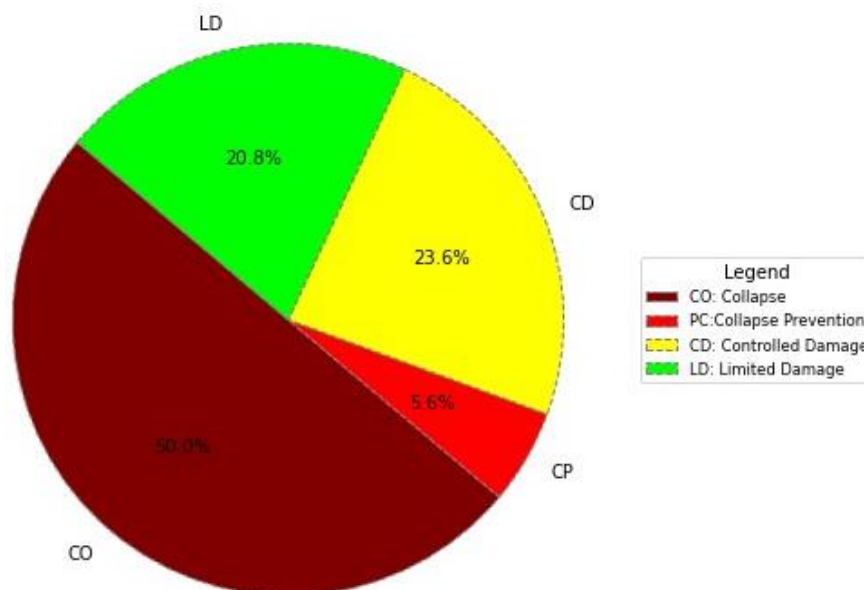


Figure 2. AFY-CO-04 performance level percentage distribution

The magnitude of the acceleration value that will come to the structure can be an important parameter in determining the seismic performance of the structures. This acceleration is significantly affected by the location of the structure and the class of the site where it is located. According to the design spectral acceleration coefficient (S_{D1}) corresponding to the 1-second period obtained from the Turkey Earthquake Hazard Map (TEHM), the damage distributions depending on the location of the structure (Bingöl, Afyonkarahisar, Kayseri) and the soil class (ZA, ZB, ZC and ZD) are shown in Figure 3 and Figure 4. In both structure models, it is observed that the damage level improves as the acceleration values decrease depending on the soil class and location, regardless of the years. It is observed that the damage level improves when the defects related to material and workmanship are eliminated, especially in small acceleration values, depending on the years.

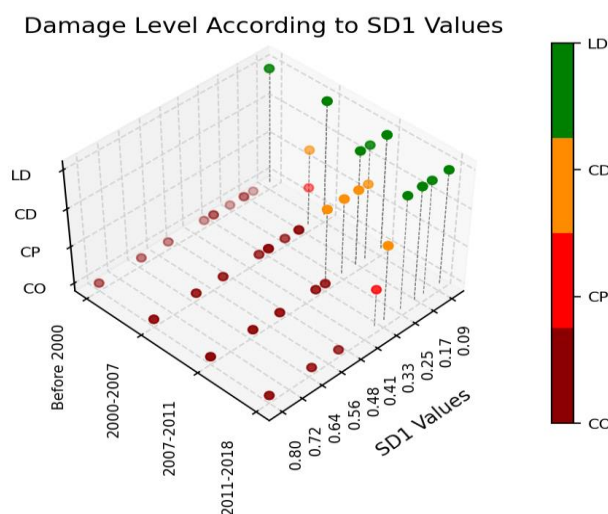


Figure 3. Distribution of BNG-6-3-12 damage levels according to periods and S_{D1} values

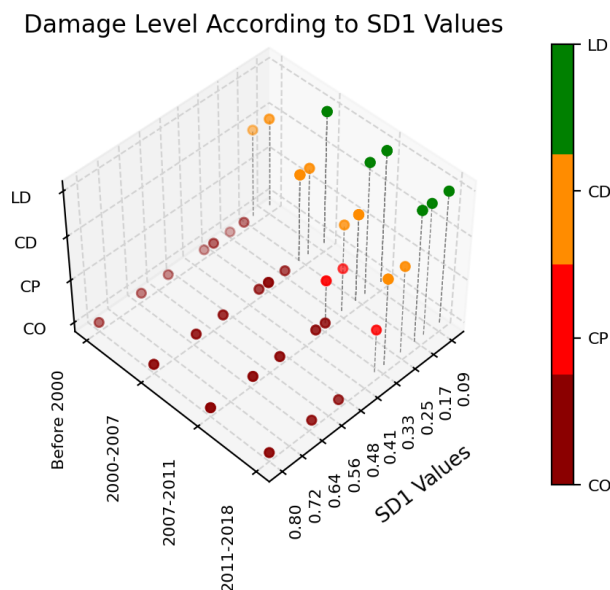


Figure 4. Distribution of AFY-CO-04 damage levels according to periods and SD_1 values

The test performances obtained as a result of training the obtained data in SVM, RF, DT and GradientBoosting algorithms are shown in Table 2 according to different performance metrics. It is seen that the highest performance is obtained with the GradientBoosting algorithm. The predictions made by this algorithm on the test data are shown in the confusion matrix in Figure 5. It is seen that the algorithm correctly predicts all the situations with 1st degree risk, incorrectly predicts all the situations with 2nd degree risk due to insufficient data, correctly predicts the vast majority of the situations with 3rd degree risk and correctly predicts all the situations with Level 4th risk.

Table 2. Evaluation of machine learning models according to different performance metrics.

Model	Accuracy (%)	F1-score (%)	Recall (%)	Precision (%)
SVM	59	48	89	41
RF	72	69	72	65
DT	77	76	76	77
GradientBoosting	89	88	89	86

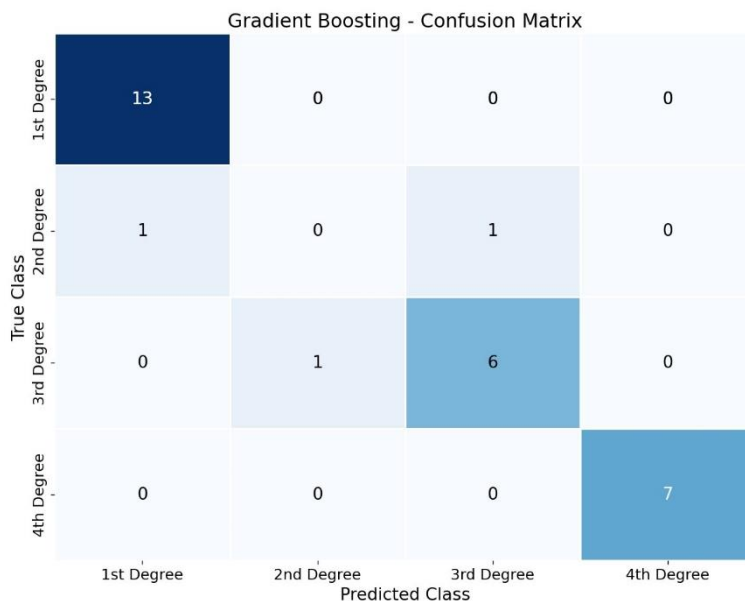


Figure 5. GradientBoosting algorithm confusing matrix

CONCLUSION

Within the scope of the study, the usability of artificial intelligence methods was investigated in order to predict the seismic risk levels of low-rise reinforced concrete buildings in the Turkish building stock before an earthquake. The concrete strength, reinforcement yield strength, stirrup spacing, longitudinal reinforcement ratio and corrosion statuses of the building plans obtained from the SERU database, which changed over the years, were subjected to performance analysis according to three different locations and four different soil classes, and the performance results were estimated with machine learning algorithms. As a result of the machine learning analyses, the performance results were estimated correctly with 89% success with the GradientBoosting algorithm. It is evaluated that the risk levels of low-medium-rise reinforced concrete structures with reinforced concrete structural systems can be estimated with artificial intelligence methods with the data set created by enriching the data set with building models having different plan and vertical structural system features and simulating the existing building stock.

REFERENCES

1. AFAD. 2023 [cited 2023 October]; Available from: <https://www.afad.gov.tr>.
2. TEC, Ministry of Public Works and Settlement. 2007.
3. TBEC, Disaster and Emergency Management Presidency. 2018: Ankara.
4. PDRS, Ministry of Environment, Urbanization and Climate Change. 2013.
5. PDRS, Ministry of Environment, Urbanization and Climate Change. 2019.
6. FEMA, *Rapid Visual Screening of Buildings for Potential Seismic Hazards : a Handbook*. 2017: Federal Emergency Management Agency.

7. NRCC, *Manual for screening of buildings for seismic investigation*. 1995: National Research Council of Canada.
8. Sucuoğlu, H., U. Yazgan, and A. Yakut, *A Screening Procedure for Seismic Risk Assessment in Urban Building Stocks*. 2007. **23**(2): p. 441-458.
9. Temür, R., *Hızlı durum tespit (DURTES) yöntemi ve bilgisayar programının geliştirilmesi*, in *İnşaat Mühendisliği Ana Bilim Dalı*. 2006, İstanbul Üniversitesi: Fen Bilimleri Enstitüsü. p. 127.
10. Aydogdu, H.H. and A. Ilki, *Case study for a performance based rapid seismic assessment methodology (PERA2019) based on actual earthquake damages*. Bulletin of Earthquake Engineering, 2024. **22**(4): p. 1965-1999.
11. Kaplan, O., et al., *A rapid seismic safety assessment method for mid-rise reinforced concrete buildings*. Bulletin of Earthquake Engineering, 2018. **16**(2): p. 889-915.
12. Yakut, A., *Preliminary seismic performance assessment procedure for existing RC buildings*. Engineering Structures, 2004. **26**(10): p. 1447-1461.
13. Aydogdu, H.H., et al., *Evaluation of rapid seismic safety assessment methods on a substandard reinforced concrete building stock in Istanbul*. Structures, 2023. **56**: p. 104962.
14. Harirchian, E., et al., *A Synthesized Study Based on Machine Learning Approaches for Rapid Classifying Earthquake Damage Grades to RC Buildings*. Applied Sciences, 2021. **11**(16): p. 7540.
15. Morfidis, K. and K. Kostinakis, *Approaches to the rapid seismic damage prediction of r/c buildings using artificial neural networks*. Engineering Structures, 2018. **165**: p. 120-141.
16. Tesfamariam, S. and Z. Liu, *Earthquake induced damage classification for reinforced concrete buildings*. Structural Safety, 2010. **32**(2): p. 154-164.
17. Yilmaz, M., et al., *Categorization of Post-Earthquake Damages in RC Structural Elements with Deep Learning Approach*. Journal of Earthquake Engineering, 2024. **28**(9): p. 2620-2651.
18. Bülbül, M.A., et al. *A Hybrid ANN-GA Model for an Automated Rapid Vulnerability Assessment of Existing RC Buildings*. Applied Sciences, 2022. **12**, DOI: 10.3390/app12105138.
19. Arslan, M.H., M. Ceylan, and T. Koyuncu, *Determining earthquake performances of existing reinforced concrete buildings by using ANN*. International Journal of Civil Environmental Engineering 2015. **9**(8): p. 1097-1101.
20. Sucuoğlu, H.J.M.E.T.U., (<http://www.metu.edu.tr/~wwweerc/guncel/koca-dzc.pdf>), *The 1999 Kocaeli and Düzce-Turkey Earthquakes*. 2000.
21. Doğançün, A., *Performance of reinforced concrete buildings during the May 1, 2003 Bingöl Earthquake in Turkey*. Engineering Structures, 2004. **26**(6): p. 841-856.

22. Arslan, M.H. and H.H. Korkmaz, *What is to be learned from damage and failure of reinforced concrete structures during recent earthquakes in Turkey?* Engineering Failure Analysis, 2007. **14**(1): p. 1-22.
23. Tapan, M., et al., *Failures of structures during the October 23, 2011 Tabanlı (Van) and November 9, 2011 Edremit (Van) earthquakes in Turkey.* Engineering Failure Analysis, 2013. **34**: p. 606-628.
24. Yakut, A., et al., *Performance of structures in İzmir after the Samos island earthquake.* Bulletin of Earthquake Engineering, 2022. **20**(14): p. 7793-7818.
25. İnce, O., *Structural damage assessment of reinforced concrete buildings in Adıyaman after Kahramanmaraş (Türkiye) Earthquakes on 6 February 2023.* Engineering Failure Analysis, 2024. **156**: p. 107799.
26. METU, Available from: https://seru.metu.edu.tr/arsiv_tr.html.
27. USGS. 2023; Available from: <https://www.usgs.gov>.

KIZILÖTESİ KURUTMA TEKNİĞİ İLE HURMA PESTİLİ ÜRETİMİ
PRODUCTION OF DATES LEATHER WITH INFRARED DRYING METHOD

Suzan TİREKİ

Dr., Özyeğin Üniversitesi, Uygulamalı Bilimler Fakültesi, Gastronomi ve Mutfak Sanatları Bölümü
Dr., Özyeğin University, Faculty of Applied Sciences, Department of Gastronomy and Culinary Arts

ORCID ID: 0000-0002-7424-7378

ÖZET

Geleneksel güneşte kurutma prosesi endüstriyel kurutma teknolojilerine göre daha düşük verimli ve daha uzun sürede gerçekleşmektedir. Ayrıca, geleneksel kurutma açık havada yapıldığından toz, yağmur ve böcek gibi kontaminasyon riskleri bulunmakta ve ürün kalitesi olumsuz yönde etkilenmektedir. Kızılötesi elektromanyetik spektrumda mikrodalga ile görünür ışık bölgelerinin arasında yer alan bir ışınım çeşidi olup, ısı enerjisi elektromanyetik dalga olarak iletir. Güneşin ısıtma etkisinden büyük oranla sorumlu olan kızılötesi vasıtasıyla termal enerji, çevredeki havayı ısıtmadan ürüne doğrudan aktarılmaktadır. Bu yüzden, daha hızlı bir ısı transferini mümkün kılar. Kızılötesi kurutma modern ve inovatif bir kurutma tekniği olup, daha kısa süreli, maliyeti düşük ve etkin olarak gıda güvenliğinin sağlanmasını kolaylaştıran oldukça avantajlı bir yöntemdir. Günümüzde sağlık ve beslenme tüketici eğilimlerinin ve bilincinin yükselişi ile ilave şeker ve un içermeyen, kullanım kolaylığı olan atıştırmalık ürünlerin tüketimi oldukça artmıştır ve bu ürünlerin pazar payları belirgin bir şekilde artmış. Bu artışın devam edeceği tahmin edilmektedir. Bu konulara istinaden, bu çalışmada şeker ve un ilavesi yapılmadan besin değeri oldukça yüksek olan hurma ile pestil üretimi kızılötesi kurutma tekniği ile yapılmış ve pişirme süresinin kuruma davranışı üzerine etkisi araştırılmıştır. Çalışmada hurmalar yıkanmış ve çekirdekleri çıkarılmış, 1:2,5 (hurma:su) oranında su ilavesi sonrası 30, 45 ve 60 dakika boyunca pişirilmiştir. Sonrasında pişirilen pestil hamuru preslenmiş, 10 mm kalınlığına getirilmiş ve kızılötesi kurutma yapılmıştır. Kuruma eğrileri incelendiğinde pişirme süresi artığında efektif difüzyon katsayısının (D_{eff}) değiştiği gözlemlenmiş, bu değer 30, 45 ve 60 dakika pişirilen hurma pestil ürünleri için sırasıyla $1,53 \times 10^{-9}$, $1,70 \times 10^{-9}$ ve $1,74 \times 10^{-9}$ m²/s olarak saptanmıştır.

Anahtar Kelimeler: Kızılötesi Kurutma, Hurma, Pestil, Pişirme.

ABSTRACT

Traditional sun drying process is less efficient and takes longer time compared to the industrial drying technologies. In addition, since drying is carried out outdoors in traditional drying, there are contamination risks such as dust, rain and insects, and product quality is negatively affected. Infrared is a type of radiation between microwave and visible light regions in the electromagnetic spectrum and it transmits thermal energy as an electromagnetic

wave. Thermal energy via infrared, which is largely responsible for the heating effect of the sun, is transferred directly to the product without heating the surrounding air. Therefore, it enables a faster heat transfer. Infrared drying is a modern and innovative drying technique and it is a very advantageous method that facilitates food safety in a shorter time, lower cost and more effectively. Today, with the rise of health and nutrition consumer trends and awareness, the consumption of convenient snack products that do not contain added sugar and flour has increased significantly, and the market shares of these products have increased significantly. It is estimated that this increase will continue. Based on these, in this study, production of fruit leather from dates, which has very high nutritional value, was made by using infrared drying technique without adding sugar and flour, and the effect of cooking time on the drying behavior was studied. In the experiments, dates were washed and their seeds were removed, and after adding water at a ratio of 1:2.5 (dates:water) they were cooked for 30, 45 and 60 minutes. Afterwards, the cooked dates leather paste was pressed, brought to a thickness of 10 mm and infrared drying was carried out. When the drying curves were examined, it was observed that the effective diffusion coefficient (D_{eff}) changed as the cooking time increased, and this value was determined as 1.53×10^{-9} , 1.70×10^{-9} and 1.74×10^{-9} m^2/s for dates leather products cooked for 30, 45 and 60 minutes, respectively.

Keywords: Infrared Drying, Dates, Fruit Leather, Cooking.

NANOPARTİKÜLLERİN MAYALAR ARACILIĞIYLA YEŞİL SENTEZİ
GREEN SYNTHESIS OF NANOPARTICLES THROUGH YEASTS

Güliden KILIÇ

Dr., Alanya Üniversitesi, Sanat ve Tasarım Fakültesi, Gastronomi ve Mutfak Sanatları Bölümü
Dr., Alanya University, Art and Design Faculty, Gastronomy and Culinary Arts Department

ORCID ID: 0000-0001-6125-6219

ÖZET

Nanoteknoloji; atomik, makromoleküler ve/veya moleküler maddelerin nanometre ölçeğindeki maddelere indirgenmesi olarak ifade edilmektedir ve biyoteknoloji, kimya, malzeme bilimi ve tıp alanında çeşitli uygulamaları olan popüler bir çalışma alanıdır. Son yıllarda, nanoteknolojinin gelişmesi, en az bir boyutu 1-100 nm olan çeşitli nanopartiküllerin (NP) sentezlenmesini sağlamıştır. Bu kapsamda, metalik NP'ler de genellikle metal oksit, organik veya inorganik bir kabuk ile kaplanmış, metal veya metal oksitten oluşan bir çekirdeğe sahip NP'lerdir. NP üretiminde birçok sentez yöntemi bulunmakla birlikte, yeşil sentez yöntemi temiz, çevre dostu, kolay, etkili ve toksik olmayan bir yol sağlaması ve ayrıca ekonomik olması nedeniyle büyük ilgi görmektedir. Bu yöntem genel olarak, biyolojik kaynaklar tarafından sentezlenen vitamin, enzim, pigment, karotenoid ve protein gibi biyomoleküller sayesinde NP'lerin metal tuzlarından indirgenmesi olayıdır. Ayrıca, yeşil sentezi yöntemiyle NP üretilmesinde bitkiler, bitki ekstraktları ve çeşitli mikroorganizmalar kullanılabilir. Yeşil sentez olarak mikrobiyal NP sentezi, genellikle hücre yüzeyine yerleşen (hücre dışı yaklaşım) veya mikrobiyal hücrelerin içinde oluşan (hücre içi yaklaşım) metal iyonlarının içselleştirilmesiyle gerçekleşmektedir. Bu kapsamda, NP sentezinde mayaların kullanımı, bakterilere kıyasla daha yüksek verimde NP sentezlenmesi açısından daha avantajlıdır. Yapılan birçok çalışmada, *Candida glabrata*, *C. albicans*, *Filobasidium stepposum*, *Pichia kudriavzevii*, *Rhodotorula glutinis*, *R. mucilaginosa*, *Saccharomyces cerevisiae*, *S. uvarum*, ve *Yarrowia lipolytica* gibi mayalar kullanılarak çeşitli morfolojik özelliklere (5-100 nm boyutlarında, yuvarlak, küresel, kübik, düzenli veya oval şekilli) sahip gümüş, selenyum, platin, titanyum dioksit ve çinko oksit gibi NP'ler sentezlenmiştir. Sentezlenen NP'lerin boyut, morfoloji ve karakteristik özellikleri sentez sürecinin koşullarına (sıcaklık, pH, inkübasyon süresi vb.) bağlı olarak değişebilmekte ve bu özelliklerine bağlı olarak, NP'ler ilaç iletim sistemleri, tarım ve gıda endüstrisi gibi birçok alanda antimikrobiyal, antioksidan ve antikanser ajan olarak kullanım potansiyeline de sahiptir. Bununla birlikte, NP'lerin birçok avantajına karşın, çevre ve canlılar üzerindeki olası olumsuz etkileri de araştırılmalıdır. Bu çalışmada, NP'lerin yeşil sentezi, mayalar tarafından sentezlenen NP'ler ve potansiyel uygulama alanları ile ilgili yapılan çalışmalar değerlendirilmiştir.

Anahtar Kelimeler: Mikrobiyal sentez, Maya, Nanopartikül, Nanomateryal.

ABSTRACT

Nanotechnology; is defined as the reduction of atomic, macromolecular, and/or molecular matter to nanometer-scale substances, and is a popular field of study with various applications in biotechnology, chemistry, materials science, and medicine. Recently, the development of nanotechnology has provided the synthesis of various nanoparticles, which are at least one dimension in 1-100 nm. In this context, metallic NPs are NPs that have a core composed of metal or metal oxide, usually covered with a metal oxide, organic or inorganic shell. Although there are many synthesis methods for NP production, the green synthesis method attracts great attention because it provides a clean, eco-friendly, easy, effective, and non-toxic route, and is also economical. This method is generally the reduction of NPs from metal salts by biomolecules such as vitamins, enzymes, pigments, carotenoids, and proteins synthesized by biological sources. Also, plants, plant extracts, and various microorganisms can be used in the production of NPs by the green synthesis method. Microbial NP synthesis as green synthesis is usually performed by internalizing metal ions that settle on the cell surface (extracellular approach) or form inside microbial cells (intracellular approach). In this scope, the usage of yeasts in NP synthesis is more advantageous in terms of synthesizing NPs at higher yields compared to bacteria. In many studies, many NP such as silver, selenium, platinum, titanium dioxide, and zinc oxide with various morphology (at 5-100 nm sizes with rounded, spherical, cubic, regular, or oval shapes) have been synthesized by using yeasts such as *Candida glabrata*, *C. albicans*, *Filobasidium stepposum*, *Pichia kudriavzevii*, *Rhodotorula glutinis*, *R. mucilaginosa*, *Saccharomyces uvarum*, *S. cerevisiae*, *Yarrowia lipolytica*. The size, morphology, and characteristic properties of the synthesized NPs may vary depending on the conditions of the synthesis process (temperature, pH, incubation time, etc.), and depending on these properties, NPs also have the potential to be used as antimicrobial, antioxidant and anticancer agents in many fields such as drug delivery systems, agriculture, and food industry. However, despite the many advantages of NPs, their possible negative effects on the environment and living things should also be investigated. In this study, studies about the green synthesis of NPs, NPs synthesized by yeasts, and potential application fields were evaluated.

Keywords: Microbial synthesis, Yeast, Nanoparticle, Nanomaterial.

**PORTAKAL KABUĞU TOZU EKLENEN BESİYERLERİNDEN ELDE EDİLEN
POSTBİYOTİKLERİN BİYOAKTİF ÖZELLİKLERİNİN BELİRLENMESİ**
DETERMINATION OF BIOACTIVE PROPERTIES OF POSTBIOTICS OBTAINED
FROM CULTURE MEDIA SUPPLEMENTED WITH ORANGE PEEL POWDER

Nurşah Zeynep ÖZTÜRK

*Arş., Gör., Tekirdağ Namık Kemal Üniversitesi, Ziraat Fakültesi, Gıda Mühendisliği Anabilim Dalı
Res. Assist. at Tekirdag Namik Kemal University, Faculty of Agriculture, Department of Food Engineering*

ORCID ID: 0000-0002-9501-475X

Aysel GÜLBANDILAR

*Doç. Dr., Eskişehir Osmangazi Üniversitesi, Ziraat Fakültesi, Gıda Mühendisliği Anabilim Dalı
Assoc. Prof. Dr., Eskişehir Osmangazi University, Faculty of Agriculture, Department of Food Engineering*

ORCID ID: 0000-0001-9075-9923

ÖZET

Postbiyotik terimi; canlı probiyotik mikroorganizmalar tarafından üretilen veya mikrobiyal parçalanmadan sonra ortama salınan, konakçıda faydalı aktiviteleri kanıtlanmış metabolitleri ve hücre duvarı bileşenlerini ifade etmektedir. Bu metabolitler arasında; vitaminler, bakteriyosinler, organik asitler, kısa zincirli yağ asitleri, enzimler, hücre proteinleri, kofaktörler, peptitler, teikoik asitler, endopolisakkaritler ve ekzopolisakkaritler yer almaktadır. Güçlü antimikrobiyal, antioksidan, antienflamatuvar, bağışıklık düzenleyici ve antihipertansif özelliklere sahip olduğu kanıtlanan postbiyotiklere olan ilgi tüm dünyada giderek artmaktadır. Bu çalışmada, besiyeri ortamına biyoaktif bileşenlerce zengin bir gıda atığı olan portakal kabuğu eklenmesinin, postbiyotiklerin biyoaktif özelliklerine etkisi incelenmiştir. 3 farklı konsantrasyonda (%0,5, %1, %1,5) portakal kabuğu tozu (PKT) eklenen besiyerlerine probiyotik iki suş (*Lactobacillus plantarum* UALp-05 ve *Bifidobacterium bifidum* UABb-10) inoküle edilmiş, inkübasyon süreci sonunda besiyeri ortamına ultrasonikasyon işlemi (US) uygulanmış, ardından santrifüjlenerek postbiyotikler elde edilmiştir. Postbiyotiklerin biyoaktif özellikleri, Toplam Fenolik Madde Miktarı (TFM) ve antioksidan aktivite (DPPH) açısından incelenmiştir. TFM değeri tüm postbiyotik örnekleri arasında en yüksek *B. bifidum* suşuna ait %1,5 oranında PKT içeren besiyerinden US uygulanarak elde edilen postbiyotiklerde (860,53 mgGAE/L) bulunmuştur. Bunu takiben en yüksek TFM değerlerine sahip olan; %1,5 PKT içeren besiyerinde *B. bifidum* suşu ile US uygulanmadan elde edilen ve %1,5 PKT içeren besiyerinde *L. plantarum* suşu ile US uygulanarak elde edilen postbiyotikler (sırasıyla 859,29 ve 855,89 mg GAE/L) arasındaki fark istatistiksel açıdan önemsiz bulunmuştur ($P>0.05$). DPPH sonuçları, TFM ile benzerlik göstermektedir. %1,5 oranında PKT içeren besiyerlerinden elde edilen postbiyotiklerin daha yüksek % inhibisyona sahip olduğu görülmüştür (%66,72 ile %72,62 arasında). Her iki suş için de TFM ve antioksidan aktivitesi (DPPH) değerleri, PKT eklenmeden elde edilen

postbiyotiklere göre önemli oranda yüksek bulunmuştur ($P<0.05$). PKT konsantrasyonunun artmasıyla bu değerler artış göstermiştir.

Bu çalışma, Eskişehir Osmangazi Üniversitesi Bilimsel Araştırma Projeleri Koordinasyon Birimi tarafından FLY-2024-2969 nolu yüksek lisans projeleri kapsamında desteklenmiştir.

Anahtar Kelimeler: Postbiyotik, *B. bifidum*, *L. plantarum*, Portakal Kabuğu Tozu

ABSTRACT

The term postbiotics refers to metabolites and cell wall components produced by live probiotic microorganisms or released into the environment after microbial degradation, which have proven beneficial activities in the host. These metabolites include vitamins, bacteriocins, organic acids, short-chain fatty acids, enzymes, cell proteins, cofactors, peptides, teichoic acids, endopolysaccharides, and exopolysaccharides. Interest in postbiotics, which have demonstrated strong antimicrobial, antioxidant, anti-inflammatory, immunomodulatory, and antihypertensive properties, is increasing globally. This study investigates the effect of adding orange peel powder, a food waste rich in bioactive compounds, to the culture media on the bioactive properties of postbiotics. Two probiotic strains (*Lactobacillus plantarum* UALp-05 and *Bifidobacterium bifidum* UABb-10) were inoculated into media supplemented with orange peel powder (OPP) at three different concentrations (0.5%, 1%, 1.5%). After the incubation period, the culture media underwent ultrasonic treatment (US), followed by centrifugation to obtain postbiotics. The bioactive properties of the postbiotics were analyzed in terms of Total Phenolic Content (TPC) and antioxidant activity (DPPH). The highest TPC value (860.53 mg GAE/L) was found in the postbiotics obtained from media containing 1.5% OPP and inoculated with the *B. bifidum* strain. Following this, the postbiotics obtained from the media with 1.5% OPP without US treatment and those obtained with *L. plantarum* strain using US treatment had the next highest TPC values (859.29 and 855.89 mg GAE/L, respectively), with the difference found to be statistically insignificant ($P>0.05$). The DPPH results show similarity to the TPC. It was observed that the postbiotics obtained from media containing 1.5% OPP had a higher percentage of inhibition (ranging from 66.72% to 72.62%). For both strains, the TPC and antioxidant activity (DPPH) values were found to be significantly higher than those of postbiotics obtained without OPP ($P<0.05$). These values increased with the rising concentration of OPP.

This study was supported by the Eskişehir Osmangazi University Scientific Research Projects Coordination Unit within the scope of the master's projects numbered FLY-2024-2969.

Keywords: Postbiotics, *B. bifidum*, *L. plantarum*, Orange Peel Powder

**OPTIMIZATION OF SOLVENT AND PROCESS PARAMETERS FOR THE
PRODUCTION OF EXTRACELLULAR MATRIX-MIMICKING POLYMERIC
FIBRES**

Rana YORNUK

MSc Student, Izmir Institute of Technology, Faculty of Engineering, Department of Bioengineering, Izmir,
Turkey

Serkan DİKİCİ

Dr. Öğr. Üyesi, Izmir Institute of Technology, Faculty of Engineering, Department of Bioengineering, Izmir,
Turkey

ABSTRACT

Tissue engineering (TE) offers a promising alternative to restore, maintain, or improve damaged/lost tissues. TE scaffolds are engineered constructs with desired mechanical, biochemical, and biological functions to provide a host that supports the target cells. Polycaprolactone (PCL) is a biocompatible, mechanically durable, and biodegradable synthetic polymer approved by the U.S. Food and Drug Administration for various biomedical applications. These properties make it a great candidate for TE scaffolds.

Several methods, including electrospinning, additive manufacturing, porogen leaching, freeze drying, and emulsion templating, were suggested to fabricate porous TE scaffolds for cells to attach and grow. Electrospinning is a highly controllable route that uses electrical force to draw charged polymer threads to manufacture micro or nano-sized fibers that mimic the native extracellular matrix (ECM). Solvent type, polymer molecular weight and concentration, viscosity and solution conductivity, applied voltage, flow rate, and distance are the solution and process parameters that significantly alter the features and morphology of produced fibers.

Accordingly, in this research, we studied the effect of (i) type and concentration of different solvent blends prepared from dichloromethane, chloroform, acetone, dimethylformamide, and methanol and (ii) process parameters on the ease of fabrication, bead-less and continuous fiber formation, and morphology and diameter of the PCL fibers. Then, a model pro-angiogenic drug was introduced into the fibers, and its release over twenty-eight days was evaluated. Our results demonstrated that both nanofibers and microfibers could be fabricated without any bead formation changing solvent and process parameters. Drug release studies showed that it was released in the bioactive range over twenty-eight days. This study revealed that nano- and microfibers could be precisely engineered via the electrospinning method by changing solvent and process parameters to mimic target-tissue ECM. In addition, electrospun PCL fibers were found suitable for readily loading and releasing drugs at a specific dose range.

Keywords: Electrospinning, biomaterials, tissue engineering, polycaprolactone.

TUZ STRESİ KOŞULLARINDA YETİŞTİRİLEN SOYA FASULYESİ (*GLYCINE MAX L.*)' NDE MİKORİZA UYGULAMALARININ BAZI FİZİKSEL ÖZELLİKLER ÜZERİNE ETKİSİ
EFFECT OF MYCORRHIZA APPLICATIONS ON SOME PHYSIOLOGICAL
PROPERTIES OF SOYBEAN (*Glycine max L.*) GROWN UNDER SALT STRESS
CONDITIONS

Rüveyde TUNÇTÜRK

Prof. Dr., Van Yuzuncu Yil University, Faculty of Agriculture, Department of Field Crops/65100, Tusba-Van
ORCID NO: 0000-0002-3759-8232

Murat TUNÇTTÜR

Prof. Dr., Van Yuzuncu Yil University, Faculty of Agriculture, Department of Field Crops/65100, Tusba-Van
ORCID NO: 0000-0002-7995-0599

Erol ORAL

Assoc. Prof., Van Yuzuncu Yil University, Faculty of Agriculture, Department of Field Crops/65100, Tusba-Van
ORCID NO: 0000-0001-9413-1092

LÜTFÜ NOHUTÇU

Asist. Prof. Dr., Van Yuzuncu Yil University, Faculty of Agriculture, Department of Field Crops/65100, Tusba-Van
ORCID NO: 0000-0003-2250-2645

EZELHAN ŞELEM

Öğr. Gör., Van Yuzuncu Yil University Muradiye Vocational School, Department of Parks and Gardens/65100,
Tusba-Van
ORCID NO: 0000-0003-4227-5013

ÖZET

Bu çalışma, soya fasulyesinde (*Glycine max L.*) tuz stresi (kontrol, 50, 100, 150, 200 mM) altında mikoriza uygulamalarının (AMF) bazı biyokimyasal değişiklikler üzerine etkilerini belirlemek amacıyla yürütülmüştür. Araştırmada uygulanan faktörlerin etkisi doğrultusunda soya fasulyesinde bitki boyu (38.8-25.1 cm), kök boyu(23.9-16.5 cm), gövde yaş ağırlığı (3.21-1.77 g) , gövde kuru ağırlığı (1.02-0.35 g), kök yaş ağırlığı (3.32-1.32 g) ve kök kuru ağırlığı (0.435-0.196 g) gibi özellikler incelenmiştir. Çalışma sonucunda; tuz stresi altında tüm parametrelerde artan tuz stresine karşı azalma tespit edilmiştir. AMF uygulamalarının tuz stresine karşı bazı fizyolojik özellikler üzerinde meydana gelen olumsuz etkiyi azaltıcı ve düzenleyici etkiye sahip olduğu tespit edilmiştir.

Anahtar kelime: AMF, fizyolojik özellikler, soya fasulyesi, tuz stresi

ABSTRACT

This study was conducted to determine the effects of mycorrhizal applications (AMF) on some biochemical changes in soybean (*Glycine max* L.) under salt stress (control, 50, 100, 150, 200 mM). In line with the effect of the factors applied in the research, plant height (38.8-25.1 cm), root length (23.9-16.5 cm), stem fresh weight (3.21-1.77 g), stem dry weight (1.02-0.35 g), root fresh weight (3.32 g) in soybeans. -1.32 g) and root dry weight (0.435-0.196 g) were examined. In the results of working; under salt stress, a decrease was detected in all parameters against increasing salt stress. It has been determined that AMF applications have a reducing and regulating effect on the negative effects of salt stress on some physiological characteristics.

Keywords: AMF, physiological properties, soybean, salt stress

GİRİŞ

İnsanoğlu yer yüzünde var olduğu günden beri bitkileri farklı amaçlar için kullanmıştır. Bunlar arasında, hastalıkların tedavisinde, beslenme, barınma, savunma ve ısınma materyali olarak kullanımı en fazla dikkat çekmiştir. Günümüzde ise bu daha bilinçli bir şekilde yapılmakta ve gıda, kozmetik, ilaç, endüstri ve ziraat gibi pek çok alanda bitkiler kullanılmaktadır (Göktaş ve Gıdık, 2019). Özellikle insan sağlığı göz önünde bulundurularak, yeni beslenme alışkanlıkları içerisinde birçok ürün yer almıştır. Protein oranı oldukça yüksek bir yağ bitkisi olan soya bunlardan biridir (Hartwig and Kihl, 1979). Gen merkezi Kuzey Çin olan soya (*Glycine max* L. Merrill) baklagiller familyasına ait tek yıllık bir bitkidir. Bitki tohumlarında %18-26 yağ ve %40 protein içeren soya, insan ve hayvan beslenmesi açısından çok önemli bir yere sahiptir (İlker ve ark., 2010). Ayrıca, dünya yağlı tohum üretiminin %50'sinden fazlası soya bitkisinden karşılanmaktadır (Arioğlu, 1994). Soya, kolesterol ve doymuş yağlar içermemesi nedeniyle, protein içeriği yüksek kalitede olup, çok yönlü kullanım alanı olan bitkisel gıda maddesidir. Soya yağı, B ve E vitaminleri ile demir, çinko, magnezyum açısından oldukça zengindir. Son 20 yılda uygulanan 2. ürün projesi ile Akdeniz ve Ege Bölgesi'nin sulanabilir alanlarında yetiştirilmeye başlanmış olan soya tarımı günümüzde ağırlıklı olarak Çukurova Bölgesi'nde yapılmaktadır. Soya üretiminin %80-85'i Adana ve Osmaniye illerinde yapılmakta olup. Son yıllarda soya üretimi 50-60 bin tona gerilemiştir. Özellikle üreticilerimizin bu değerli ürünü 2. ürün olarak değerlendirmeleri ve yaygınlaşmasını sağlamaları önem arz etmektedir (Nazlıcan, 2017).

İç ve dış pazarda önemli bir yere sahip olan soya fasulyesi yetiştiriciliğinde kalite ve verim söz konusu olduğunda çevresel faktörlerin bitki üzerine etkilerinin bilinmesi önemlidir. Bitkiler normal yaşam süreçleri içerisinde büyüme ve gelişimlerini olumsuz etkileyen, verimlerini sınırlandıran elverişsiz koşullarla karşılaşabilirler. Bu elverişsiz koşulların oluşmasına neden olan faktörlere 'stres' adı verilmektedir. Bitkisel üretimi etkileyen stres faktörleri biyotik (bitkiler, funguslar, nematodlar, mikroorganizmalar, hayvanlar, antropojenik

etkiler vb.) ve abiyotik stres faktörleri (kuraklık, tuzluluk, yetersiz beslenme, radyasyon, atmosfer kirliliği, yüksek veya düşük sıcaklık, yüksek veya düşük ışık şiddeti vb.) olmak üzere ikiye ayrılmaktadır (Büyük ve ark., 2012). Abiyotik stres faktörlerinden biri olan tuzluluk, bitkisel üretimde, bitkinin yetiştirildiği ortamdaki farklı etmenlerin tohumun çimlenmesinden başlayarak bitki gelişimini ve verimi olumsuz olarak etkilemesine yol açmaktadır. Tuzluluk, tarımsal üretkenliği azaltan ve tarımsal üretim alanlarını sınırlayan önemli bir çevresel etmendir (Rengasamy, 2010). Dünya üzerinde özellikle kurak ve yarı kurak bölgelerde global bir sorun haline gelen tuzluluk problemi tarım arazilerinin %20'sini tehdit etmekte, önlem alınmaz ise bu oranın önümüzdeki 20 yıl içerisinde %50'lere ulaşabileceği öngörülmektedir (Hasanuzzaman ve ark., 2013). Tuzluluk ile mücadelede çeşitli biyolojik yöntemler uygulanmaya başlanmıştır. Özellikle mikrobiyal uygulamalar gerek uygulama pratikliği ve etkinliklerinin uzun süreli olması, gerekse de tuza toleransı önemli düzeyde arttırmaları nedeniyle tüm dünyada yaygın olarak tercih edilmektedir. Mikrobiyal uygulamalar içerisinde en etkili alternatiflerden birisi de mikorizadır. Bitkiler doğal yaşamlarında birçok mikroorganizma ile iletişim halindedir ve bazıları ile simbiyotik yaşam sürerler (Smith ve Read, 1997). Bitki kökleri ile simbiyotik ilişki kurabilme yeteneğine sahip olan mikoriza fungusları, bitkiden kendisinin sentezleyemediği karbonhidratları hazır alırken, hifleri sayesinde bitkilerin kök etki alanını genişleterek daha fazla su ve besin elementi alabilmelerine katkı sağlamaktadır (Smith ve Read, 1997). Mikorizanın olumlu etkisi sadece su ve besin elementlerinin alınımını artırması olmayıp, bitkilerin abiyotik ve biyotik stres koşullarına toleransını da yükseltmektedir (Ruiz-Lozano, 2003; Carvalho ve ark., 2004). Mikoriza türleri, tuz stresine karşı bitki boyu, yaprak alanı, kök ve gövde gelişimi üzerine olumlu katkı yaptığı belirtilmiştir (Ruiz-Lozano, 2003; Çekiç ve ark., 2012).

Bu çalışmada tuzlu koşullarda yetiştirilen soya fasulyesi (*Glycine max* L.)'nde AMF uygulamalarının bitkide bazı fizyolojik parametreler üzerine etkilerinin belirlenmesi amaçlanmaktadır.

MATERIAL VE YÖNTEM

Materyal

Araştırma, 2023 yılında Van Yüzüncü Yıl Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü'ne ait tam kontrollü bitki büyütme odasında yürütüldü. Araştırmada, Ege Tarımsal Araştırma Enstitüsü Müdürlüğü'nden temin edilen yeşilsoy (*Glycine max* L.) çeşidi kullanılmıştır. AMF izolatu, İran Urmie Üniversitesi Ziraat Fakültesi Bitki Koruma Bölümü'ndeki kültür koleksiyonundan temin edilmiştir. AMF izolatu olarak ise *Glomus intraradices* bu çalışmada kullanılmıştır.

Yöntem

Araştırma, Van Yüzüncü Yıl Üniversitesi Tarla Bitkileri Bölümü'nün iklimlendirme odasında tam şansa bağlı tesadüf parselleri deneme deseninde 4 tekerrürlü olarak yürütülmüştür. Bu çalışmada kontrol dahil 5 farklı tuz dozu (0, 50, 100, 150, 200) genç fide dönemindeki soya

fasulyesine uygulanmıştır. AMF uygulamaları için izolattaki spor sayıları: 455 spor/g inokulum toprağı formunda hazırlanmıştır. AMF aşısı, saksılara tohum ekimi sırasında %20 oranında ilave edildi. Tohumlar, kabuk sterilizasyonunu yapmak amacıyla %95' lik etanolde 5 dk tutulduktan sonra, %3' lük hidrojen peroksit ile 5 dk. muamele edilip, distile su ile 6 kez yıkanmıştır(Öğütçü ve ark., 2010). Çalışmada, arbusküler mikoriza fungusları (Rhizophagus irregularis)' nin büyüme ortamına verildiğı çalışmada farklı konsantrasyonlarda (kontrol, 50, 100, 150 ve 200 mM NaCl) tuz çözeltileri uygulamaları ile tuz stresi oluşturulmuştur. Denemede %40 kum, %40 toprak ve %20 mikoriza içeren inokulant karışımı ile doldurulan 500 cc' lik plastik bardak saksılara 5' şer adet olmak üzere soya fasulyesi tohumu ekildi. Ekimden sonra saksılar 16/8 saatlik aydınlık/karanlık fotoperiyotta, $250 \pm 10 \mu\text{molm}^2 / \text{s}$ ışık yoğunluğunda, 25 °C sıcaklık ve %65 neme sahip tam kontrollü iklim odasına yerleştirildi. Çıkıştan sonra tüm saksıların nem miktarı Field Scout dijital nem sensörü kullanılarak toprağın mevcut nem miktarı belirlenecek ve ihtiyaç halinde Hoagland besin solüsyonu ile sulama yapılmıştır. Hazırlanan Hoagland besin solüsyonunun pH (5.5-6.5) (Taiz ve Zeiger, 2002) kontrolü yapıldıktan sonra steril bir ortamda muhafaza edilmiştir.

Bitki çıkışları tamamlandığında saksıda üçer adet bitki olacak şekilde seyreltme işlemi yapılmıştır. Bitkiler belirli bir olgunluğa geldiğinde (30 ± 5 gün) tuz stresi uygulamalarına başlandı. Sulama suyu olarak farklı osmotik basınca sahip tuz solüsyonlarının verildiğı çalışmada, kontrol uygulamalarına, saf su verilmiştir. Bitkiler, tohum çıkışından hasada kadar iklim odasında kontrol altında tutulmuştur. Denemede fizyolojik sorunların şiddeti arttığında (45 ± 5 gün) hasat edilmiştir. Hasat sonrasında bitki ve kök boyu, gövde yaş ve kuru ağırlığı, kök yaş ve kuru ağırlığı gibi fizyolojik parametreler ölçülmüştür(Kurt ve ark., 2023).

İstatistiksel Analiz

Araştırma sonucunda elde edilen veriler Tesadüf Parselleri Deneme Deseni'ne göre varyans analizine tabi tutulmuştur. İstatiksel hesaplamalar COSTAT (Versiyon 6.3) bilgisayar analiz programı kullanılarak yapılmıştır. Ortalamalar arasındaki farklılıklar Duncan Çoklu Karşılaştırma Yöntemi'ne göre belirlenmiştir.

BULGULAR VE TARTIŞMA

Bitki boyu(cm)

Çalışmada, bitki boyu üzerinde Tuz dozları ve T x AMF interaksiyonunun etkisi %1 seviyesinde istatistiksel olarak önemli bulunurken AMF uygulamalarının etkisi önemsiz bulunmuştur. Tuz dozları arttıkça bitki boyunun azaldığı belirlenirken en uzun boylu (38.8 cm) bitkiler kontrol uygulamalarından, en kısa boylu (25.1 cm) bitkiler ise 400 mM tuz dozundan elde edilmiştir. Bu çalışmada 300 ve 400 mM tuz dozlarından elde edilen bitki boyu değerleri aynı grupta yer alırken aralarında istatistiksel olarak önemli bir farklılığın olmadığı belirlenmiştir. AMF uygulamaları bakımından bitki boyu değerleri 31.2-33.0 cm arasında kaydedilmiştir. T x AMF interaksiyonunda en yüksek bitki boyu 38.8 cm (T0 x M1), en düşük değer ise 25.1 cm (T4 x M0) olarak belirlenmiştir (Tablo 1). Benzer bir çalışmada biber

bitkisinde tuz uygulaması sonucunda fide boyu değerinde %30.7 oranında azaldığını bildirmiştir(Altunlu, 2020). Mikorizanın olumlu etkisi sadece su ve besin elementlerinin alınımını arttırması olmayıp, bitkilerin abiyotik ve biyotik stres koşullarına toleransını da yükseltmektedir (Ruiz-Lozano, 2003; Carvalho ve ark., 2004). Elde ettiğimiz bulguları bu araştırmacıların sonuçlarının desteklediği görülmüştür.

Kök boyu(cm)

Bu çalışmada kök yaş ağırlığı üzerine Tuz dozları ve T x AMF interaksiyonunun etkisi %1 ile %5 seviyesinde istatistiksel olarak önemli bulunurken, AMF uygulamalarının etkisi önemsiz bulunmuştur. Tuz dozları arttıkça kök boyunun azaldığı belirlenirken en uzun kök boyu (23.6 cm) olan bitkiler T0 uygulamasından, en kısa boylu (17.1 cm) bitkiler ise 400 mM tuz dozundan elde edilmiştir(Tablo 2). Elde edilen sonuçlara bakıldığında bitki boyu değerleri gibi kök boyu özelliğinde de 300 ve 400 mM tuz dozlarından elde edilen bitki boyu değerleri aynı grupta yer alırken aralarında istatistiksel olarak önemli bir farklılığın olmadığı belirlenmiştir. AMF uygulamaları bakımından bitki boyu değerleri 19.8-20.7 cm arasında kaydedilmiştir. T x AMF interaksiyonunda en yüksek kök boyu 23.9 cm (T1 x M1), en düşük değer ise 16.5 cm (T4 x M0) olarak belirlenmiştir. Yüksek dozlarda tuzluluğa maruz kalan bitkilerde osmotik basıncın yüksek olmasından dolayı tohumların su absorbe etme kabiliyetlerinde azalmalar meydana gelmektedir. Düşük tuz dozlarında , kök uzunluğunun azaldığını tespit etmişlerdir (Kızılgeçi ve ark., 2010). Kök uzunluğu bu bakımdan önemli olmakla beraber tuza dayanıklılık ıslahında bir seleksiyon kriteri olarak değerlendirilmektedir (Atak ve ark., 2006). Bitki kökleri ile simbiyotik ilişki kurabilme yeteneğine sahip olan mikoriza mantarları, bitkiden kendisinin sentezleyemediği karbonhidratları hazır alırken, hifleri sayesinde bitkilerin kök etki alanını genişleterek daha fazla su ve besin elementi alabilmelerine katkı sağlamaktadır (Smith ve Read, 1997).

Gövde yaş ağırlığı(g)

Gövde yaş ağırlığı üzerine AMF etkisi önemsiz, Tuz ve Tuz x AMF uygulamalarının etkisi istatistiksel olarak %1 düzeyinde önemli bulunmuştur. Tuz uygulamaları bakımından en yüksek değer 3.09 g ile kontrolden, en düşük değer ise 1.88 g ile T4 tuz dozundan belirlenmiştir. AMF uygulamaları bakımından ise gövde ağırlığı 2.37-2.50 g arasında tespit edilmiştir. Tuz x AMF uygulamaları arasında en fazla gövde yaş ağırlığı 3.21 g ile T0 x M1 uygulamalarından belirlenmiştir. En düşük değer ise 1.77 g ile T4 x M0 uygulamaları sonucunda elde edilmiştir (Tablo 1). Benzer bir çalışmada artan tuz konsantrasyonları ile bitkilerin ilk gelişim dönemlerinin inhibe edildiği belirlenmiştir (Sadat Noori ve McNeilly, 2011). Diğer bir çalışmada kontrol grubuna göre tuz uygulaması ile gövde yaş ağırlığı %36.5 oranında azaldığını bildirmiştir (Altunlu, 2020). Benzer bir çalışmada, Sannazzaro ve ark., (2007) tarafından, lotus çiçeği yetiştiriciliğinde tuzlu koşulların (200 mM NaCl) olumsuz etkisini azaltmada *Glomus intraradices* kullanımının araştırıldığı bir çalışmada, mikoriza uygulamalarının bitki gelişimini olumlu yönde etkilediği bildirilmiştir.

Tablo 1. Tuz stresi koşullarında yetiştirilen soya fasulyesi bitkisinin fide büyüme parametreleri üzerine mikoriza uygulamalarının etkisi

Uygulamalar		BB(cm)	KB (cm)	GYA(g)	GKA(g)	KYA (g)	KKA(g)
Tuz Dozları	AMF Uygulamaları						
Kontrol (T0)	Kontrol (M0)	35.6 ab	20.8 b	2.98 ab	0.84 ab	3.12 ab	0.384 ab
	AMF (M1)	38.8 a	22.9 ab	3.21 a	1.02 a	3.32 a	0.435 a
T0 Ort.		37.2 A	21.8 B	3.09 A	0.94 A	3.22 A	0.409 A
T1 50 (T1)	Kontrol (M0)	33.6 ab	23.3 ab	2.57 b	0.69 abc	2.66 b	0.379 b
	AMF (M1)	35.8 ab	23.9 a	2.73 b	0.82 ab	2.79 b	0.395 ab
T1 Ort.		34.7 AB	23.6 A	2.65 B	0.76 B	2.72 B	0.387 B
T 100 (T2)	Kontrol (M0)	32.2 b	21.8 ab	2.28 c	0.58 bc	2.22 c	0.331 c
	AMF (M1)	34.3 b	20.9 b	2.46 bc	0.62 bc	2.39 bc	0.347 bc
T2 Ort.		33.2 B	21.3 B	2.37 C	0.60 C	2.30 C	0.339 C
T150 (T3)	Kontrol (M0)	29.7 bc	16.9 d	2.27 c	0.45 d	1.86 d	0.292 d
	AMF (M1)	29.8 c	18.5 c	2.23 c	0.47 d	1.88 d	0.313 cd
T3 Ort.		29.7 C	17.7 C	2.25 C	0.46 D	1.87 D	0.302 D
T 200 (T4)	Kontrol (M0)	25.1 d	16.5 d	1.77 e	0.35 f	1.32 f	0.196 e
	AMF (M1)	26.3 c	17.7 cd	1.98 d	0.38 e	1.56 e	0.202 de
T4 Ort.		25.7 C	17.1 C	1.88 D	0.37 E	1.44 E	0.199 E
AMF Uygulamaları	Kontrol (M0)	31.2	19.8	2.37	0.58 B	2.38 B	0.269 B
	AMF (M1)	33.0	20.7	2.50	0.66 A	2.38 A	0.316 A
Tuz dozları (T)		**	**	**	**	**	**
AMF		öd	öd	öd	**	**	**
T x AMF		**	*	**	**	*	*
VK (%)		8.48	5.12	5.52	7.06	5.17	3.79
LSD (0.05)		3.27	1.26	0.16	0.05	0.15	0.02

*P<0.05 düzeyinde, ** P<0.01 düzeyinde önemli. öd: önemli değil.

Gövde kuru ağırlığı(g)

Gövde kuru ağırlığı üzerinde Tuz, AMF ve T x AMF interaksiyonunun etkisi %1 düzeyinde önemli bulunmuştur. Tuz uygulamaları sonucunda en yüksek değer 0.94 g ile T0 uygulamalarından elde edilirken, en düşük değer ise 0.37 g ile T4 dozundan elde edilmiştir (Tablo 2). AMF uygulamaları bakımından en yüksek değer 0.66 g ile M1 uygulamalarından, kontrol grubundan ise 0.58 g olarak daha düşük belirlenmiştir. T x AMF interaksiyonunda en yüksek değer 1.02 g ile T0 x M0 uygulamalarından tespit edilmiştir. Bu özellik açısından en düşük değer ise 0.35 g ile T4 x M0 uygulamasından elde edilmiştir (Tablo 1). Çalışmamız ile benzer sonuçların elde edildiği başka bir araştırmada, artan tuz konsantrasyonlarının gövde kuru ağırlıklarını azalttığı tespit edilmiştir. (Kızılgücü ve ark., 2010). Benzer araştırmalarda artan tuz konsantrasyonlarının bitkilerde gövde kuru ağırlıklarını azalttığı belirtilmiştir (Muhammad ve Hussain 2012).

Kök yaş ağırlığı(g)

Kök yaş ağırlığı üzerine Tuz ve AMF uygulamalarının etkisi %1, T x AMF interaksiyonunun etkisi %5 seviyesinde etkili olmuştur. En yüksek değer 3.22 g ile kontrolden, en düşük değer ise 1.44 g ile T4 dozundan belirlenirken, mikoriza uygulamaları bakımından en düşük değer 2.23 ile M0 uygulamalarından, en yüksek değer ise 2.38 g ile M1 uygulamalarından elde edilmiştir. Uygulamaların interaksiyonu bakımından ise en yüksek kök yaş ağırlığı değeri 3.32 g olarak T0 x M1 uygulamalarından en düşük değer ise 1.32 g T4 x M0 uygulamasında tespit edilmiştir (Tablo 1). Tuz dozlarındaki artış bitkide su alım etkinliğini azaltarak yaş ve kuru kök ağırlıklarının düşüşlere neden olduğu bildirilmiştir. (Kızılgöçü ve ark. 2010; Oral ve ark. 2020).

Kök kuru ağırlığı(g)

Kök kuru ağırlığı üzerine T ve AMF uygulamalarının etkisi %1 önemli iken, T x AMF uygulamalarının etkisi ise istatistiksel olarak % 5 düzeyinde önemli bulunmuştur (Tablo 1). En fazla kök kuru ağırlığı 0.409 g ile kontrolden, en az kuru ağırlık ise 0.199 g ile T4 dozundan belirlenmiştir. AMF uygulamaları bakımından incelendiğinde; en fazla kök ağırlığı 0.316 g ile M1 uygulamalarından, en düşük değer ise 0.269 g ile M0 uygulamasından elde edilmiştir. Tuz x AMF uygulamaları sonucunda en yüksek kök kuru ağırlığı değeri 0.435 g olarak T0 x M1 uygulamalarından en düşük değer ise 0.196 g T4 x M0 uygulamasında tespit edilmiştir (Tablo 1). Benzer bir araştırmada tuz stresinde bitkilerin su alımı olumsuz etkilenmektedir. Bunun sonucunda bitkide kök yaş ve kuru ağırlıklarında azalma meydana geldiği bildirilmiştir (Hattori ve ark. 2005). Soya fasulyesi bitkisinin farklı tuz konsantrasyonlarına (0, 3, 6 ve 9 mM NaCl) maruz bırakıldığında kök yaş ve kuru ağırlığının azaldığı görülmüştür (Weisany ve ark., 2012).

Soya Fasulyesi Bitkisinin Mikorizal Frekans Kolonizasyon Oranı, AMF Spor Sayıları

Tüm tuz seviyelerinde bitki kökünün tüm kısımlarında Arbusküler Mikorizal Fungus yapıları oluşmuştur. Dolayısıyla mikorizal frekans (% F) değerleri tüm tuz dozlarında %90-100 arasında tespit edilmiş ve istatistiksel olarak uygulamalar arasında anlamlı bir farklılığın çıkmaması nedeniyle tablo şeklinde verilmesine gerek duyulmamıştır. Tüm tuz stresine maruz kalan bitki kökünün tüm kısımlarında AM mantar oluşumu gözlemlenmiştir. İncelenen örneklerde ekstra ve intra miselyumlar, kesecikler, sporlar ve arbusküller gibi farklı mantar yapıları tespit edilmiştir (Şekil 1). Mantar yapılarının yoğunluğu uygulamalara göre değişiklik göstermiştir. Özellikle tuz stresi konsantrasyonunun yüksek olduğu örneklerde vezikül yoğunluğunun diğer yapılara

göre daha fazla olduğu dikkat çekmektedir. Veziküllerin depolama veya yayılma işlevlerine sahip olması ve uygun koşullar oluştuğunda hücreler arası hiflerin yeniden büyümesini destekleyebilmesi nedeniyle bu beklenen bir durumdur (Smith ve Read, 1997). Stresli ortamlarda AM mantarları, hayatta kalmaları için gerekli olan depolama yapılarına daha fazla

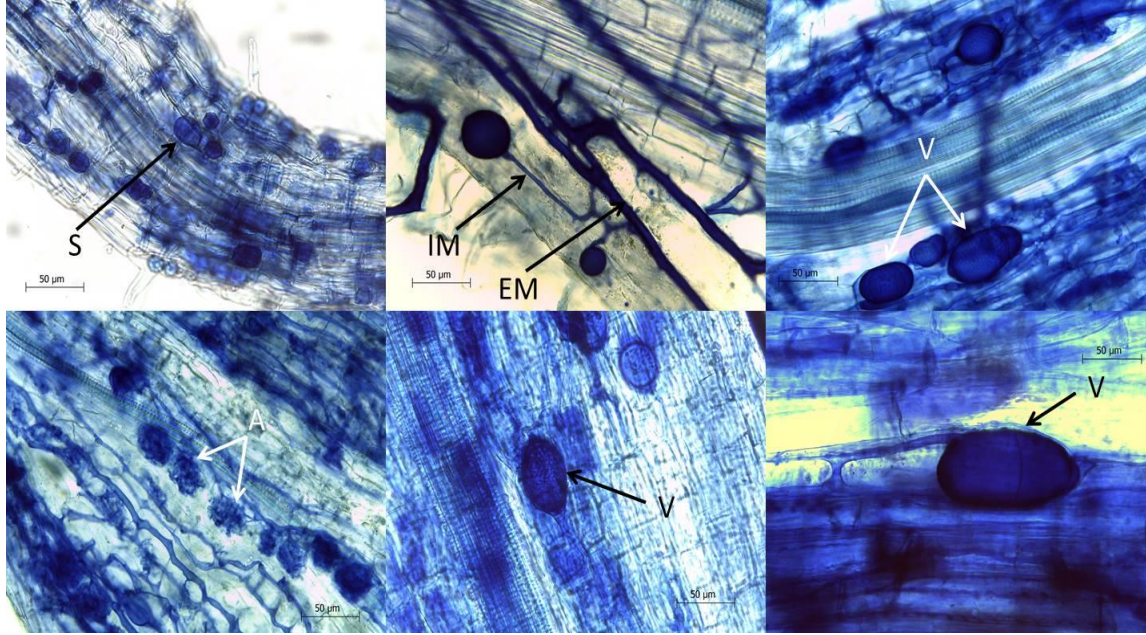
enerji yatırma eğilimindedirler (Turnau ve ark., 1996). Dolayısıyla tuz stresinin yüksek olduğu topraklarda bu yapıların yoğun olarak oluşması beklenmektedir.

Tablo 2. Farklı tuz stresi koşullarında AMF Spor sayılarının varyans analizi

	SD	KO	F
Uygulamalar	4	7193.73	793.43**
Hata	10	9.07	
Toplam	14		

** : P<0.01 önemli

Bu sonuçlara göre AMF spor sayıları üzerinde tuz stresi uygulamalarının etkisi %1 seviyesinde önemli bulunmuştur. En düşük AMF spor sayısı (135 spor/g toprak) kontrolden elde edilirken, en yüksek değer (260 spor/g toprak) 200 mM (T2) tuz dozundan elde edilmiştir. Ortalama spor sayısı 193.40 ± 11.72 spor/g toprak olarak belirlenmiştir.



Şekil 1. Konukçu bitki köklerinde AMF yapıları. A: Arbüsküler; V: Vezikül; H: Hif; S: Spor (50 µm: 40X; 200 µm: 10X).

Tablo 3. Farklı tuz stresi koşullarında AMF spor sayıları (g^{-1}) ortalama değerlerinin karşılaştırılması

Tuz Stresi Uygulamaları (mM)	AMF Spor Sayıları (g^{-1})
200	257.33 ± 1.45 a
150	224 ± 2.08 b
100	192.67 ± 1.76 c
50	157.67 ± 1.86 d
Kontrol	137.33 ± 1.45 e

Duncan çoklu karşılaştırma testine göre aynı harfle gösterilen ortalamalar arasında farklılık bulunmamaktadır ($P<0.01$).

Bu çalışmada en yüksek AMF spor sayısı ortalama değeri (257.33 ± 1.45 spor/g toprak) 200mM tuz uygulamalarından elde edilmiştir. En düşük AMF spor sayısı ortalama değerleri (137.33 ± 1.45 spor/g toprak) kontrol uygulamalarından belirlenmiştir. Ancak 50 mM tuz dozu uygulamaları ile istatistiksel olarak farklılık tespit edilmemiştir.

Tablo 4. Farklı tuz stresi koşullarında Mikorizal yoğunluk indeksi (%M) varyans analizi

	SD	KO	F
Uygulamalar	4	345.98	162.53**
Hata	10	2.13	
Toplam	14		

** : $P<0.01$ önemli

Çalışma sonucunda AMF mikorizal yoğunluk indeksi (% M) üzerinde tuz stresinin etkisi %1 seviyesinde önemli bulunmuştur. En az mikorizal yoğunluk indeksi (%15) kontrol uygulamalarında tespit edilmiştir. Ayrıca en yüksek mikorizal yoğunluk indeksi (%44,20) 200 mM tuz stresi uygulamalarında ölçülmüştür. Mikoriza yoğunluk indeksinin toplam ortalaması 31.31 ± 2.59 'dur.

Tablo 5. Farklı tuz stresi koşullarında Mikorizal yoğunluk indeksi (%M) ortalama değerlerinin karşılaştırılması

Tuz stresi Uygulamaları (mM)	Mikorizal yoğunluk indeksi (%M)
200	43.40 ± 0.49 a
150	38.47 ± 0.76 b
100	33.70 ± 0.62 c
50	24 ± 0.99 d
Kontrol	17 ± 1.15 e

Duncan çoklu karşılaştırma testine göre aynı harfle gösterilen ortalamalar arasında farklılık bulunmamaktadır ($P<0.01$).

Farklı tuz stresi konsantrasyonları altında mikorizal yoğunluk indeksi karşılaştırıldığında, bu indeksin en yüksek ortalamasının (43.40 ± 0.49) 200 mM tuz stresi konsantrasyonunda tespit edilerek ayrı bir istatistiksel grupta yer almıştır. Ayrıca mikorizal yoğunluk indeksinin en düşük ortalaması da (17 ± 1.15) kontrol uygulamalarından elde edilmiştir.

SONUÇ

Bu çalışmada soya fasulyesinde (*Glycine max* L.) tuz stresine karşı AMF uygulamalarının bazı fizyolojik özellikler üzerine etkisi incelenmiştir. Soya fasulyesinde kontrol uygulamasına göre 200 mM tuz dozu ile oluşturulan stres sonucunda bitki boyu, kök boyu, gövde yaş ağırlığı, gövde kuru ağırlığı, kök yaş ağırlığı ve kök kuru ağırlığı değerlerinde sırasıyla %35.3, %28.3, %44.8, % 65.7, %60.2 ve % 54.9 oranında azalmıştır. Bitkide kontrol uygulamasına göre AMF uygulamalarının tuz stresi karşısında gövde kuru, kök yaş ve kuru

ağırlıklarında istatistiksel olarak önemli artışlar tespit edilmiştir. AMF bitkide tuz stresinin biyokimyasal zararını iyileştirici ve düzenleyici etkisi olduğu görülmüştür. Benzer sonuçlar bitki boyu, kök boyu, gövde yaş ve kuru ağırlıklarında görülmesine karşın istatistiksel olarak önemsiz bulunmuştur

Bu sonuçlara göre tuz stresi karşısında AMF uygulamalarının hasar düzeyini azalttığı tespit edilmiştir. Ancak daha gerçekçi sonuçlara ulaşabilmek için bu çalışmanın farklı bitki ve ortamlarda test edilmesi gerekmektedir. Bu amaçla tuz stresine karşı benzer çalışmaların yürütülmesinin literatüre ve problemin çözümüne katkı sağlayacağı kanaati hasıl olmuştur.

TEŞEKKÜRLER

Bu çalışma Van Yüzüncü Yıl Üniversitesi Bilimsel Araştırma Projeleri Koordinasyon Birimi tarafından FBA-2023-10654 nolu “Tuz Stresi Koşullarında Yetiştirilen Soya Fasulyesi (*Glycine max* L) 'nde Mikoriza Uygulamalarının Morfolojik ve Fizyolojik Özellikler Üzerine Etkisi” isimli proje kapsamında desteklenmiştir. Desteklerinden dolayı BAP birimine teşekkür ederiz.

KAYNAKLAR

- Arıoğlu, H., 1994. Yağ Bitkileri (Soya ve Yerfıstığı). Çukurova Üniversitesi Ziraat Fakültesi Ders Kitabı No:35, 354 s.
- Altunlu, H. 2019. Tuzlu Koşullarda Mikoriza Uygulamasının Kapa Biberde (*Capsicum annuum* L.) Fide Gelişimi ve Antioksidant Enzimler Üzerine Etkisi. Ege Üniversitesi Ziraat Fakültesi Dergisi, 56(2): 139-146.
- Atak, M., Kaya, M.D., Kaya, G., Kılılı, Çiftci, C.Y., 2006. Effects of NaCl on the germination, seedling growth and water uptake of triticale. Turkish J. Agric. Forestry, 30: 39-47.
- Büyük, İ., Soydam-Aydın, S., Aras, S., 2012. Bitkilerin Stres Koşullarına Verdiği Moleküler Cevaplar. Turkish Bulletin of Hygiene and Experimental Biology/Türk Hijyen ve Deneysel Biyoloji, 69 (2):97-110.
- Carvalho, L.M., Correia, P.M., Martins-Louçao, A.M. (2004) Arbuscular mycorrhizal fungal propagules in a salt marsh. Mycorrhiza 14: 165-170.
- Hasanuzzaman, M., Nahar, K., Fujita, M., 2013. Plant response to salt stress and role of exogenous protectants to mitigate saltinduced damages, In: Ecophysiology and Responses of Plants under Salt Stress (Eds: Ahmad P, Prasad MNV, Azooz MM), Springer-Verlag, New York. pp 25-87.
- Hattori T, Inanaga S, Araki H, Morita S, Luxova M, Lux A 2005. Application of Silicon Enhance. Drought Tolerance in Sorghum bicolor. Physiologia Plant, 123(4):459-466.
- Hartwig, E.E., Kihl, R.A.S. 1979. Identification and Utilization of Delayed Flowering Character in Soybean for Short Day Conditions. Field Crops Research, 2: 145-151.

- Kurt, C.H., Tunçtürk, M., Tunçtürk, R., 2023. Tuzluluk stresi koşullarında yetiştirilen soya (*Glycine max L.*) bitkisinde bazı fizyolojik ve biyokimyasal değişimler üzerine salisilik asit uygulamalarının etkileri. *Ege Üniv. Ziraat Fak. Dergisi*, 60 (1):91-101.
- Kızılgöçü F, Yıldırım M, Akıncı C 2010. Bazı ekmeklik buğday genotiplerinin tuzluluğa tepkilerinin belirlenmesi. *Diyarbakır 1. Uluslararası Katılımlı Kamu-Üniversite-Sanayi İşbirliği Sempozyumu ve Mermencilik Şurası*, 24-26 Mayıs 2010: 301-307.
- Göktaş, Ö., Gıdık, B. (2019). Tıbbi ve aromatik bitkilerin kullanım alanları. *Bayburt Üniversitesi Fen Bilimleri Dergisi*, 2(1): 145-151.
- Öğütçü, H., Algur, Ö. F., Güllüce, M., Adıgüzel, A., 2010. Mikrobiyal gübre olarak kullanılan ve yabancı bitkilerden izole edilen *Rhizobium* suşlarının farklı sıcaklık şartlarında azot bağlama potansiyellerinin Araştırılması. *Biyoloji Bilimleri Araştırma Dergisi*, 3(1): 47-52.
- Sadat Noori, S.A., McNeilly, T. 2000. Assessment of variability in salt tolerance based on seedling growth wheat (*Triticum durum Desf.*). *Genetic Resources and Crop Evolution*, 47:285-291.
- Sannazzaro, A.I., Echeverria, M., Alberto, E.O., Ruiz, O.A., Menendez, A.B. (2007) Modulation of polyamine balance in lotus glaber by salinity and arbuscular mycorrhiza. *Plant Physiol. Biochem.* 45: 39-46.
- Smith, S.E., Read, D.J., 1997. *Mycorrhizal symbiosis* 1997 San Diego, CA Academic press.
- Rengasamy, P., 2010. Soil Processes Affecting Crop Production in Salt-Affected Soils. *Australian Journal of Soil Research*, 37:613–620.
- Ruiz-Lozano, J.M. (2003). Antioxidant activities in mycorrhizal soybean plants under drought stress. *New Phytologist*, 157(1): 135-143.
- Ruiz-Lozano, J. M., Azcón R., Gómez M., 1996. Alleviation of salt stress by arbuscular-mycorrhizal *Glomus* species in *Lactuca sativa* plants. *Physiologia Plantarum*, 98:767–772.
- İlker, E., Tatar, Ö., Gökçöl, A., 2010. Konvansiyonel ve organik tarım koşullarında bazı soya çeşitlerinin performansları. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, 47 (1): 87-96.
- Muhammad, Z., Hussain, F. 2012. Effect of NaCl salinity on the germination and seedling growth of seven wheat genotypes. *Pak. J. Botanic* 44(6): 1845-1850.
- Nazlıcan, A.N. (2017). Soya fasulyesi yetiştiriciliği. (Web sayfası: https://arastirma.tarimorman.gov.tr/cukurovataem/Belgeler/Yeti%C5%9Ftiricilik/soya-yetistiriciligi_1.pdf) (Erişim Tarihi: 12.20.2019).
- Weisany, W., Sohrabi, Y., Heidari, G., Siosemardeh, A., Ghassemi-Golezani, K.(2012). Changes in antioxidant enzymes activity and plant performance by salinity stress and zinc application in soybean (*Glycine max L.*). *Plant Omics*, 5(2): 60-67.

**ARONYA (*Aronia Melanocarpa*) MEYVESİNDEN FENOLİK MADDELERİN
ULTRASES DESTEKLİ EKSTRAKSİYONU**
ULTRASOUND-ASSISTED EXTRACTION OF PHENOLIC COMPOUNDS FROM
ARONIA (*Aronia Melanocarpa*) FRUIT

İnci CERİT

Dr., Sakarya Üniversitesi, Mühendislik Fakültesi, Gıda Mühendisliği Bölümü
Dr., Sakarya University, Faculty of Engineering, Department of Food Engineering

ORCID ID: 0000-0002-3106-8951

Omca DEMİRKOL

Dr., Sakarya Üniversitesi, Mühendislik Fakültesi, Gıda Mühendisliği Bölümü
Dr., Sakarya University, Faculty of Engineering, Department of Food Engineering

ORCID ID: 0000-0002-6026-5997

Özlem AKTÜRK GÜMÜŞAY

Dr., Maltepe Üniversitesi, Güzel Sanatlar Fakültesi, Gastronomi ve Mutfak Sanatları Bölümü
Dr., Maltepe University, Faculty of Fine Arts, Department of Gastronomy and Culinary Arts

ORCID ID: 0000-0001-9106-3151

ÖZET

Aronya (*Aronia melanocarpa*), ılıman iklime sahip bölgelerde yetişen, ekşi ve buruk bir tada sahip üzüksü bir meyvedir. Yüksek antioksidan etki gösteren antosiyaninler, karotenoidler, fenolik bileşikler ve vitaminler bakımında oldukça zengin olan bu meyvenin insan sağlığı üzerinde olumlu etkilerinin olduğu bilinmektedir. Bu çalışmada aronya meyvesinin içermiş olduğu fenolik maddelerin ekstraksiyonunda ultrases yönteminin kullanımı araştırılmıştır. Çözücü olarak etanol çözeltisi (%50) kullanılarak ve ultrases gücü 90 W olacak şekilde oda sıcaklığında farklı sürelerde (10-20-40-60-90 dakika) ekstraksiyon gerçekleştirilmiştir. Belirtilen sürelerde hazırlanan ekstraktlarda toplam fenolik madde miktarı ile birlikte serbest 2,2-diphenyl-1-picrylhydrazyl (DPPH) radikal süpürme aktivitesi, 2,2'-azinobis (3-etil-bezotiazolin 6 sulfonat) (ABTS) radikal süpürme aktivitesi ve demir iyonu indirgeme gücü (FRAP) yöntemlerine göre antioksidan aktiviteleri belirlenmiştir. En yüksek toplam fenolik madde içeriği (117,45 mg GAE/g) 60 dakikalık ekstraksiyon sonucunda elde edilmiştir. Toplam fenolik madde miktarı 60. dakikaya kadar polinomal şekilde bir artış göstermiş ve 60.dakikadan itibaren azalmaya başlamıştır. FRAP ve DPPH ile tayin edilen antioksidan aktivite değerlerinde benzer bir eğilim söz konusudur, 60. dakikadan sonra her ikisi içinde etkili bir azalma gözlenmiştir. ABTS ile saptanan antioksidan aktivitede ise 60. dakikadan sonra daha yavaş seyreden bir azalma gözlenmiştir. Sonuç olarak ısı, ışık ve oksidasyona karşı hassas olan bu fenolik bileşiklerin oda sıcaklığında ultrases ile ekstraksiyonunda sürenin önemli bir parametre olduğu ve optimum noktadan sonra fenolik bileşenlerin kavitasyon etkisiyle parçalanarak azaldığı saptanmıştır.

Anahtar Kelimeler: Aronya, Fenolik, Antioksidan, Ekstraksiyon, Ultrases

ABSTRACT

Aronia (Aronia melanocarpa) is a berry-like fruit with a sour and astringent taste that grows in moderate climatic regions. It is known that this fruit, which is rich in anthocyanins, carotenoids, phenolic compounds, and vitamins with high antioxidant effects, has a positive impact on human health. In this study, the utilization of the ultrasound method in extracting phenolic substances including in aronia fruit was investigated. Extraction was carried out for different periods (10-20-40-60-90 minutes) at room temperature, using ethanol solution (50%) as the solvent and ultrasound power of 90 W. Antioxidant activities according to different methods; free 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, 2,2'-azinobis (3-ethyl-benzothiazole 6 sulfonate) (ABTS) radical scavenging activity, iron ion reducing power (FRAP) together with the total phenolic content were determined in the extracts prepared at the specified periods. The highest total phenolic content (117.45 mg GAE/g) was obtained after 60 minutes of extraction. The total phenolic content increased polynomial up to the 60th minute and started to decrease from the 60th minute onwards. There was a similar trend in antioxidant activity values determined by FRAP and DPPH, with a significant decrease observed for both after 60 minutes. A slower decrease in antioxidant activity detected by ABTS was observed after the 60th minute. As a result, it has been observed that time is an important parameter in the ultrasound extraction of phenolic compounds, which are sensitive to heat, light, and oxidation, at room temperature, and after the optimum point for the time, the phenolic compounds decrease by fragmentation with the effect of cavitation.

Keywords: Aronia, Phenolic, Antioxidant, Extraction, Ultrasound

**PARKING SPACE PLANNER ALGORITHM ON LIDAR BASED MAP WITH
AUTONOMOUS VEHICLE**

Cem Tolga MÜNYAS

TOFAŞ R&D İzmir Branch

ORCID NO: 0009-0002-9878-9566

Sibel DEMİR

TOFAŞ R&D İzmir Branch

ORCID NO: 0009-0005-8245-0607

Boğaçhan Ali DÜŞGÜL

Izmir Institute of Technology, Engineering Faculty, Department of Electrical & Electronics Engineering

ORCID NO: 0009-0004-2273-0538

ABSTRACT

This paper proposes an effective solution to the shortcomings of urban parking inside the university campus (IZTECH) by developing an autonomous decision-making method in the parking space planner algorithm within the framework of an open-source autonomous driving stack called Autoware. Through the use of the libraries and components provided by Autoware, along with the Robot Operating System (ROS2) architecture, an efficient algorithm is developed that enables to locate the nearest parking facility and closest available parking space on the PointCloud map that we created using the Ouster OS-1 LIDAR scans within the campus. The main goal is to park the vehicle fully-autonomously inside the nearest empty parking space relative to the current position of the self-driving vehicle, considering dynamic objects, obstacles, pedestrians, and other vehicles. The results for autonomous vehicle to locate and park inside the closest empty parking space are observed on the 3D visualization tool called Rviz. The parking space planner node which is specifically designed for this operation is subscribed to three different nodes in Autoware which provides the mapping, localization and perception information for the autonomous vehicle. On the other hand, it publishes messages to the goal pose topic to keep update the goal position and orientation of the vehicle. Thus, the autonomous vehicle makes driving decision meticulously to identify and navigate to the nearest empty parking space on the map. To sum up, this parking space planner solution minimizes the time and effort for drivers to search for empty parking spaces in urban environments.

Keywords: Autonomous Parking, Decision-Making Algorithm, Robot Operating System, Urban Parking Solutions

INTRODUCTION

Nowadays, autonomous driving vehicles use advanced technologies to navigate and perform driving tasks without human intervention. Autonomous vehicles can make decisions based on their programming and by processing the sensor inputs which they are equipped with. On the other side, finding a suitable parking space in modern urban environments has become a significantly hard mission for drivers for many reasons [1]. The most significant reason is the human error in parking [1]. One bad parking in tight urban environments could effect other drivers to park their cars properly between the predetermined parking areas. In order to minimize this kind of human error, several automotive manufacturers have developed and released semi-autonomous parking systems as commercial products [2]. Moreover, automated valet parking systems have been introduced in a way that drivers can control their autonomous vehicles by the mobile application, which enables an autonomous car to drive to a parking spot and parks itself [2]. Despite the extensive research in the field of autonomous parking for vehicles, generating a free-obstacle trajectories for the autonomous vehicles in tight urban areas remains as a difficult task. Furthermore, this kind of semi-autonomous parking systems still depends on the existence of driver and the car should be under control until it is placed on the entrance of the parking facility or the vehicle should be in suitable position for parallel-parking [2]. The main goal of this project is to design an autonomous parking algorithm that utilizes the capabilities of Autoware and the Robot Operating System (ROS2) to identify and navigate the autonomous vehicle to the nearest available parking space within the nearest parking lot relative to the current position of the vehicle in IZTECH (Izmir Institute of Technology) map. We called this algorithm parking space planner and it can be applied and executed in any environment with a LIDAR scanned map. The overall project provides an effective solution to the shortcomings of urban parking by providing an efficient, safe and user-friendly solution to the problem of finding and utilizing parking spaces especially in narrow urban areas. We believe that this autonomous parking project provides a critical improvement in comparison with the current parking technologies since it does not need the existence of driver activity.

MATERIALS AND METHOD

The autonomous parking algorithm is developed on Autoware which is an open source autonomous driving stack software for self-driving vehicles. Autoware was used as the primary software framework for managing various aspects of autonomous driving and autonomous parking. Autoware's modular architecture facilitated the integration of different subsystems such as mapping, localization, motion planning, sensing, and control, into a unified system tailored for autonomous parking [3]. Autoware needs a middleware platform as a basis so that different nodes in Autoware can communicate in real-time [3]. Robot Operating System (ROS2) was used for this operation to ensure efficient communication between mapping, planning, perception etc. nodes.

ROS2 is a highly flexible, distributed framework especially designed for real-time robotics applications [4]. It enables communication between different components known as nodes, through its publisher-subscriber architecture [5]. For the project, ROS2 serves as the middleware that provides the real-time communication infrastructure, runtime environment and low-latency data transfer, while Autoware utilizes this foundation to implement higher-level features needed for autonomous driving [3]. Autoware also provides sample vehicle and sample sensor kit which composed of 3D LIDAR scanner, Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) mainly used for mapping, localization and perception [3]. Autoware relies on high-definition point cloud and maps and vector maps of the driving environment to perform various tasks such as localization, decision-making, generating trajectories, etc [3]. Mapping in Autoware provides two types of information to the rest of the stack. It provides geometric information (3D visualization of other vehicles, nearby buildings, etc.) of the environment as point cloud map and semantic information about roads as a vector map. Vector map basically contains highly precise information about the lane geometry, road networks, parking lots, parking spaces and the traffic lights. One of the most significant contribution of this project to Autoware is mapping. We recorded the point cloud data in IZTECH campus by using a high-resolution LIDAR sensor Ouster-OS1 on top of the vehicle. Then, 3D pointcloud map is generated from recorded LIDAR scans which was placed on top of the vehicle. Here is an image taken from the generated point cloud map inside the campus.

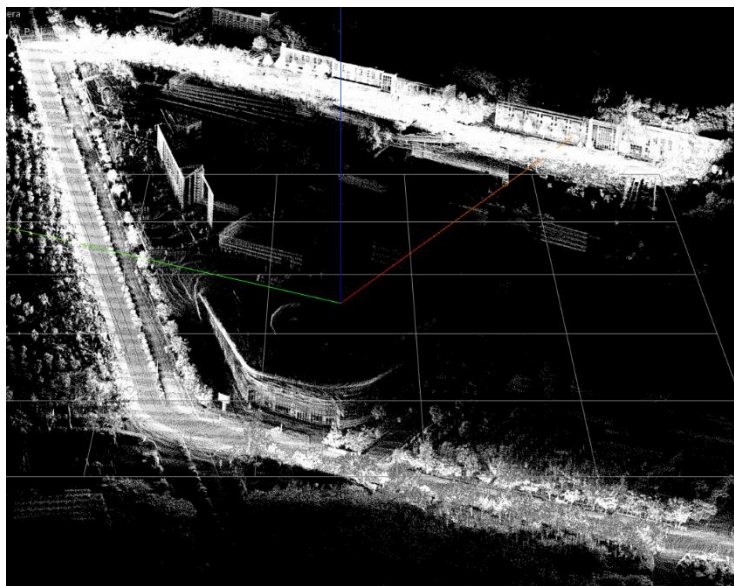


Figure 1. 3D point cloud map generated from LIDAR scans

3D Ouster-OS1 LIDAR is the only sensor that is used for creating a virtual environment from reality. Since the LIDAR has also equipped with an inner IMU, the mapping results were precise. On the software basis, sample vehicle is equipped with LIDAR, GNSS and IMU for basically localization and perception. Here is an image of the Ouster-OS1 LIDAR sensor

mounted on top of the vehicle in order to collect data from the IZTECH environment and create a 3D map.



Figure 2. Ouster-OS1 LIDAR mounted on top of the vehicle to collect data

In addition to these sensors, software, and middleware; a 3D visualization tool for ROS is used to visualize and verify the autonomous driving and parking features of the self-driving vehicle. As mentioned earlier in the abstract, the most significant improvements to enhance such parking algorithm are the redesign and construction of mapping and planning components. On the other hand, perception packages in Autoware was utilized in order to enable object detection and path prediction. Each component in Autoware is connected each other and ROS2 provides the communication basis between different nodes within different packages [3]. Here is the high-level architecture of Autoware which consists of six stacks which the autonomous vehicle utilizes.

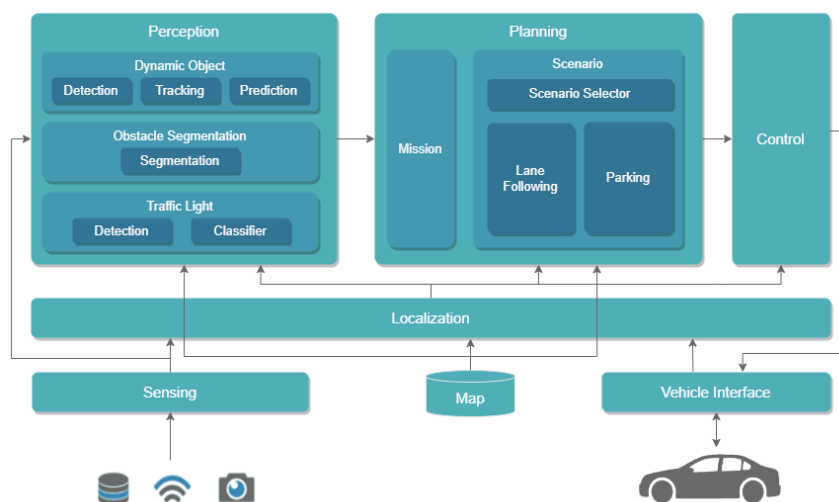


Diagram 1. High-level architecture of Autoware [6]

The planning component in autonomous driving systems plays a crucial role in generating a target trajectory, determining a goal pose while ensuring all of the safety standards and following the traffic rules [7]. The planning stacks in Autoware generates trajectories based on outputs from all of the components that we mentioned earlier. Path planning is separated into two classes: mission and motion planning [7]. Autoware plans the trajectory based on the current position of the self-driving vehicle and the desired position. Search algorithms are used in order to generate the efficient trajectory to the goal position. In our case, we used the A* path finding algorithm since it provides the most efficient and shortest path to the goal pose [8]. Planning module basically consists of two submodules which are mission planning and motion planning [7]. Mission planner employs a rule-based approach to calculate path trajectories depending on the driving states [7]. The mission planning also includes navigation from the current position to the destination [7]. On the other hand, motion planner is responsible for generating efficient and feasible trajectories by considering the states of the vehicle, drivable areas indicated by 3D point cloud map, surrounding objects, and desired goal pose [7]. The main aim of this project is to design and implement a planner package and a parking space planner node so that it could communicate with other nodes in Autoware. When this node is executed, it basically locates the nearest available parking space inside the nearest parking lot depending on the current position of the self-driving vehicle inside the IZTECH campus map. Since ROS2 is based on publisher-subscriber model, the parking space planner node is subscribed to four different topics in order to utilize these messages to update the goal pose of the self-driving vehicle. The subscribed nodes are “Vector Map” for mapping, “Odometry” for localization, and also “Predicted Objects” and “Detected Objects” for perception. By utilizing the messages published by the related nodes through topics, parking space planner node publishes messages to the goal pose topic so that the goal pose of the vehicle keeps updating itself while executing the parking maneuvers. Here is the publisher-subscriber architecture of the parking space planner node.

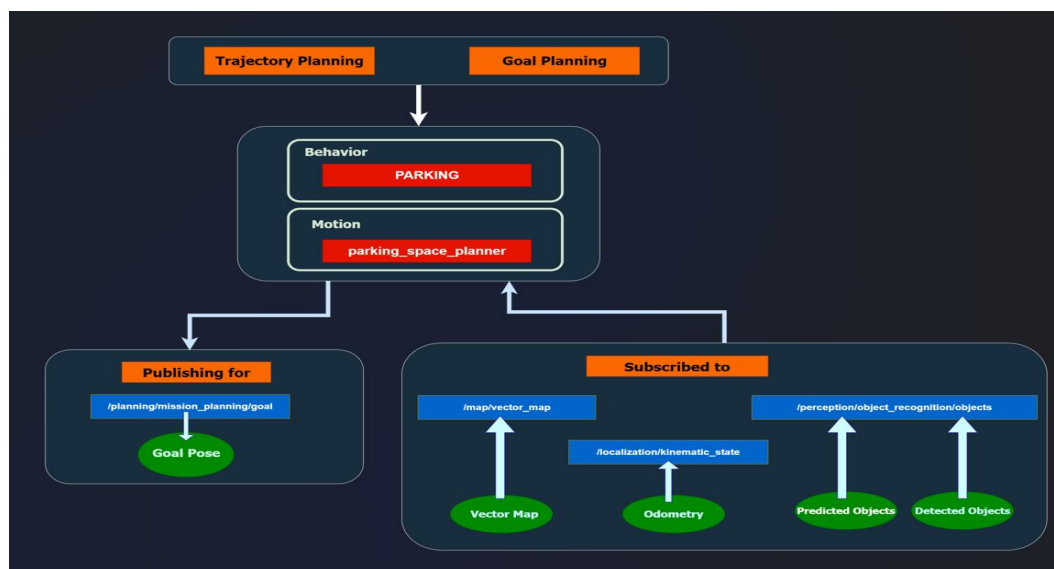


Diagram 2. Architecture of publisher-subscriber model of the parking space planner node

RESULTS AND DISCUSSION

The main purpose of the parking space planner algorithm is to locate the nearest empty parking space inside of the nearest parking facility (parking lot) on the IZTECH campus map. As explained earlier on the “Materials & Method” part, the map of IZTECH campus has been generated by the collected 3D point cloud data scans with Ouster-OS1 LIDAR sensor. A consistent point cloud data has been collected from the environment, especially nearby the parking lots. Here is the 3D view of parking lot in campus which is generated from recorded LIDAR scans which was placed on top of the vehicle.

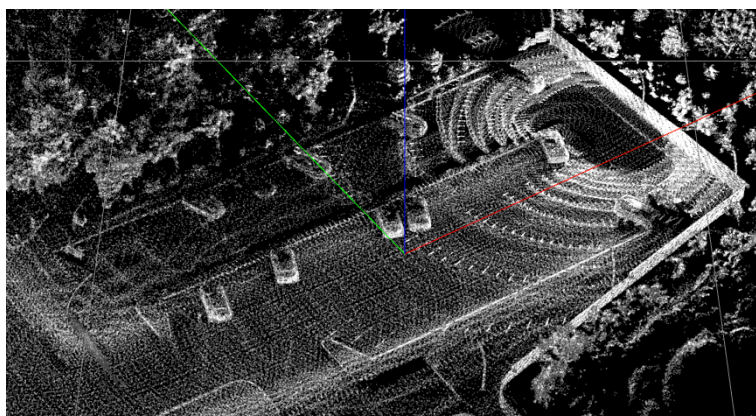


Figure 3. 3D view of point cloud map of the parking lot in campus

In order to spot the differences of the point cloud map versus the parking facility in real-life, the bird-eye-views of the parking lots are compared. Here is the bird-eye-view of the same parking lot in real-life.

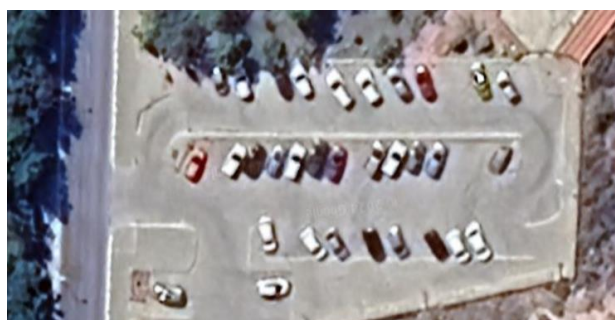


Figure 4. Bird-eye-view of the parking lot in IZTECH campus

On the other hand, here are the results for point cloud map generated from LIDAR scans for the same parking lot.

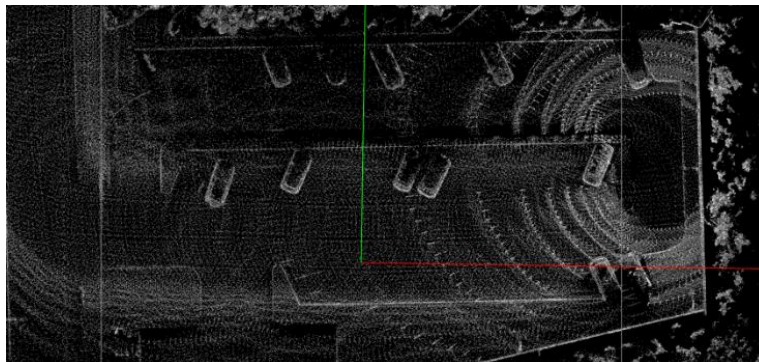


Figure 5. 3D point cloud map generated from LIDAR records

As mentioned earlier, Autoware recognizes the lanes, traffic rules, parking lots and parking spaces with a vector map [3]. In a web-based tool called Vector Map Builder, the lanelets (lanes), parking lots which are the parking facilities with many parking spaces inside, and the parking spaces are indicated. The parking lots are defined with polygons and the parking spaces are the areas which the self-driving vehicle should park inside, indicating with a line-string in Vector Map Builder. This process is the manual annotation to label specific features as in our case parking spaces and parking lots. These annotations help the autonomous vehicle better understand the boundaries and rules of the parking area, ensuring accurate planning.

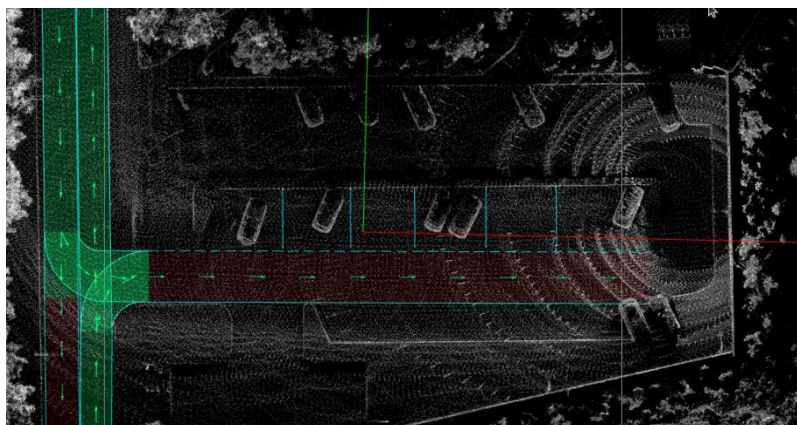


Figure 6. Vector map of the parking lot in campus

The mapping has been completed with the combination of point cloud map and the vector map (lanelet2 map). Once the map is created, the vehicle uses it for precise localization. In this project, a combination of NDT (Normal Distributions Transform) matching and GNSS (Global Navigation Satellite System) was used for localization within the overall map [9]. The NDT algorithm matches real-time sensor data from the LIDAR with the pre-built map to estimate the vehicle's position with high accuracy [9]. In other words, the NDT matching process uses the point cloud data to align the self-driving vehicle's current environment with the stored map which provides precise localization even in GNSS denied environments, such as indoor parking lots [9]. The generated vector map is used not only for localization but also for path planning. At this point, parking space planner package takes the control. This package plans the vehicle's behavior to find the nearest empty parking space inside the

nearest parking lot including target trajectory and concerning traffic rules, avoiding other objects, etc.

The vector map includes predefined information about the parking lots and the parking spaces, which self-driving vehicle uses to locate available spots and navigate to them. Parking spaces are predefined on the vector map based on their physical locations in the real world. These parking spaces are marked with specific attributes such as their width, coordinates and boundaries. The physical boundaries of each parking space is included it allows planner to asses whether a particular space is suitable for the vehicle. Here is a visual from Rviz which shows five parking spaces inside of a parking lot.

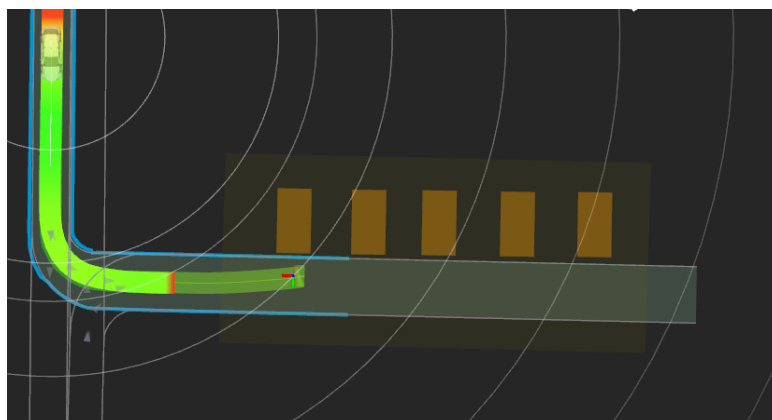


Figure 7. Pre-built parking spaces marked with yellow rectangles visualized on Rviz

The vector map also includes parking lot areas where groups of parking spaces are clustered. Each parking lot is predefined with attributes such as its coordinates of the boundaries. Since the parking lots can be created as polygons on vector map, boundaries define the limits of the parking lot area, ensuring that the vehicle understands where it is allowed to navigate and search for parking spaces. The predefinition of parking lots is crucial since Autoware allows parking spaces to be inside of the parking lots only [10].

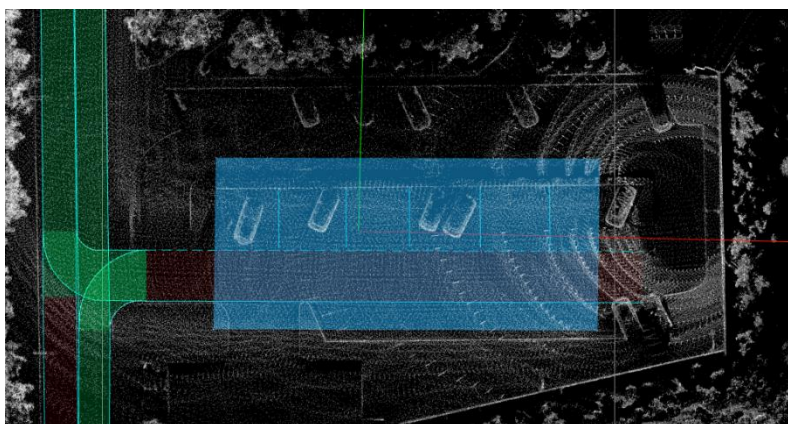
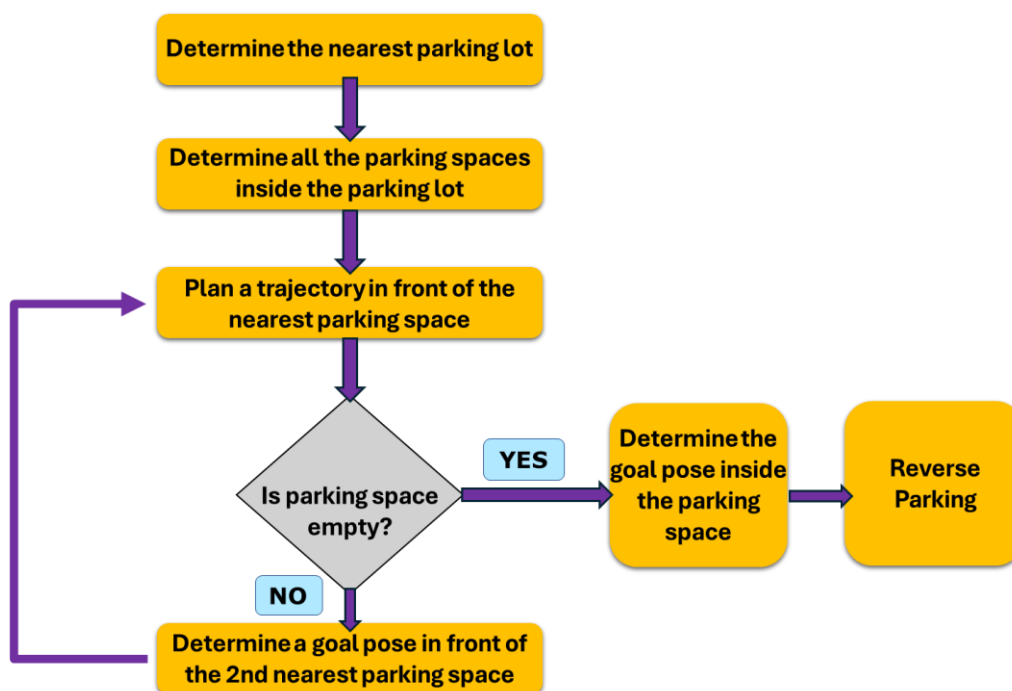


Figure 8. Pre-built parking lot marked with a blue polygon on vector map

As mentioned earlier, the self-driving vehicle uses LIDAR and GNSS sensors to determine its current position on the map, continuously updating its location relative to the IZTECH

campus map. Based on the current position, the parking space planner node first identifies the closest predefined parking lot on the map among the other parking lots. Once the nearest parking lot is identified, the node searches for all the parking spaces within that parking lot and defines their coordinations on the map. Then, the algorithm prioritizes parking spaces based on proximity to the vehicle's current position. After that step, the node plans a trajectory to reach in front of the closest parking space. Once the vehicles reaches in front of the nearest parking space, the decision-making mechanism takes over control. The perception modules "Detected Objects" and "Predicted Objects" check the availability of the parking space. If algorithm decides that the parking space is not occupied with any other vehicles, pedestrians, or obstacles, parking space planner node determines a new goal pose inside of the parking space which enables reverse parking. Otherwise, if the parking space is occupied with any other objects, obstacles, pedestrians, etc., the node determines a new goal pose in front of the second closest parking space. It again checks the availability of the parking space and decides to move on to the third one or to park inside of it depending on the occupancy. Once the parking space is determined as occupied, the node generates the trajectory in order to reach to the new determined goal pose. In some cases, parking space availability may change dynamically based on sensor data or external inputs such as arrival and departure of other vehicles. The mapping messages continuously feed the vector map topic, so that self-driving vehicle is aware of the dynamic changings in environment. The flowchart given below indicates the processes and the decision-making mechanism of the parking space planner node.



Flowchart 1. Decision making algorithm of parking space planner node

The perception module plays a critical role in determining the availability of parking spaces. This is done by processing 3D LIDAR data and utilizing two perception modules [11]. As mentioned earlier, “Predicted Objects” and “Detected Objects” messages in perception module were used check the availability of the parking spaces.

While object detection module detects the pose and velocity of dynamic objects on the environment, object prediction module predicts the possible paths of the dynamic objects. “Detected Objects” message contains information about objects that have been directly detected through LIDAR data [11]. The detection pipeline classifies and segments the sensor data, transforming it into clusters that represent various objects, such as cars, pedestrians, or obstacles in the parking lot [11]. The parking space planner node uses this message to look for potential vehicles, pedestrians, and obstacles inside or near parking spaces to determine if they are occupied or not. The 3D detection algorithm can recognize these objects based on their shape, size, and motion which enables self-driving vehicle to determine occupancy. Contributively, “Predicted Objects” messages provide predictions about the possible future positions and behavior of the detected objects [11]. For example, if a vehicle is detected approaching a parking space, the prediction module might estimate its trajectory and determine whether it will occupy the parking space shortly [11]. These predictions are especially important in dynamic environments such as parking lots where vehicles are moving in and out of parking spaces. In combination, the detected and predicted objects data allow the self-driving vehicle to check the current and future availability of parking spaces by considering both the static and dynamic environments. As an example from the IZTECH campus map, the first parking space was occupied by a pedestrian. The self-driving vehicle detects the pedestrian existence and predicts their possible future paths.

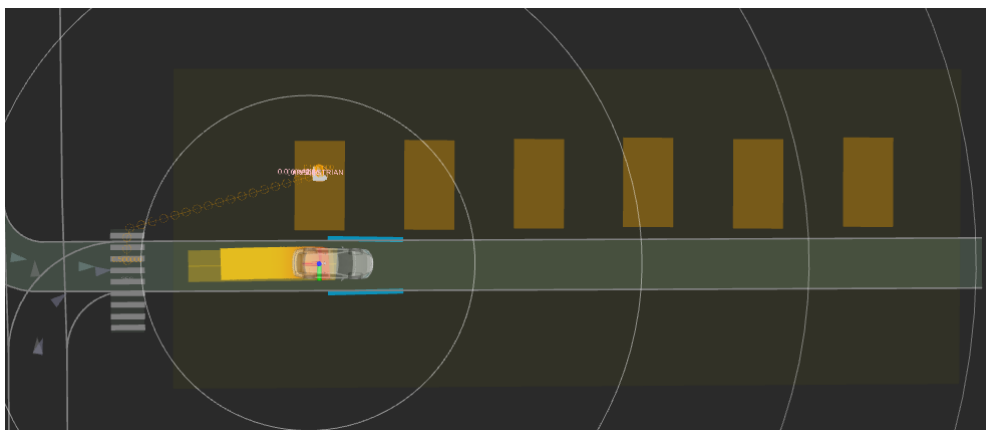


Figure 9. Parking space occupancy detection

Once the self-driving vehicle spots that the first parking space is occupied by a pedestrian, the goal pose is updated in front of the second one.

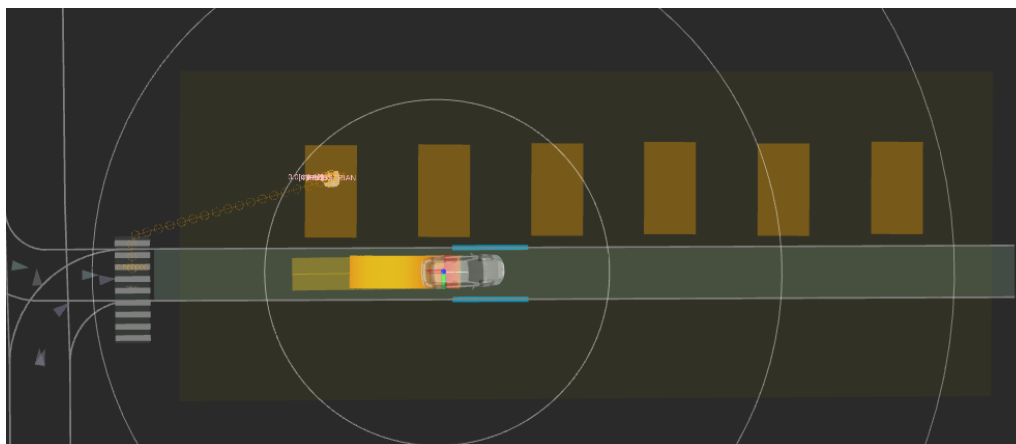


Figure 10. Updating goal pose in front of the second nearest parking space

In combination, cooperation of object detection and path prediction algorithms allow the self-driving vehicle to check the current and future availability of parking spaces by understanding both the static environment (e.g., parked cars) and dynamic factors (e.g., pedestrians on move, cars about to park). The detected objects are processed in the segmentation phase of the perception stack, while prediction is applied to analyze the future movements of the objects [11]. By leveraging these messages, parking space planner node efficiently evaluates the parking availability and guides the self-driving vehicle to the nearest unoccupied space. As a final demonstration of all the work done combined together, the parking space planner algorithm will be in action on the IZTECH map generated with real-life LIDAR scans and drawn lanelets, parking lot, and parking spaces. All figures are collected from Rviz while parking space planner node was active. The system begins by identifying the self-driving vehicle's initial pose and recognizing the parking lot layout, which includes five linked parking spaces. The first two parking spaces are occupied with the pedestrians.

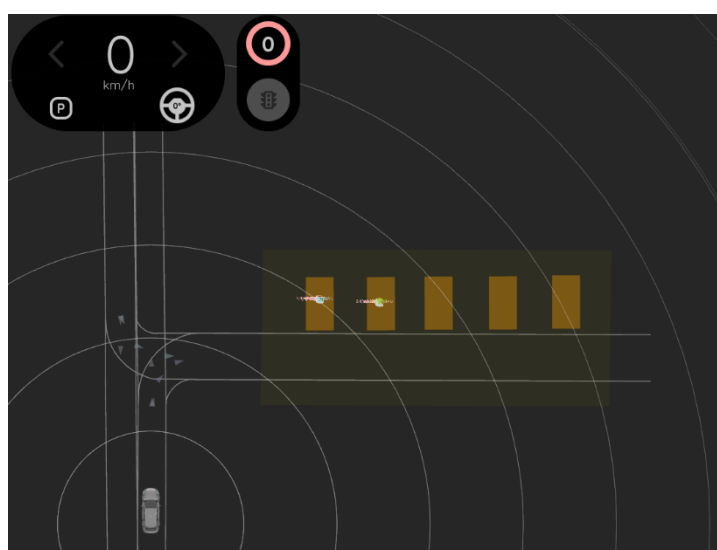


Figure 11. Setting initial pose of the self-driving vehicle on the IZTECH map

Once the parking space planner node is initialized, the self-driving vehicle locates the nearest parking space relative to its current position on the map. It determines a goal pose in front of this parking space and approaches it autonomously.

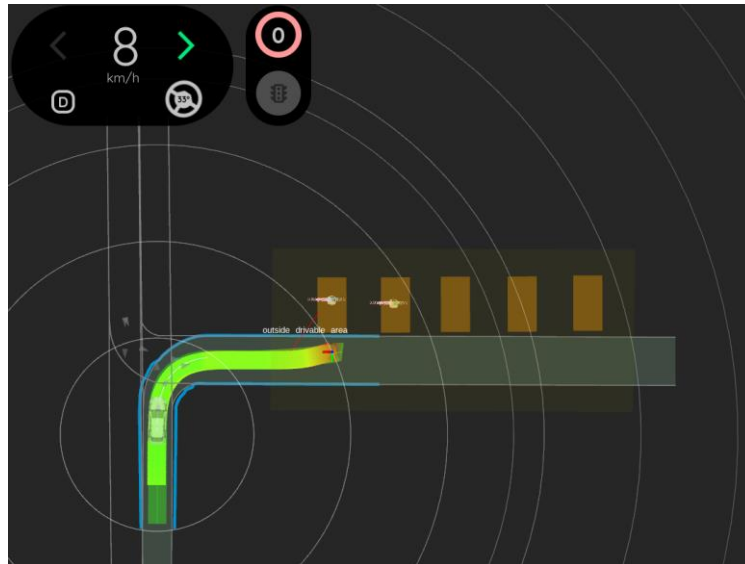


Figure 12. Determining the goal pose in front of the nearest parking space

When the self-driving vehicle reaches to that goal pose, it conducts a space check based on the data from the perception module using the “Detected Objects” and “Predicted Objects” messages and determining that it is occupied with a pedestrian. The vehicle then locates the second closest parking space regarding to its initial position, and it changes the driving mode from “Stop” to “Autonomous”. The vehicle again checks the availability of the space when it arrives in front of second nearest parking space, which is also deemed unavailable due to the presence of another pedestrian.

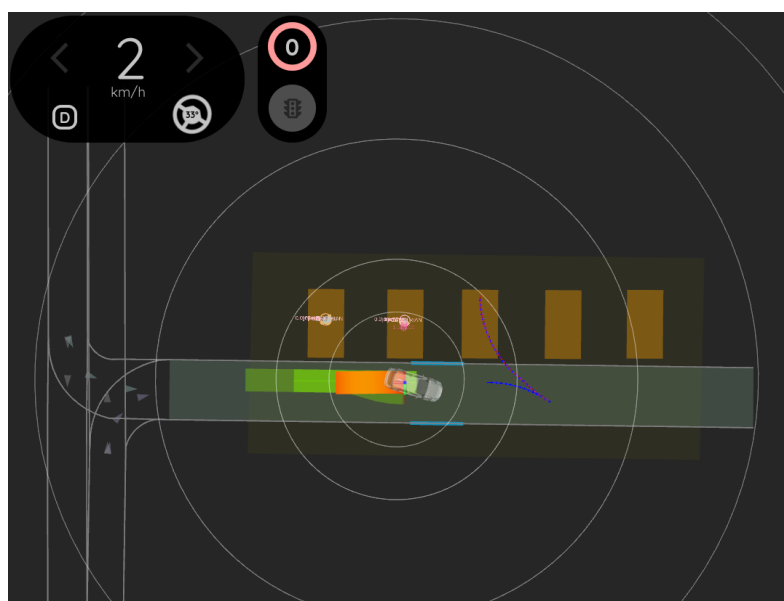


Figure 13. Arriving in front of the second closest parking space and checking its availability

Finally, the vehicle proceeds to the third closest parking space. Once the messages from the perception module feed the subscription module in the parking space planner node, the algorithm decides that the space is unoccupied.

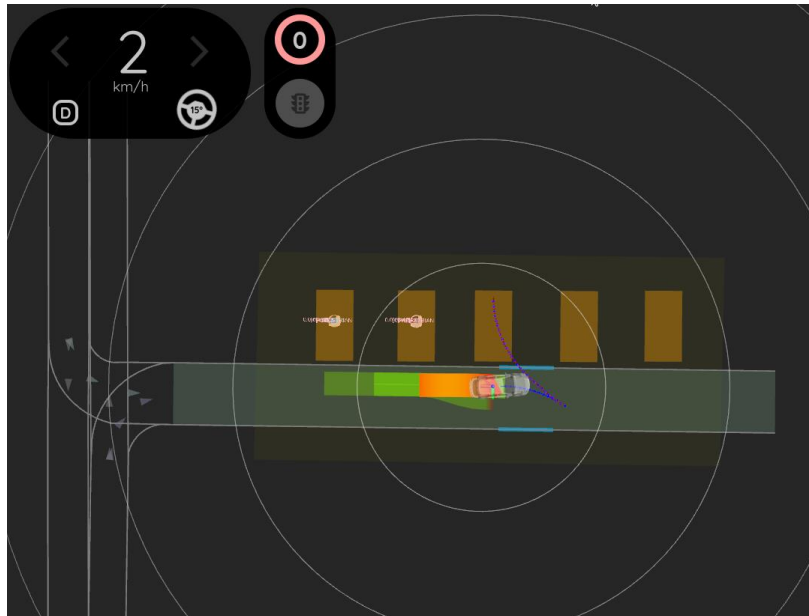


Figure 14. Arriving in front of the third closest parking space and checking its availability

At this point, the parking space planner node computes a goal pose for the vehicle inside of this parking space, taking into account the vehicle's dimensions as well as the length and width of the parking space.

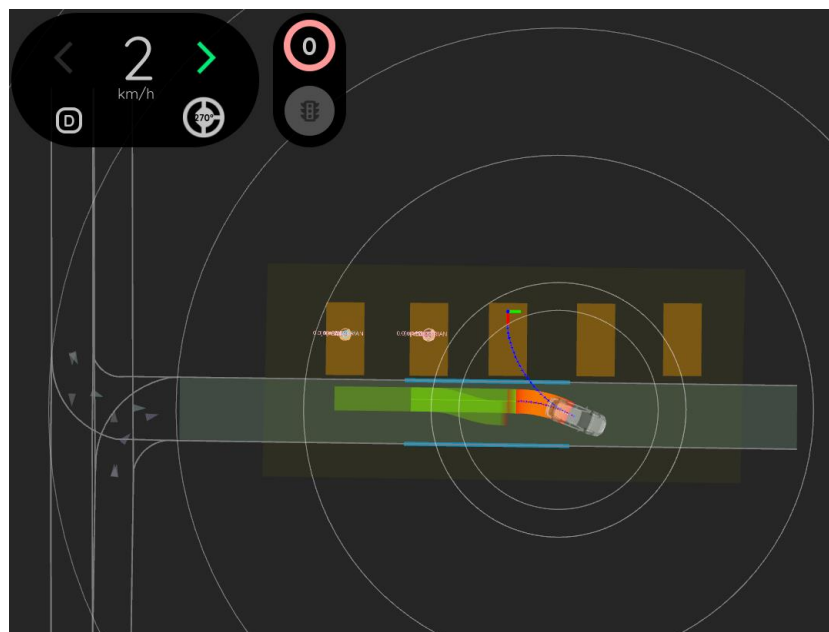


Figure 15. Determining the goal pose inside the nearest empty parking space

Once the criteria for safe parking are met, the self-driving vehicle performs a reverse parking maneuver by using the A* search algorithm (single curvature case) to shorten the distance while parking [12]. The A* search algorithm is used to calculate an optimal trajectory that guides the self-driving vehicle into the parking space while considering the constraints of the vehicle's steering capabilities, represented by a single fixed curvature [12]. A* also helps by ensuring the selected path avoids collisions while adhering to the vehicle's turning constraints. This is particularly important when parking in tight spaces or reversing into a spot like in our parking scenario.

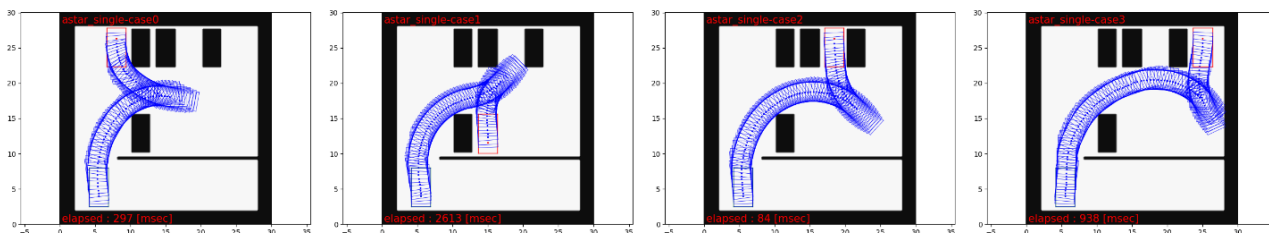


Figure 16. A* Path finding algorithm (single curvature case) [12]

When the self-driving vehicle finishes its reverse parking maneuver and successfully parks in the closest available parking space, it changes the driving state from “Autonomous” to “Stop” and sends a message to the planner node that the parking operation is successfully completed. Here is the final output of the successful execution of the parking space planner algorithm.

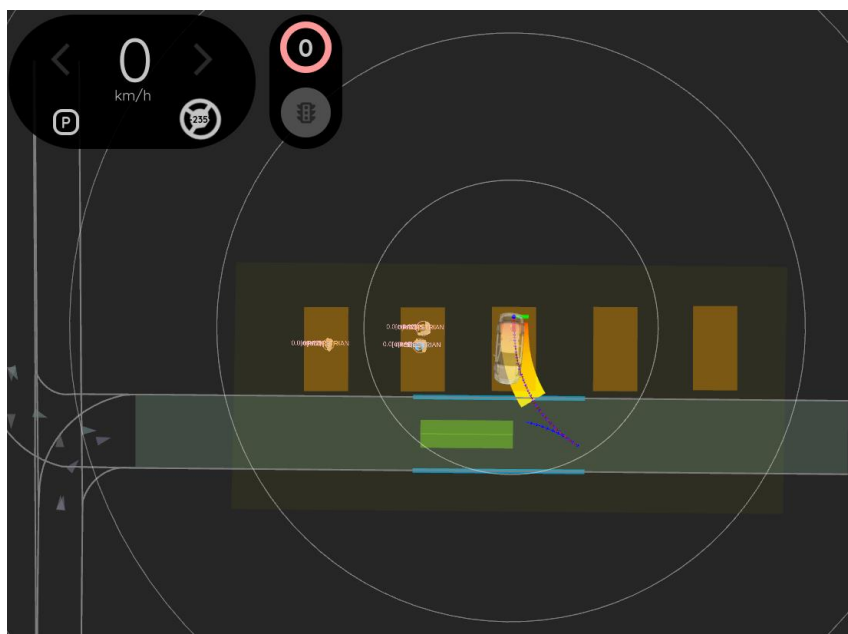


Figure 17. Autonomous parking is completed into the closest empty parking space on IZTECH map

These sequences illustrate the parking space planner algorithm's ability to dynamically evaluate parking space availability and adjust its path to ensure a safe and efficient parking operation.

CONCLUSION

The overarching goal of this project was to develop a cost-effective, fully-autonomous, and safe urban parking solution that could compete with existing market solutions. By leveraging a comprehensive open-source autonomous driving stack software Autoware, built on top of ROS2, a system has been built which is capable of performing autonomous parking in real-world conditions with a focus on safety, efficiency, and affordability. Autoware provides essential components for autonomous driving, such as localization, decision-making, perception, control, sensing, and generation of feasible trajectories [6]. Utilizing the Autoware architecture, an autonomous parking solution was developed that integrates real-time sensor-data, perception algorithms, behavior and motion planning, to ensure safe and efficient parking. One of the key elements in this implementation was the creation of a custom map, which was generated from point cloud data recorded at the IZTECH campus using an Ouster OS-1 3D LIDAR sensor. Then, the vector map was generated onto the point cloud map which includes the actual lanes (lanelets), crosswalks, parking lot and parking spaces indications, traffic lights, etc. This map was critical for the vehicle's localization, enabling the system to understand its position relative to the parking lot and parking spaces. The mapping module combined with the perception messages "Predicted Objects" and "Detected Objects", allowed the vehicle to identify obstacles and predict their possible paths like pedestrians or parked vehicles, ensuring accurate decision-making when scanning the parking spaces. The parking space planner algorithm was crucial in enabling the self-driving vehicle to locate the nearest parking lot, and within that lot, the closest unoccupied parking space. The planner relied on the localization and perception modules to process 3D LIDAR data and the messages from three different ROS2 topics helped vehicle to understand the surroundings, localize on every point of the lanelet map, and anticipate the future movements of detected obstacles providing self-driving vehicle to make forward-looking decisions about the parking space availability. In this step, the localization and the perception informations should be precise for safety considerations in order to enable operation in tight urban environments with dynamic obstacles, such as pedestrians moving near the parking area, vehicles entering or exiting the parking lot, etc [11]. To conclude, the system successfully demonstrated its ability to navigate within a complex parking environment, detect obstacles and predict their paths, and autonomously park in the closest available space. The use of Autoware and ROS2 proved to be an effective combination for achieving the objectives of the project, and the custom-designed parking space planner algorithm allowed self-driving vehicle to present an efficient and safe autonomous parking system in urban environments. This work demonstrates the potential of open-source autonomous driving software in practical applications, showing that it is possible to achieve high levels of performance without the need for expensive, proprietary systems.

REFERENCES

- [1] H. Ibrahim , “Car Parking Problem in Urban Areas, Causes and Solutions,” *papers.ssrn.com*, Nov. 25, 2017. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3163473 (accessed May 15, 2024).
- [2] A. Suppé, L. Navarro-Serment, and A. Steinfeld, “Semi-Autonomous Virtual Valet Parking.” [Online]. Available: <https://www.auto-ui.org/10/proceedings/p139.pdf> (accessed Aug. 14, 2024)
- [3] S. Kato et al., “Autoware on Board: Enabling Autonomous Vehicles with Embedded Systems,” *IEEE Xplore*, Apr. 01, 2018. <https://ieeexplore.ieee.org/document/8443742> (accessed Nov. 08, 2023).
- [4] “Why ROS 2?” Available: <https://docs.ros.org/en/foxy/downloads/2a9c64e08982f3709e23d20e5dc9f294/ros2-brochure-ltr-web.pdf> (accessed Nov. 11, 2023).
- [5] “Understanding nodes — ROS 2 Documentation: Humble documentation,” docs.ros.org. <https://docs.ros.org/en/humble/Tutorials/Beginner-CLI-Tools/Understanding-ROS2-Nodes/Understanding-ROS2-Nodes.html> (accessed Nov. 11, 2023).
- [6] Tier4, “Architecture overview - Autoware Documentation,” autowarefoundation.github.io. <https://autowarefoundation.github.io/autoware-documentation/main/design/autoware-architecture/> (accessed Feb 08, 2024).
- [7] Tier4, “Planning component design - Autoware Documentation,” autowarefoundation.github.io. <https://autowarefoundation.github.io/autoware-documentation/main/design/autoware-architecture/planning/> (accessed Feb 08, 2024).
- [8] Amit’s Thoughts on Pathfinding, “Introduction to A*,” theory.stanford.edu. <https://theory.stanford.edu/~amitp/GameProgramming/AStarComparison.html> (accessed Mar. 04, 2024).
- [9] S. Chen et al., “NDT-LOAM: A real-time lidar odometry and mapping with weighted NDT and LFA,” *IEEE Sensors Journal*, vol. PP, p. 12, Jan. 2022, doi: <https://doi.org/10.1109/JSEN.2021.3135055>. (accessed May 12, 2024).
- [10] Tier4, “The `freespace_planner` - Autoware Universe Documentation,” Github.io, 2022. https://autowarefoundation.github.io/autoware.universe/pr-2609/planning/freespace_planner/ (accessed Mar. 01, 2024).
- [11] Tier4, “Perception Component Design - Autoware Documentation,” Github.io, 2023. <https://autowarefoundation.github.io/autoware-documentation/main/design/autoware-architecture/perception/> (accessed Feb. 12, 2024).
- [12] Tier4, “freespace planning algorithms - Autoware Universe Documentation,” Github.io, 2014. https://autowarefoundation.github.io/autoware.universe/main/planning/autoware_freespace_planning_algorithms/ (accessed Feb. 08, 2024).
- [13] yodayoda, “Localization with Autoware,” *Map for Robots*, Jul. 21, 2021. <https://medium.com/yodayoda/localization-with-autoware-3e745f1dfe5d> (accessed Apr. 17, 2024).

**IMPACT OF CARBON EMISSION PRICING IN ELECTRICAL TRANSMISSION
NETWORK UNDER CONSTRAINED DEREGULATED ELECTRICITY MARKET**

Manikandan Tiruchengode Ramadurai

Lecturer, College of Engineering and Technology, Engineering Department, University of Technology and
Applied Science, Ibra, Sultanate of Oman

ABSTRACT

Approximately 40% of worldwide energy-related carbon dioxide (CO₂) emissions may be attributed to the process of power production. Projections indicate that by the year 2050, the demand for electricity would surpass double the present level. The proposed environmental policy aims to promote the adoption of low carbon emission power production methods by implementing a mechanism that internalizes the external costs associated with carbon emissions. This mechanism involves the implementation of a carbon-emissions tax. These policies often overlook the majority of locational considerations, perhaps due to the fact that the impacts of greenhouse gas emissions are not contingent upon the precise location of emission sources. The reaction to emission policy and the cost-effectiveness of emission reduction measures have a spatial dimension. In the context of electricity markets that have undergone deregulation, the implementation of an efficient transmission pricing mechanism is crucial in order to effectively manage transmission company concerns and provide appropriate economic incentives to producers. The presence of transmission line restrictions has a significant impact on energy pricing throughout the network. The rates of utilities are contingent upon the bids made by generators, the levels of load, and the limitations of the transmission network. The Locational Marginal Pricing (LMP) method is widely used in energy market operations to determine nodal prices and effectively handle transmission congestion. This study examines the influence of marginal carbon emissions on the location of transmission utility pricing, using the IEEE 30 bus test system with transmission congestion.

Keywords: Carbon pricing, LMP, Congestion rent, Marginal Carbon emission.

ALLELOCHEMICAL EFFECT ON *AVERRHOA CARAMBOLA L.* IN ANATOMICAL ARCHITECTURE ON WHEAT GROWTH

Syeda Sabika Zahra Naqvi

Department of Botany, Division of Science and Technology, University of Education, Lahore, Pakistan

ABSTRACT

Allelopathy is recognised as a potential technology to control weeds, and could also be a suitable approach for enhancement of crop yield. The study was conducted to investigate the allelopathic role of *Averrhoa carambola* leaf extract on growth, anatomical and physiological features of three wheat lines, namely 3094, 7076 and A2011. Three dilutions i.e. 0% (control), 15% and 30% of the leaf aqueous extract were applied at 15 day intervals (total five applications) on wheat lines until maturity. All wheat lines showed differential behaviour to allelochemicals of *A. carambola* leaf extract. Increased root area was accompanied by a high proportion of storage parenchyma tissues and enlarged vascular bundles in line. Disintegration of root cortical parenchyma and complete transformation of chlorenchyma into sclerenchyma in stem was recorded in all wheat lines, particularly at the highest concentration of leaf extract. Line 7076 showed very different behaviour, as it possessed a proportionally enlarged root cortex, enlarged stem vascular bundles and increased leaf thickness, primarily at the highest concentration of leaf extract. Line A2011 was relatively more sensitive, indicating a significant reduction ($P < 0.05$) in root and stem area and deformed leaves. A low concentration (15%) of leaf extract promoted growth and development, whereas a higher concentration caused significant reduction in growth and anatomical attributes. A lower dose of *Averrhoa* leaf extract promoted growth and development in all wheat lines, and hence can be used as a growth promoter. A higher concentration is important for eradicating unwanted plants.

Keywords: allelochemicals, anatomical architecture, chlorenchyma, growth promotion, leaf thickness, parenchyma, sclerenchyma.

**A CONCISE REVIEW ON WOMEN IN SCIENCE AND TECHNOLOGY ON 20TH
CENTURY**

K.R.Padma

Assistant Professor, Department of Biotechnology, Sri Padmavati Mahila Visvavidyalayam (Women's
University), Tirupati, Andhra Pradesh, India. Email id:

ORCID NO: 0000-0002-6783-3248.

K.R.Don

Reader, Department of Oral Pathology & Microbiology, Sree Balaji Dental College & Hospital, Bharath Institute
of Higher Education & Research (BIHER) Bharath University, Chennai, Tamil Nadu, India

ORCID NO: 0000-0003-3110-8076.

ABSTRACT

The International Day of Women and Girls in Science, established by the UN General Assembly on December 22, 2015, promotes gender equality in STEM areas. This year's theme is "Women and Girls in Science Leadership, a New Era for Sustainability." The goal is to increase the number of female researchers working on pressing issues such as improving health and combating climate change, as outlined in the 2030 Agenda for Sustainable Development. Research shows a significant disparity in the number of works generated by men and women in science, which has implications for women's retention and advancement. The gender gap could be due to productivity differences or underappreciation of women's contributions. Women in research teams are far less likely than men to be credited with authorship, potentially contributing to the gender gap. Women have made numerous truly significant and sometimes spectacular contributions to science. Equally remarkable is the rise in women's scientific success over the twentieth century. According to an authorized list of all scientists, regardless of nationality, who have made game-changing advances throughout history, women account for less than 7% of the total. However, if the computation is performed for scientists born after 1900, about 20% are female. I am confident that this perfect trend will continue. Women in science have faced numerous challenges throughout the years, but occasionally a source of encouragement and practical assistance has stepped forward to help them. Our perspective is based on twentieth-century philosophical frameworks that call for a shift from the metaphysical and abstract to the daily and contextual in knowledge acquisition, as well as research describing the various neurological routes to motherhood and fatherhood. We finish by emphasizing our unique historical period and the birth of fresh neuroscience themes through the work of female and male scientists, including interaction synchrony, inter-brain communication, and social and affiliative neuroscience.

Keywords: Women in Science, Neuroscience, Gender equality, Sustainability, Female researchers.

**UNVEILING THE THERAPEUTIC POTENTIAL OF *LACTUCA SERRIOLA*:
PHYTOCHEMICAL ANALYSIS AND PHARMACOLOGICAL APPLICATIONS''**

Neha Singh

Assoc. Prof. Dr., Mangalayatan University Aligarh

Suneel Kumar Singh

Assist. Prof. Dr., Mangalayatan University Aligarh

ABSTRACT

Prickly lettuce, or *Lactuca serriola* Linn, is a prevalent weed in agricultural areas and a member of the Asteraceae family. The present investigation set out to find out if the methanolic extract of *Lactuca serriola* possessed phytochemical screening agents. *Lactuca serriola* leaf methanolic extracts were screened for phytochemicals, and the results revealed the presence of carbohydrates, glycosides, flavonoids, triterpenoids, phenolic compounds, saponins, Phytosteroids, and tannins. They have a wide range of pharmacological properties, such as hypnotic, diuretic, antioxidant, sedative, antispasmodic, antibacterial, anticancer, bronchodilator, and vasorelaxant effects. It's a significant herbal remedy, and components of it, such the leaves (Barg-i-Kahu), the seeds (Tukhm-i-Kahu), and the latex (A fiyun Kahu) are used medicinally to treat a variety of conditions, including fever, jaundice, gonorrhoea, cough, pruritus, sadness, mania, and headaches. It also serves as a very helpful source of nourishment and is utilised as a preventive treatment during epidemics and pandemics. Numerous effects, including sedative, hypoglycaemic, anti-inflammatory, and antioxidant, have been proven. Chemical components such as lactucin, lectopicrin, hyoscyamine, stearic acid, arachnidan acid, oleic acid, the fatty acid, etc. are responsible for these activities. Because of its numerous pharmacological effects, Kahu has the potential to be an effective traditional herbal medicine. As a result, there is interest in drug discovery and formulation development.

**DIGITALIZATION PROCESS AS A TOOL FOR THE ASSESSMENT OF LAND
EROSION AND ECOSYSTEM ADAPTATION IN THE ADRIATIC LAGOONS IN
ALBANIA**

Aurora Dibra

Dr., University of Shkodra “Luigj Gurakuqi”

Leonora Haxhiu

MSc., Polis University Tirana

ABSTRACT

The study of coastal ecosystems and their operational monitoring are very important nowadays in the Albanian scientific research because sustainable development and the economy of societies living nearby depend heavily on them. Man, himself is part of nature by occupying most of the urban ecosystem, although urbanized areas occupy a fraction of the continental surface area of less than 1% in the biosphere. In Albania we are also suffering the significant changes in temperature or water balance, rising sea levels on coastal regions and deltas, land erosion, loose on wetland surfaces and biodiversity. The article is presenting the assessment of the ecological situation in some lagoons in Adriatic area, presenting some scientific aspects of how the climate works and some effects of climate changes in those ecosystems; presentation the vulnerability of social, economic, and natural systems to climate change and the possibilities for adaptation; recommendations and solutions as actions to minimize the negative effects of climate change. Adaptation to the environment has often been the key to rehabilitation. This adaptation is all the easier when the environment is favorable. Through the maps in GIS format, we will show the significant changes in water balance, land surfaces, the impacts of the rising sea levels on coastal regions and deltas, effects on biodiversity etc. Digitalization process makes easy and reachable all data and facts important for the analysis, for that it is done a kind of SWOT analysis in the areas. Social and economic aspects are part of the analyze and we will show that behavioral approach and cultural aspect has an impact on the spatial heterogeneity of vegetation, affecting ecosystem processes and wetland landscapes also. Communities have used local resources in supporting peripheral economies in the rural contexts of villages and inland areas, which have been facing massive depopulation. The article is based on a short review of materials published on climate change and ecosystem resilience on Lagoons in North Albania, expedition in the field and data collected directly in the ecosystems, photos, and maps assessments. SWOT analyze and the problem tree analyze lied to the list of recommendations for the best way to adopt strategies to combat climate changes in such ecosystems, as lagoons in Albania. Through the recommendations we aim to enhance local and national awareness on the advantages of Ecosystems based Adaptations to increase resilience towards climate change impacts. Such

interventions, considering their protection effectiveness, will help to improve the socio-economic status of the community, by reducing negative effects caused by climate change, and improving fishing and nature tourism potential and capabilities in the lagoon's areas.

Keywords: Coastal Ecosystems, Climate Changes, GIS Format Maps, Ecosystems Based Adaptations, Ecosystem Resilience.

IDENTIFICATION OF PIVOTAL ACTORS IN THE INTERBANKING NETWORKS THROUGH VORONOI TESSELLATION ON NETWORKS

Saverio Storani

Sapienza University of Rome, Department of Computer Sciences, Via Regina Elena 295, I-00161 Rome (RM),
Italy

ABSTRACT

This paper deals with the relevant theme of assessing the systemic relevance of the actors populating a financial network. Specifically, we consider the paradigmatic case of the time-dependent interbanking network collected by the Bank of International Settlements (BIS). Such collection describes the mutual exposures of the countries in terms of the in- and out-flows among banks. Once some relevant nodal centrality measures are identified, we implement some clustering procedures to determine how countries can be efficiently classified. The adopted methodology is based on Voronoi tessellation, with a Euclidean-type distance and under different scenarios for centroids selection. The analysis is carried out at a quarter level by building a network for each quarter. The period under consideration is from 2000:q1 to 2023:q3. The outcomes of the clustering procedures are appropriately compared, to obtain indications of the possible presence of regularities and deviations among the considered countries. Results provide interesting insights into the most influential countries in terms of spreader or absorber nodes.

Keywords: Interbanking network, Bank of International Settlements, financial stability, Voronoi-tessellation, complex networks.

**A UNIQUE OTTOMAN MAQAM/SHRINE IN KHALDYEH-MAFRAQ SOUTH
LEVANT**

Mohammed Waheeb

Prof. Dr., Professors in Archaeology; Department of Sustainable Tourism, Queen Rania Faculty of Tourism and Heritage (QRFTH), The Hashemite University.

ABSTRACT

Field studies conducted in the town of Al-Khalidiyah, northeast of the capital Amman, revealed many heritage and archaeological sites spread over the mountains and plains, consisting of watchtowers, old camps, and remains of human settlements next to water sources and flowing valleys such as Wadi Al-Aqab. The team reached the shrine of one of the Muslim leaders called the Shrine of Khalid bin Al-Walid near one of the water ponds called Ghadeer Al-Tayr to the east of the town of Al-Khalidiyah, which bears the same name as the shrine. The results of field surveys and scientific documentation showed that the discovered shrine consists of a circular stone building made of basalt stones, with an entrance and a building inside in the form of a shrine. There are a number of historical archaeological buildings around it that were used as traps during ancient times, starting from the Stone Age and reaching the classical and Islamic eras. The shrine area was also distinguished by being a crossing point for commercial caravans coming from the Arabian Peninsula through the Jordanian desert. It was also a settlement for many civilizations that left landmarks on the surface of the earth since historical times dating back to 5000 years BC to modern times. The Ottomans resided in the area before leaving Jordan in 1918. Many of the elderly who were interviewed indicated that the local residents. They built this shrine based on oral heritage narratives passed down between ancestors and sons, and that an annual celebration was held in the area of the shrine, in which meat and milk were distributed, and a portion of it was given to the Ottoman soldiers who lived in that area. This is considered clear evidence that the shrine was built during the late Ottoman period, as the place and the shrine are still appreciated by the residents of that area as a tangible and intangible heritage linked to their ancient Islamic history, especially during the Ottoman period.

Keywords: Jordan, Ottoman Maqam/ Shrine, Wadi Al-Aqab, Ottoman Period, Khalid bin Al-Walid, Architecture.

**DIAGENETIC FEATURES OF EARLY EOCENE AGE CHORGALE FORMATION
AT KHANPUR DAM ROAD SECTION, HAZARA BASIN, PAKISTAN**

Dicky Muslim

Associate Professor at Department of Geological Engineering, Padjadjaran University, Sumedang, Jatinangor
Indonesia

Bilal Shah

Department of Geological Engineering, Padjadjaran University, Sumedang, Jatinangor Indonesia

Usama Yaseen

Department of Soil Science, Faculty of Agriculture, Padjadjaran University, Sumedang Jatinangor Indonesia

ABSTRACT

The Chorgali Formation is a hydrocarbon-producing unit that occurs in the upper Indus Basin of northern Pakistan. The current study focuses on the details of diagenetic features such as micritization, microfracturing, stylolitization, compaction, dissolution, neomorphism, and cementation and their impacts on reservoir potential in the Hazara Basin, Khanpur Dam Road Section. The methods utilized in this project are Petrographic analysis, X-ray diffraction (XRD), and scanning electron microscopy (SEM) analysis. Detailed petrographic analysis reveals the presence of various diagenetic features, including micritization, dolomitization, stylolitization, compaction, dissolution, neomorphism, and cementation. These diagenetic processes have significantly altered the original texture and composition of the rocks, affecting their porosity and permeability. The micritization and cementation processes have reduced porosity by filling pore spaces, while compaction and stylolitization have further decreased porosity and permeability by reducing pore spaces and altering rock fabric. The Petrographic study reveals that diagenetic features have adversely affected the reservoir potential of the Chorgali formation.

Keywords; Khanpur Dam Road Section, Early Eocene, Petrographic analysis, Hydrocarbon potential, Diagenetic features.

1. Introduction

The study area lies at Khanpur Dam Road section, which is situated in the district of Haripur, Khyber Pakhtunkhwa, Hazara Basin, Lesser Himalayas (Gensser, 1964 and Coward et al., 1988). The Hazara Basin is bounded on the south by a regional tectonic Boundary, Main Boundary Thrust (MBT), while on the north by Panjal Thrust (Armaghan et al., 2021). The Main Boundary Thrust is the southernmost thrust, which places meta-sedimentary rocks of the

Lesser Himalayas over the unmetamorphosed clastic rocks of the Himalayas Foredeep (Singh & Patel, 2022).

The Chorgali Formation is studied in many locations in Pakistan (Awais et al., 2018). The formation consists of mostly limestone with hydrocarbon potential (Society, 2016). The study area has thick succession from Precambrian to upper Eocene and Oligocene age (Reda et al., 2021). In our area of study, the Chorgali Formation exposed in Hazara Basin by road wise cut near to Khanpur Dam Area. The Chorgali Formation (Eocene) is comprised of planar to nodular bedded limestone with shale interbeds as exposed in the Khanpur Dam Area. One of the most significant Eocene rocks with hydrocarbon potential is the Chorgali Formation (Bilawal & Shah, 2023). In several significant oil fields in the Kohat-Potwar region, the Chorgali Formation serves as the reservoir rock (Irfan & Fazeelat, 2020). In this area, the lower contact of the Formation is with the ground, and upper contact with the sky. The formation comprises limestone, marls, and shales. The shale is khaki to off-whitish grey. The limestones are light grey on a fresh surface, while pale to grey on a weathered surface (Figure 2B). Various diagenetic features Such as vugs (Figure 3B), calcite veins, massive limestone beds (Figure 3A), highly fossiliferous limestone (Figure 3C), Butcher chop weathering, and Tempethsite Beds were identified during our Fieldwork in the study area.

The petrographic analysis of Chorgali formation revealed that diagenetic fabrics such as Micritization, Dolomitization, Stylolitization, Compaction, Dissolution, Neomorphism, and Cementation had an impact on the original texture and composition. Thus, the purpose of this research is to determine the diagenetic behavior of the carbonate succession of the Early Eocene Chorgali Formation and examine and focus on how these processes affect the quality of the reservoir. According to field observations and petrographic studies, Diagenetic characteristics appear to have a significant impact on the quality of the reservoir rocks.

2. Materials and Methods

The Chorgale formation was measured and sampled in Khanpur Dam Road Section Hazara Basin, Pakistan. In the Khanpur, close to the Khanpur Dam Viewpoint, a huge outcrop of the Chorgali Formation is seen along the Taxila-to-Haripur highway (Figure 3). Following a thorough examination of the research area, the Khanpur region was chosen for the sample using the proper instruments, which included a geological hammer, a Burton compass, a camera measuring tape, a scale, a notepad, a hand lens, and a geological map.

24 samples were gathered for the study on August 21, 2021, at the Khanpur Dam Area. In this region, the Chorgali Formation is 96 meters thick overall. The sample was gathered in a methodical order. One sample and the other sample were separated by four meters. Following sample collection, each sample was assigned an appropriate name and number. After the samples were cleaned, 16 of the 24 samples that were obtained were chosen and cut into certain shapes at the Thin Section Preparation Laboratory at the National Center of Excellence in Geology (NCEG), University of Peshawar. Sixteen exemplary thin sections were ready for

the investigations of Diagenetic features. The detailed Petrographic study using a polarizing Microscope suggests that Chorgali formation is affected by diagenetic features Such as Micritization, Microfractures, Stylolitization, Compaction, Dissolution, Neomorphism, and Cementation.

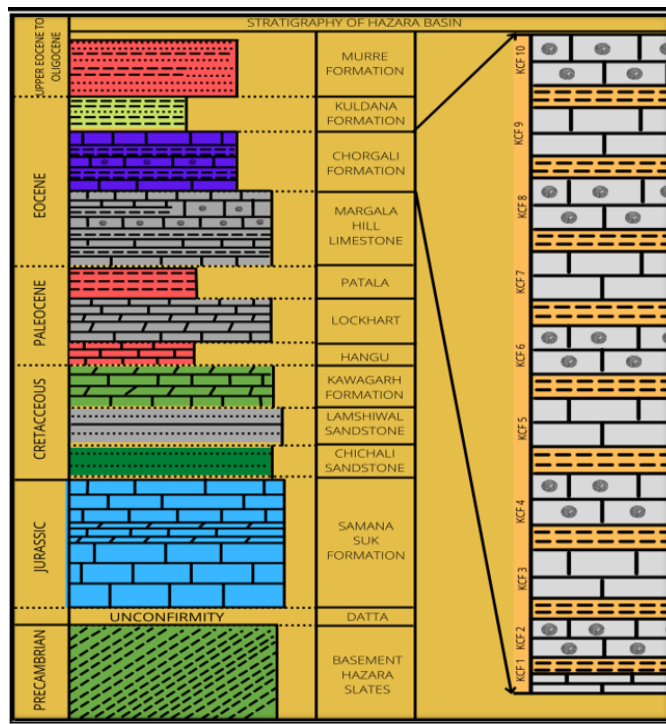


Figure 1; Stratigraphic Column of Hazara Basin

Show stratigraphy from Pre-Cambrian to Oligocene of Hazara Basin with special emphasis on Lithology of Chorgali Formation (Reda et al., 2021).

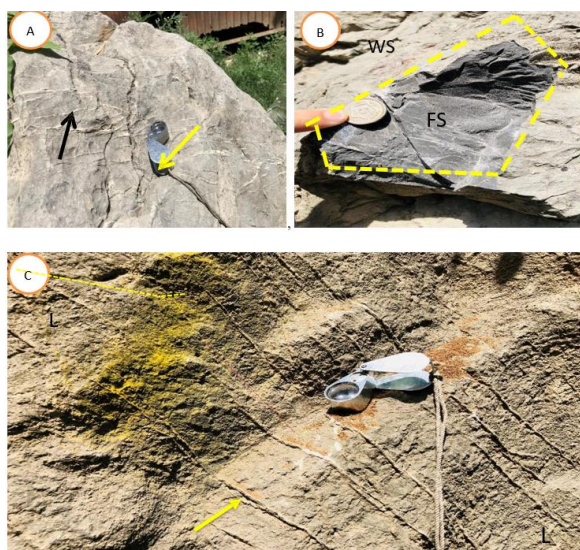


Figure 2; Shows outcrop exposures of the lithostratigraphic units recorded in the Chorgali Formation, Khanpur Dam Road Section, Hazara Basin, Pakistan

A) Shows a massive bed of limestone while the black arrow shows calcite veins and the yellow arrow shows fracture. B) Show Fresh surface and weathered surface of limestone. Fresh surfaces show a dark color while weathered surfaces show a light gray color. C) Shows limestone of brown color while the yellow arrow shows calcite veins.



Figure 3; Field Photographs

A) Show massive limestone while the yellow arrow shows dissolution and the white arrow shows calcites veins. B) The yellow arrow shows vugs or cavities in Limestone. The cavities were made due to erosion of fossils. C) Show highly fossiliferous limestone.

3. Results and Analysis

In examining the petrographic thin sections of the Chorgali Formation, several diagenetic features are observed, including micritization, microfractures, stylolitization, compaction, dissolution, neomorphism, and cementation. These diagenetic processes alter the rock's original fabric, often transforming potential reservoir-quality rocks into tight, non-reservoir rocks due to the reduction of pore spaces and the occlusion of fluid pathways. As a result, the reservoir potential of the Chorgali Formation is highly compromised, especially in zones where cementation and compaction are most prevalent. Thus, understanding the distribution and intensity of these diagenetic alterations is crucial for assessing the formation's reservoir quality and potential. The detailed description of the various diagenetic processes affecting the studied limestone is discussed below:

Compaction

The compaction refers to changes in the original fabric of the rocks under shallow to deep burial conditions as a result of overburden pressures.

The compaction features recognized in the Chorgali Formation include the following; Calcite-filled microfractures Fractures in carbonate rocks are usually important secondary features formed by either compaction or development in response to the regional tectonic regime (E.Flugel, 2004). They vary in width from hairline to several cm. These fractures are later filled with coarse sparry calcite and are termed calcite veins. A wide variety of calcite veins and veinlets are present in all Five microfacies of the Chorgali Formation. These include, single to multiple, intersecting, large to small veins displaying a wide range of thicknesses from a few mm to several cm. This diagenetic process compacts the sediment grains closer together, further reducing the primary porosity and negatively impacting the reservoir quality by limiting fluid storage capacity.

Dissolution

Dissolution is indicated by the presence of partially disintegrated skeletal grains and voids where material has been removed (Figure 4). The dissolution is indicated by the jagged edges and irregular boundaries of the fossil. This suggests that the skeletal grain has been partially dissolved by diagenetic processes, likely leading to increased porosity in the rock. Dissolution assisted the evolution of various types of porosities, such as moldic and vuggy. We noted intense twinning in calcite, which is usually caused by the dissolution and dislocation of crystals and is mainly a consequence of burial loading or tectonic deformation (Awais et al., 2018).

Cementation

Cementation occurs through the entire diagenetic process, in which chemical precipitates (in the form of new crystals) form in the pores of sediment or rock, and binds the grains together (Ahmad et al., 2020). The Chorgali Formation is cemented by calcite, iron minerals, and, to a much lesser extent, quartz. The formation of calcite veins and patches within the microfractures and pore spaces, indicative of cementation, demonstrates the precipitation of mineral-rich fluids post-deposition. This process significantly reduces both porosity and permeability by occluding the pore spaces and filling in microfractures, which drastically affects the reservoir potential by preventing fluid flow and storage.

Stylolitization

The presence of stylolites, observed as jagged, irregular seams within the rock matrix, suggests a significant pressure solution during burial. Stylolites are commonly formed under conditions of differential stress and act to reduce porosity by dissolving less stable minerals, which in turn can enhance the cementation process. The reduction in porosity directly impacts the reservoir quality by decreasing the potential for fluid storage and

movement within the rock.

Micritization

In the Chorgali Formation, micritization is not common and is noted very occasionally. The noted micritization varies from partial to intense because in some cases the allochems are completely micritized and there is no sign of the original allochem

Neomorphism

Neomorphic changes, such as the recrystallization of micrite to sparite, indicate a transformation of the carbonate mud matrix into more stable forms of calcite. This process can alter the pore structure of the rock, sometimes enhancing porosity by creating intercrystalline spaces, but more often reducing porosity if the recrystallization leads to tightly packed crystals (Budd & Hiatt, 2016).

Dolomitization

The carbonates of the Chorgali Formation have also experienced dolomitization. Early as well as late diagenetic dolomitization are noted in the Chorgali Formation (Fig 17, C). Dolomitization is determined to be the major component as revealed from Petrographic analysis and staining processes.

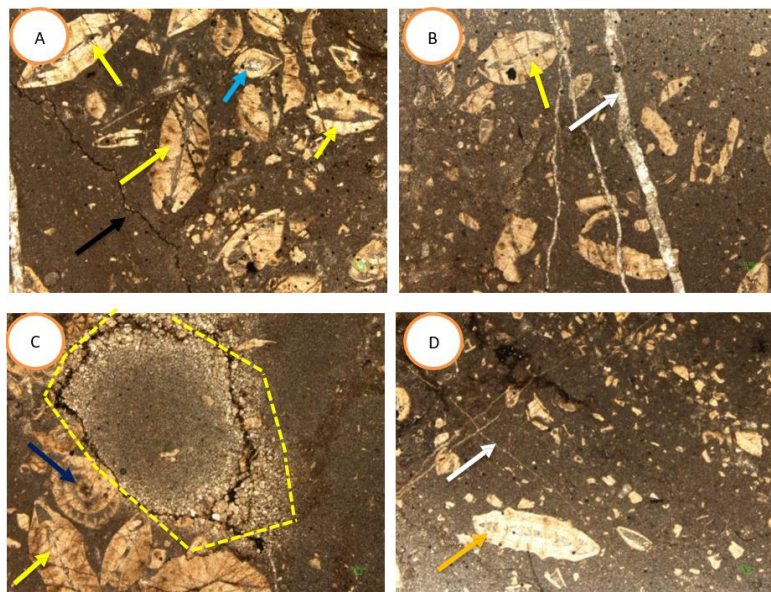


Figure 4; Photomicrographs show different diagenetic features.

A, B, C, D) Yellow arrows show *Assilina laminosa* (Gill 1953) (Muhammad T Khan, 2021), orange color arrows show *Assilina Spinosa* while blue arrows show *Nummulites mammalities*. Black arrows show stylolite and white arrows show calcite veins. Orange color arrow show *Assilina granulosa* (d'Archiac). D) The highlighted area in Photomicrograph D shows dolomitization.

4. Discussion

The petrographic analysis of the Chorgali Formation reveals several key diagenetic features that have a significant impact on the reservoir potential of the formation. The observed diagenetic processes include micritization, microfracturing, stylolitization, compaction, dissolution, neomorphism, and cementation. The photomicrographs reveal extensive evidence of compaction and cementation, critical diagenetic processes impacting reservoir potential. Compaction, as observed in Photomicrograph A has resulted in the deformation of bioclasts and the development of fractures. These compaction features suggest a significant reduction in primary porosity due to the mechanical squeezing of grains under overburden pressure, leading to pore space collapse. Photomicrograph B shows that Cementation has adverse effect on the pore spaces and permeability. The filling of fractures with calcite cement effectively seals potential migration pathways, creating barriers that can compartmentalize the reservoir and inhibit fluid flow. The Diagenetic features had a pivotal role in defining the reservoir potential of the Chorgale formation. The combination of compaction, cementation, dissolution, and stylolite formation has created a complex diagenetic landscape that degrades the reservoir quality of the formation.

5. Conclusion

The detailed petrographic analysis of the Chorgali Formation in the Hazara Basin has highlighted a range of diagenetic features that significantly influence the reservoir potential of the formation. The diagenetic processes observed, including micritization, dolomitization, stylolitization, compaction, dissolution, neomorphism, and cementation, have collectively impacted the porosity and permeability of the formation.

Micritization suggests deposition in a low-energy environment, which may limit primary porosity. Microfracturing has the potential to enhance permeability by providing secondary flow pathways, but this is countered by stylolitization and compaction, which reduce porosity by pressure solution and mineral redistribution. Dissolution features indicate some chemical enhancement of porosity, although the associated weakening of rock integrity could pose challenges to reservoir stability. Neomorphism and extensive cementation, particularly the presence of calcite veins, have further reduced the porosity and occluded pore spaces, negatively affecting the reservoir quality.

The Chorgali Formation displays a complex diagenetic history that predominantly suggests a decrease in its reservoir potential. The combined effects of these diagenetic processes have likely reduced the formation's effectiveness as a hydrocarbon reservoir, as evidenced by the limited preservation of primary and secondary porosity.

References

Ahmad, F., Hasnat, A., & Ahmad, M. (2020). *Microfacies and diagenetic overprints in the*

- limestones of Middle Jurassic Fort Member (Jaisalmer Formation), Western Rajasthan , India : Implications for the depositional environment , cyclicity , and reservoir quality. April, 1–22. <https://doi.org/10.1002/gj.3945>*
- Armaghan, M., Miraj, F., Ali, A., Ahsan, N., Muzammal, H., Saleem, R. F., Mehmood, H., & Manzoor, M. W. (2021). *Stress Pattern Simulation of Compressional Features of Potwar Region and Hazara Basin , NW Himalayas , Pakistan. 11, 275–288. <https://doi.org/10.22059/GEOPE.2021.314634.648587>*
- Awais, M., Hanif, M., Younis, M., Irfan, K., & Muhammad, U. J. (2018). *Relating petrophysical parameters to petrographic interpretations in carbonates of the Chorgali Formation , Potwar Plateau , Pakistan. 0123456789.*
- Bilawal, S., & Shah, A. (2023). *EARTH SCIENCES Integrated Interpretation of Eocene-Palaeocene Rocks in Potwar Basin , Pakistan : Implications for Petroleum Generation Interpretación integrada de rocas del Eoceno y el Paleoceno en la cuenca Potwar , Pakistán : 27(2), 149–162.*
- Budd, D. A., & Hiatt, E. E. (2016). *Mineralogical Stabilization of High-magnesium Calcite : Geochemical Evidence for Intracrystal Recrystallization Within Holocene Porcellaneous Foraminifera. January 1993. <https://doi.org/10.1306/D4267AD7-2B26-11D7-8648000102C1865D>*
- E. Flugel. (2004). *Microfacies Of Carbonates Rocks Anaysis, interpretation and Application. Gensser, 1964 and Coward et al., 1988).* Rahman, M. U., Ali, F., & Hayat, M. (2019). *Diagenetic Setting, Dolomitization and Reservoir Characterization of Late Cretaceous Kawagarh Formation, Khanpur Dam section, Hazara, Pakistan. International Journal of Economic and Environmental Geology, 64-79.*
- Irfan, M., & Fazeelat, J. (2020). *Geochemical segregation of early Permian , Paleocene and Eocene sediments of Potwar Basin , Pakistan : I Geophysical and isotopic analysis for source and depositional environment.*
- Muhammad T Khan, O. S. H. (2021). *Carbonate deposition during the terminal closing stage of the eastern Neo-Tethys Ocean : The Chorgali Formation of. 1–9.*
- Reda, A., Younsy, M. El, & Salman, A. M. (2021). *Sequence stratigraphic framework of the Upper Eocene – Oligocene succession , northwest Birket Qarun , Fayum - Egypt. Environmental Earth Sciences, 80(9), 1–18. <https://doi.org/10.1007/s12665-021-09646-y>*
- Singh, P., & Patel, R. (2022). *Formation of the Main Boundary Thrust (MBT) and its role in exhumation Of the Amritpur granite in Kumaon Himalaya , NW-India Formation of the Main Boundary Thrust (MBT) and its role in exhumation Of the Amritpur granite in Kumaon Himalaya , NW-India. October 2015, 3–5. <https://doi.org/10.1007/s10346-014-0540-7>. Roy*
- Society, G. (2016). *Petrophysical properties and hydrocarbon potentiality of Balkassar well 7 in Balkassar oilfield , Potwar Plateau , Pakistan. 62(December), 73–77.*

**ALTERNATIVE SOLUTION TO REPLACE HYDROSTATIC TESTING OF HDPE
PIPES**

Djebbara BENZERGA

Pr.,LSCMI, University of Sciences and Technology of Oran, Mechanical Department, 31000, Oran,
Algeria

Adel Chouiter

Dr., University Frères Mentouri Constantine 1, 25000, Algeria

ABSTRACT

Currently, polymer tubes, such as HDPE, occupy a significant part in the transport of water and gas, thanks to their multiple qualities (reduced cost, ease of installation, flexibility), particularly in distribution networks (secondary network). The use of these tubes in drinking water and gas supply networks is expanding but is studied much less in research work. These tubes for transporting water and gas are undoubtedly the safest way to transport such products. Their manufacturing has undergone great development to meet operating conditions, which have been pushed even further towards higher limits in terms of pressure, flow rate, lengths and thickness. However, whether during their manufacture or during their use, superficial defects are likely to appear. The main external defects on these tubes can be introduced during manufacturing, or during handling, or during service by the aggressiveness of the soil. All these defects present on the external surface of the tube significantly reduce its resistance and constitute potential sources of damage. Hydrostatic testing is used to check the structural integrity of HDPE pipes before it is put into service. The hydrostatic test pressure is always higher than the working pressure, providing a margin of safety against design tolerances and the growth of defects during pipeline operation. The logistics and implementation of the hydrostatic test remain very expensive. In this article, we present a contribution of an alternative approach that could replace hydrostatic testing.

Keywords: HDPE, Hydrotest, Pressure, Damage

**INNOVATION OF STUNTING DETECTION APPLICATION USING CHATBOT AS
STRATEGY TO ACHIEVE UNIVERSAL HEALTH COVERAGE IN SDGs**

Cyntia Lasmi Andesti

Informatic, Faculty of Information Technology and Creative Industries, Metamedia University, Padang,
Indonesia

Rahmad Dian

Information System and Technology, Faculty of Science and Technology, ITSU, Medan, Indonesia

Sri Restu Ningsih

Information System, Faculty of Information Technology and Creative Industries, Metamedia University, Padang,
Indonesia

ABSTRACT

The high prevalence of stunting in West Sumatra Province, especially Pariaman City, is currently a serious problem being faced. At least 600 children are at high risk of stunting. This is because stunting examinations are still carried out manually. This manual recording system can result in slow searches for pregnant women's health history and the potential for data loss, data redundancy and requiring a lot of time to detect stunting. The delay in detection results in toddlers not receiving early prevention of stunting indications. This is because there is no system that is able to detect stunting faster, more accurately and is used independently and the community is still not well educated about the importance of 1000 HPK. Therefore, this problem is the focus of researchers in designing an online Chatbot-based Application in detecting stunting. The purpose of the study is to create a stunting detection application in toddlers that is able to provide fast, accurate detection of stunting classification and is able to provide earlier treatment. In addition, the results of this study are one of the efforts to accelerate stunting prevention and reduce the percentage of stunted toddlers in Pariaman City. The research method begins with the stage of data analysis of factors and symptoms of stunting detection, rule formation with the Forward Chaining Method, calculation using Certainty Factor and the results of the percentage of stunting detection. The output produced can be used as a tool for pregnant women who also have toddlers and interested parties in the policy-making process related to programs that help accelerate the reduction of stunting rates in Indonesia, especially in the West Sumatra Province.

Keywords: Stunting, Chatbot, Foward Chaining, Certainty Factor

**MODELING LATERAL FACIES HETEROGENEITY OF AN EARLY JURASSIC
CARBONATE PLATFORM (TIGHZA, HIGH ATLAS OF MARRAKECH,
MOROCCO)**

Maryam ERRAMI

Dr., Cadi Ayyad University, Faculty of Sciences Semlalia, Department of Geology, MOROCCO

Ahmed ALGOUTI

Dr., Cadi Ayyad University, Faculty of Sciences Semlalia, Department of Geology, MOROCCO

Hayat GHACHOUI

PHD., Cadi Ayyad University, Faculty of Sciences Semlalia, Department of Geology, MOROCCO

Idir EL KONTY

Dr., Cadi Ayyad University, Faculty of Sciences Semlalia, Department of Geology, MOROCCO

ABSTRACT

The aim of this work is to reproduce a metre-scale facies heterogeneity 3D model of the carbonate platform deposits outcropping in the Tighza (High Atlas of Marrakech, Morocco). However, in shallow-water carbonate systems, capturing metre-scale facies heterogeneity in three-dimensional models remains controversial due to the possibility of facies coexistence and because their association can change through time and space. Within this context, the continuous and well-exposed Tighza carbonate platform allows detailed study of the distribution of lithofacies association and their architecture along the dip direction depositional profile. The lithofacies and the depositional model of the Tighza carbonate platform are referred to those defined by Pomar et al. (2014). The Tighza is a homoclinal carbonate ramp with a inner setting characterised by the extensive gypsum facies and shallow carbonate mudstones, passing into a large packstone and grainstone bioclastic facies developed in relatively deep conditions. The deeper part of this platform is characterised by bioturbated facies and large lamellibranches' packstone. The methodology used in this work combines classical field data collection (e.g., stratigraphic logs and field-facies mapping) and 3D stochastic modeling by using PetrelTM. All the data (top and base of stratigraphic logs, cross-section, key surfaces, lithofacies lateral extension etc.) were georeferenced and inserted into the software to build the digital outcrop model. The 3D facies model has been performed after several simulations through specific stochastic algorithms (SISim, TGSim), comparing the models reproduce by the two algorithms, matching the depositional geometries and the lithofacies association observed in the outcrop. The 3D modeling represents a useful tool to better understand the facies architecture and their complex heterogeneity. Moreover, a

detailed 3D facies model provides an essential tool to characterise semiquantitatively sedimentological features for subsurface reservoir studies.

Keywords: Marrakech High Atlas, Tighza, carbonate platform, 3D stochastic modeling, stochastic algorithms, SISim, TGSim.

GRAHAM'S NUMBER STABLE DIGITS: AN EXACT RESULT

Marco Ripà

Independent Researcher, Web of Science ResearcherID: GNM-9178-2022, Rome, Italy

ORCID: 0000-0002-6036-5541

ABSTRACT

In the decimal numeral system, we prove that the well-known Graham's number, $G := {}^n 3$ (i.e., $3^{3^{\dots^3}}$ n -times), and any base 3 tetration whose hyperexponent is larger than n share the same $\text{slog}_3(G) - 1$ rightmost digits (where slog indicates the integer super-logarithm). This is an exact result since the $\text{slog}_3(G)$ -th rightmost digit of G is different from the $\text{slog}_3(G)$ -th rightmost digit of ${}^{n+1}3$. Furthermore, we show that the $\text{slog}_3({}^n 3)$ -th least significant digit of the difference between Graham's number and any base 3 tetration whose integer hyperexponent is beyond n is 4.

Keywords: Graham's number, Tetration, Congruence speed, Power tower, Stable digits, Frozen digits, Powers of 3, Decimal system.

2020 Mathematics Subject Classification: 11A07 (Primary); 11F33 (Secondary).

Nota Bene. Although the original manuscript has not been published elsewhere, it has been written in LaTeX and it will not be possible for me to transpose the whole article in MS Word since it is full of numbers and contains some mathematical symbols (this would require too many hours to be properly done).

**STABLE AND HIGH PERFORMANCE LITHIUM ION BATTERIES USING
EFFECTIVE IONIC LIQUID-MODIFIED LIFSI ELECTROLYTES**

M. Thien Phung

Graduated School of Integrated Energy-AI, Jeonbuk National University, Jeonju, 54896, Republic of Korea

Eunbi Kim

Advanced Materials and Devices Laboratory, Department of Bio-Convergence Science, Jeonbuk National University, Jeongeup Campus, 56212, Republic of Korea

Sadia Ameen

Advanced Materials and Devices Laboratory, Department of Bio-Convergence Science, Jeonbuk National University, Jeongeup Campus, 56212, Republic of Korea

O-Bong Yang

Graduated School of Integrated Energy-AI, Jeonbuk National University, Jeonju, 54896, Republic of Korea

M. Shaheer Akhtar

Graduated School of Integrated Energy-AI, Jeonbuk National University, Jeonju, 54896, Republic of Korea
New and Renewable Energy Materials Development Center (NewREC), Jeonbuk National University, Jeonbuk, Republic of Korea

ABSTRACT

The employment of lithium bis(fluorosulfonyl)imide (LiFSI) as an electrolyte for lithium-ion batteries (LIBs) has gained traction due to its many benefits over conventional LiPF_6 , such as improved thermal stability, superior ionic conductivity, and the lack of hazardous HF acid production. Our work investigates the role of 1-propyl-2-methylpyridinium bis(trifluoromethylsulfonyl)imide, an ionic liquid (IL), in improving the stability and conductivity of LiFSI electrolytes. IL-modified LiFSI electrolytes were formulated by combining 1.0 M LiFSI with varying concentrations of the IL. The modified electrolyte demonstrated a substantial increase in ionic conductivity, reaching 11.862 mS/cm, compared to 10.384 mS/cm for the unmodified LiFSI. Flammability testing confirmed the IL-modified electrolyte was non-flammable, indicating enhanced safety and stability. This optimized electrolyte was utilized in the fabrication of half-cell LIBs, which were evaluated through cyclic voltammetry and galvanostatic charge-discharge tests. The results revealed that the IL-modified LiFSI electrolyte significantly enhanced battery performance, achieving a discharge capacity of 350 mAh/g at a current density of 0.2 A/g, along with improved long-cycle stability. This research underscores the potential of incorporating ionic liquids into LiFSI-based electrolytes to develop stable, high-performance liquid electrolytes for next-generation lithium-ion batteries.

**NEXT-GENERATION HEALTHCARE: AN AI-BASED AUTONOMOUS DRUG
DELIVERY SYSTEM**

MUJEEBUDHEEN KHAN

University of Technology and Applied Sciences – Ibra, PO Box 327 Ibra 400, Al Sharqiya North, Sultanate of
Oman

ABSTRACT

In today's fast-paced world, the demand for technology that addresses human needs is ever-growing. To reduce human workload and optimize task efficiency, robotics has become a pivotal solution across multiple industries. This project presents the design and development of an AI-driven robot aimed at assisting patients in hospitals by automating routine tasks. The robot is integrated with an RP LIDAR sensor, enabling it to map its environment, navigate hospital corridors, and perform essential tasks such as delivering medications.

Through the use of RP LIDAR for real-time mapping and navigation algorithms, the robot can autonomously move through hospital settings while detecting and avoiding obstacles to ensure safe operations. This intelligent system can significantly alleviate the workload of hospital staff by automating routine procedures and enhancing patient care. The implementation of such assistive technology can ultimately contribute to better efficiency, improved patient outcomes, and enhanced hospital operations.

Keywords: RP LIDAR, Artificial Intelligence, Raspberry Pi, Arduino, Autonomous Navigation, Healthcare Robotics

WATER RETENTION AND SORPTION CHARACTERISTICS OF CELLULOSE-BASED HYDROGELS

Aleksandra Mikhailidi

Dr., St. Petersburg State University of Industrial Technologies and Design, Higher School of Printing and Media Technologies, Department of Printing Production, Russia

Sofya Verbovskaya

St. Petersburg State University of Industrial Technologies and Design, Institute of Applied Chemistry and Ecology, Department of Chemical Technologies named after Prof. Kharkharov, Russia

Margarita Chepurnova

St. Petersburg State University of Industrial Technologies and Design, Institute of Applied Chemistry and Ecology, Department of Chemical Technologies named after Prof. Kharkharov, Russia

ABSTRACT

Polymer hydrogels are promising materials for applications in agriculture, medicine, environmental protection, construction, oil extraction, and other fields. Natural polymers, such as cellulose-based materials, provide hydrogels with important properties, namely biocompatibility and biodegradability, making them valuable for both human and environmental applications. Hydrogels are capable of retaining a significant amount of water, which varies depending on the source material and the method of hydrogel production.

In this study, hydrogels based on cotton microcrystalline cellulose were investigated. The hydrogels were produced by dissolving the cellulose and subsequently regenerating it in water. The solvents used were NaOH(aq), NaOH/urea, and DMAc/LiCl.

Dissolution in NaOH(aq) resulted in hydrogels with the lowest water retention capacity (WRC) of 3.66 ± 0.04 g/g. The addition of urea, which facilitated additional cross-linking of cellulose chains, increased the WRC of the hydrogels to 5.69 ± 0.35 g/g. The use of the complex solvent DMAc/LiCl led to a dramatic increase in WRC to 59.51 ± 4.61 g/g. An important feature of hydrogels for agricultural applications is their ability to re-swell. NaOH-based solvents produced hydrogels capable of swelling at least twice. However, the WRC of subsequent swelling cycles decreased.

Cellulose-based materials are well-known for their sorption properties with respect to complex organic compounds, such as dyes and pharmaceuticals. The sorption capacity of the hydrogels towards methylene blue dye was studied using the photolorimetric method. The average maximum sorption capacity for the hydrogel obtained using NaOH solvent was 0.16 mg/g. For samples produced with NaOH/urea, the values reached 0.23 mg/g. Depending on the composition, the sorption capacity of hydrogels obtained using the DMAc/LiCl varied from 0.07 to 0.51 mg/g.

The results show that the WRC and sorption capacity of cellulose hydrogels depend on the type of solvent, the composition of the initial materials, and the dissolution conditions.

Keywords: Hydrogels, Cellulose, Water retention capacity, Sorption properties.

**GENETIC DIVERSITY ANALYSIS OF EUPHORBIA RESINIFERA IN MOROCCO:
A POTENTIAL PLANT TO REMEDY CLIMATE CHANGE, PROTECTING AND
RESTORING ECOLOGICAL HABITATS OF PLANT AND ANIMAL SPECIES**

Hassane ABD-DADA

Laboratory of Agro-Industrial and Medical Biotechnologies, Faculty of Sciences and Techniques, Sultan Moulay
Slimane University, B.P. 523, Beni Mellal, Morocco

Said BOUDA

Laboratory of Agro-Industrial and Medical Biotechnologies, Faculty of Sciences and Techniques, Sultan Moulay
Slimane University, B.P. 523, Beni Mellal, Morocco

Atman ADIBA

Laboratory of Agro-Industrial and Medical Biotechnologies, Faculty of Sciences and Techniques, Sultan Moulay
Slimane University, B.P. 523, Beni Mellal, Morocco

Sadik DANI

Laboratory of Agro-Industrial and Medical Biotechnologies, Faculty of Sciences and Techniques, Sultan Moulay
Slimane University, B.P. 523, Beni Mellal, Morocco

Abdelmajid HADDIOUI

Laboratory of Agro-Industrial and Medical Biotechnologies, Faculty of Sciences and Techniques, Sultan Moulay
Slimane University, B.P. 523, Beni Mellal, Morocco

ABSTRACT

Euphorbia resinifera an endemic Moroccan plant plays a significant role in the structure and functioning of pre-forest ecosystems. The vegetative formations of this species occupy various ecological situations, suggesting a high specific biodiversity. It has multiple and varying roles at different scales, such as combating pollution, protecting and restoring habitats of mountain plant and animal species, inhibiting soil erosion, providing protection against heat, and producing O₂. In order to safeguard, conserve and develop the genetic resources of this plant, we are interested to study the genetic diversity of natural populations of this species in Morocco.

Genetic variation was estimated using 14 ISSR markers. The mean values obtained for the PIC (0.33) and Rp (2.8) PBP (74.81%) parameters demonstrated the efficiency of these markers to analyse the variability and genetic differentiation of natural populations of Euphorbia resinifera. Similarly, the results obtained showed a high genetic variability within the studied populations (HT= 0.21 and I= 0.35), and strong differentiation between the analysed populations (F_{ST}= 0.24) and restricted gene flow between them (N_{em}= 0.77). Furthermore, multivariate analyses revealed that the structuring of the genetic diversity of the

populations into two groups occurred independently of geographical origin, mountain range type and the altitude.

This study highlights the importance of preserving the genetic diversity of *E. resinifera*. The results provide valuable information to support management and improvement of this endemic species in Morocco.

Keywords *Euphorbia resinifera*, genetic diversity, ISSR, ecology, biodiversity



T.C.
ARDAHAN ÜNİVERSİTESİ REKTÖRLÜĞÜ
İlahiyat Fakültesi



Sayı : E-56430641-900-2400029572
Konu : Akademisyen Temsilci Hk.

05.09.2024

İLGİLİ MAKAMA

İlgi : Din Psikolojisi Ana Bilim Dalı Başkanlığının 03.09.2024 tarihli ve E-21509696-051-2400029557 sayılı yazısı.

İlgide kayıtlı yazıya istinaden, 5-7 Ekim 2024 tarihleri arasında İzmir’de düzenlenecek olan "**10. ULUSLARARASI EGE KONGRELERİ'nin (Sosyal ve Beşeri Bilimler Kongresi, Sağlık ve Fen Bilimleri Kongresi, İnovasyon ve Mühendislik Bilimleri Kongresi)**" düzenleme komitesinde, Fakültemiz Felsefe ve Din Bilimleri Bölümü Din Psikolojisi Ana Bilim Dalı'nda görevli Doç. Dr. Mehmet Emin KALGI'nın, akademisyen temsilci olarak görev alması Dekanlığımızca uygun görülmüştür.

Bilgilerinizi ve gereğini arz/rica ederim.

Prof. Dr. Mustafa YILDIZ
İlahiyat Fakültesi Dekanı

Bu belge, güvenli elektronik imza ile imzalanmıştır.

Belge Doğrulama Kodu: 49T9UA9

Belge Takip Adresi: <https://www.turkiye.gov.tr/ardahan-universitesi-ebys>

Adres: Ardaahan Üniversitesi Kampüsü, Çamlıçatak Mevkii, 75002, Merkez/ARDAHAN

Telefon No: (0 478) 2117563

e-Posta: if@ardahan.edu.tr

Keop Adresi: ardahanuni@hs01.kep.tr

Faks No: (0 478) 2117565

İnternet Adresi: www.ardahan.edu.tr

Bilgi için :

Telefon No:

Direkt Hat:

Mesut Akçay

Bilgisayar İşletmeni

(0 478) 2117563

