INTERNATIONAL MESOPOTAMIAN SCIENTIFIC RESEARCH CONGRESS

APRIL 4–5, 2026 | DİYARBAKIR, TÜRKİYE | HYBRID

PROCEEDINGS BOOK

Editor: Prof. Dr. Abdulkadir AYDIN

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ISARC

INTERNATIONAL SCIENCE AND ART RESEARCH CENTER

INTERNATIONAL MESOPOTAMIAN SCIENTIFIC RESEARCH CONGRESS

April 4-5, 2026 / Diyarbakır, Türkiye

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Dicle University

by

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CONGRESS ID

CONGRESS TITLE

INTERNATIONAL MESOPOTAMIAN SCIENTIFIC RESEARCH CONGRESS

DATE and PLACE

April 4-5, 2026 / Diyarbakır, Türkiye

PARTICIPATION

Keynote & Invited

PARTICIPANTS COUNTRY

Algeria, India, Indonesia, Indonesia, Jordan, Kosovo, México, Morocco, Nigeria, Pakistan, Portugal, Republic of Belarus, Romania, South Africa, TRNC, Türkiye, Vietnam

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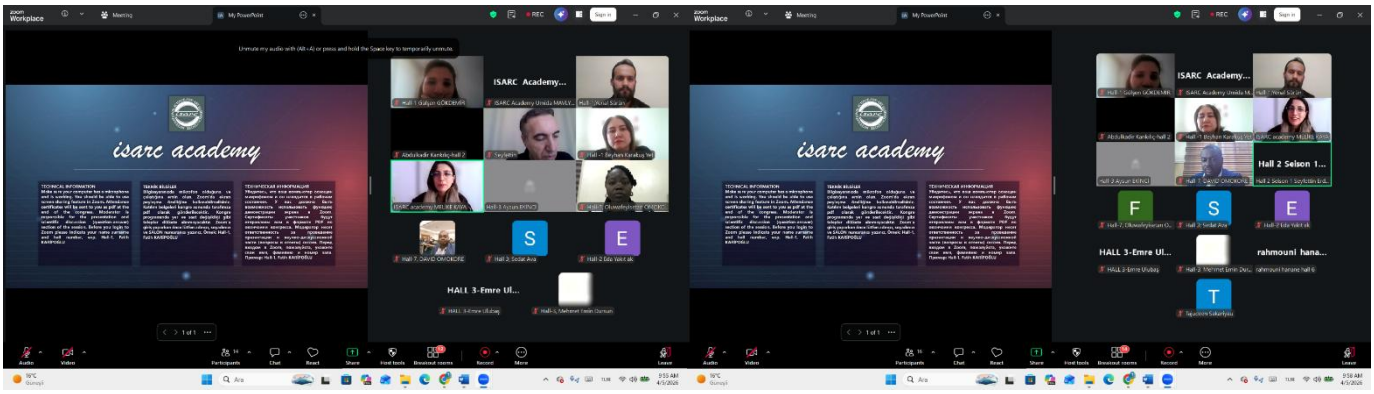

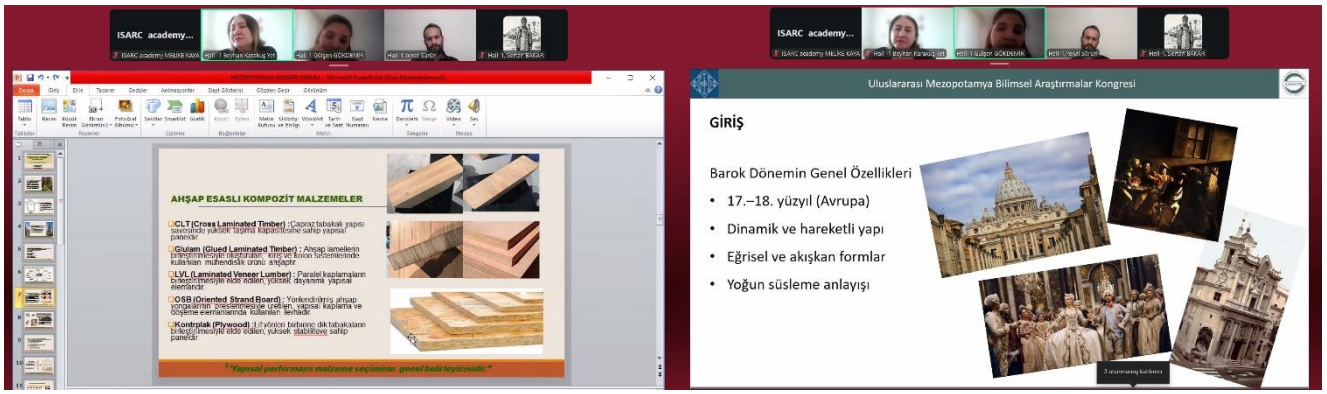

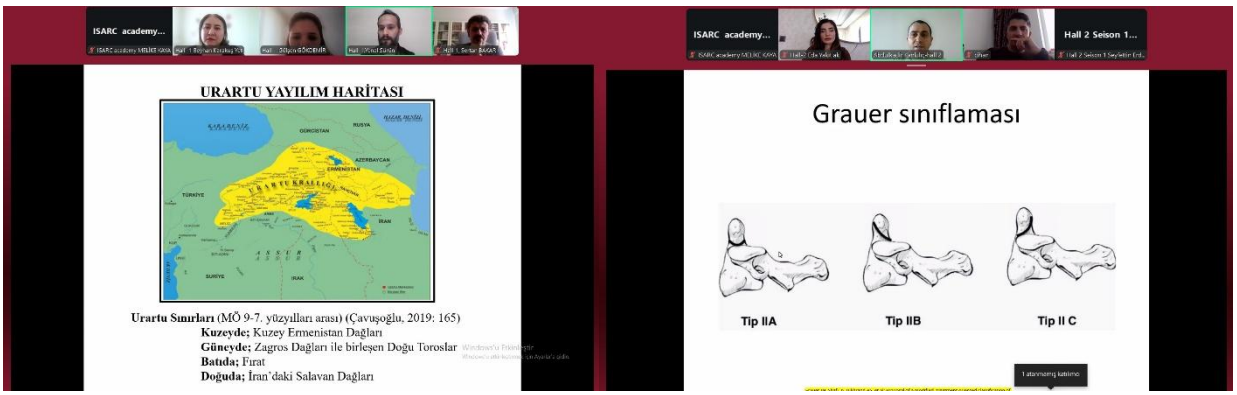

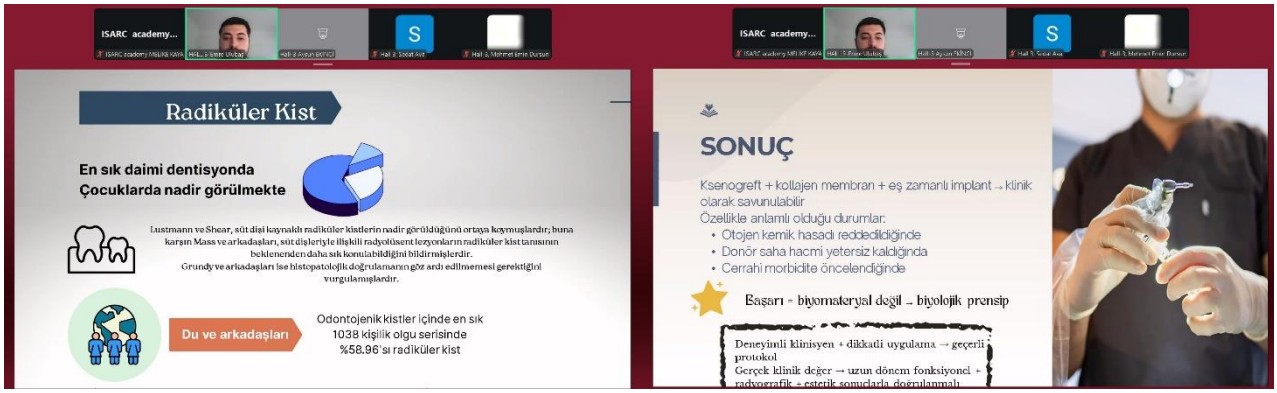

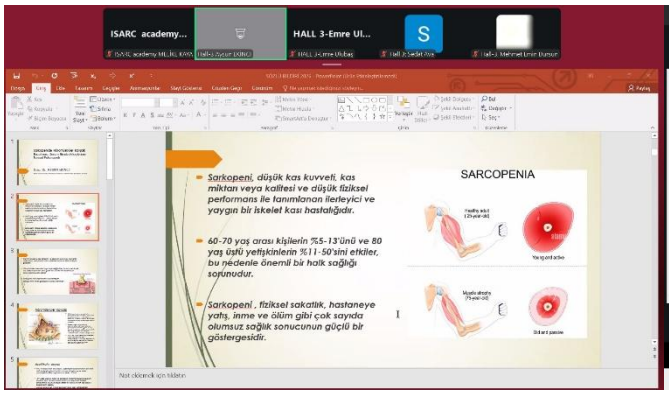
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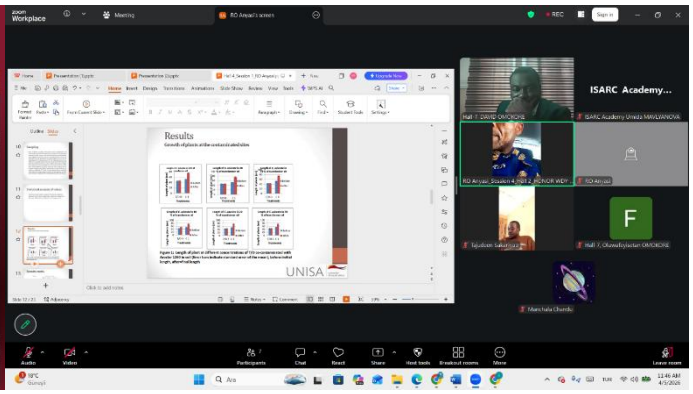
HALL 3-Emre Ul...
SARCOPENIA
Sarkopeni, düşük kas kuvveti, kas miktarı veya kalitesi ve düşük fiziksel performans ile tanımlanan ilerleyici ve yaygın bir iskelet kası hastalığıdır.
60-70 yaş arası kişilerin %5-13'ünü ve 80 yaş üstü yetişkinlerin %11-50'sini etkiler, bu nedenle önemli bir halk sağlığı sorunudur.
Sarkopeni , fiziksel sakatlık, hastaneye yatış, imme ve ölüm gibi çok sayıda olumsuz sağlık sonucunun güçlü bir göstergesidir.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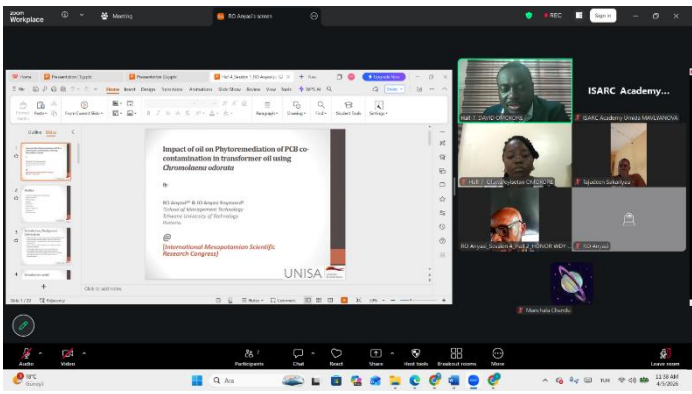
Results
UNISA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Impact of oil on Phytoremediation of PCB co-contamination in transformer oil using Chromolaena odorata
UNISA

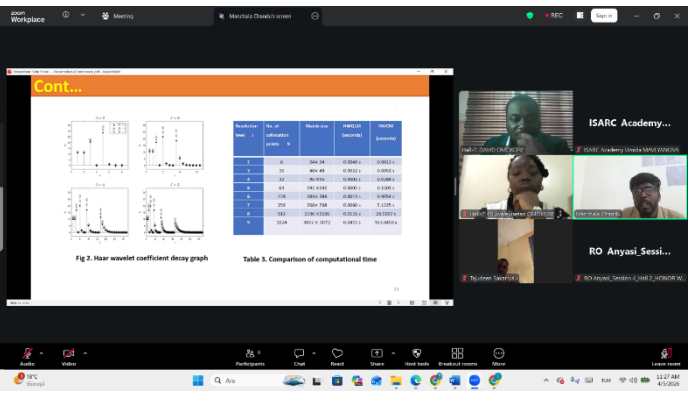
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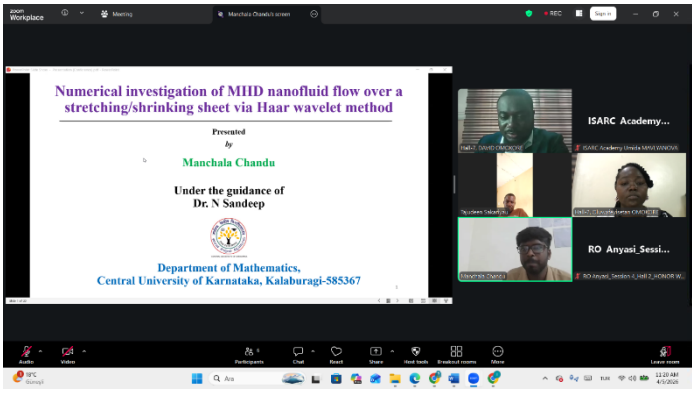
Fig 2. Haar wavelet coefficient decay graph
Table 3. Comparison of computational time


Numerical investigation of MIID nanofluid flow over a stretching/shrinking sheet via Haar wavelet method
Presented by
Manchala Chandu
Under the guidance of
Dr. N Sandeep
Department of Mathematics,
Central University of Karnataka, Kalaburagi-585367
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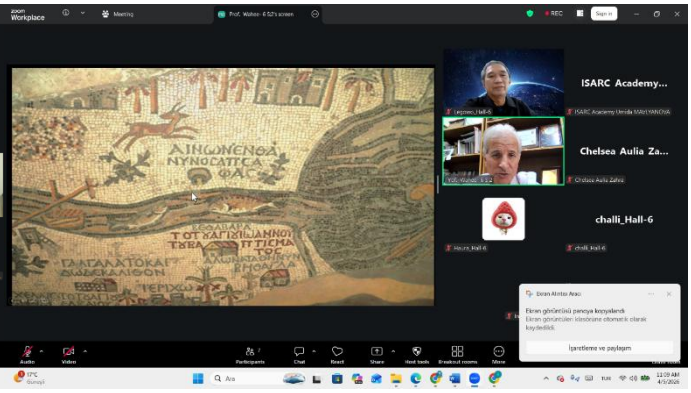
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PACKAGING PHASE IN JORDAN VALLEY
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Chelsea Aulia Z...
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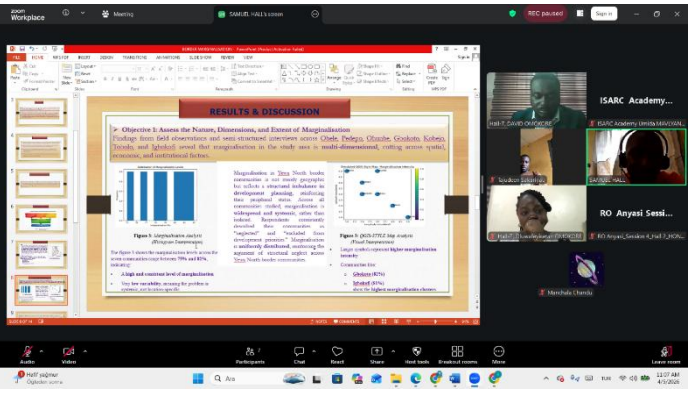
RESULTS & DISCUSSION
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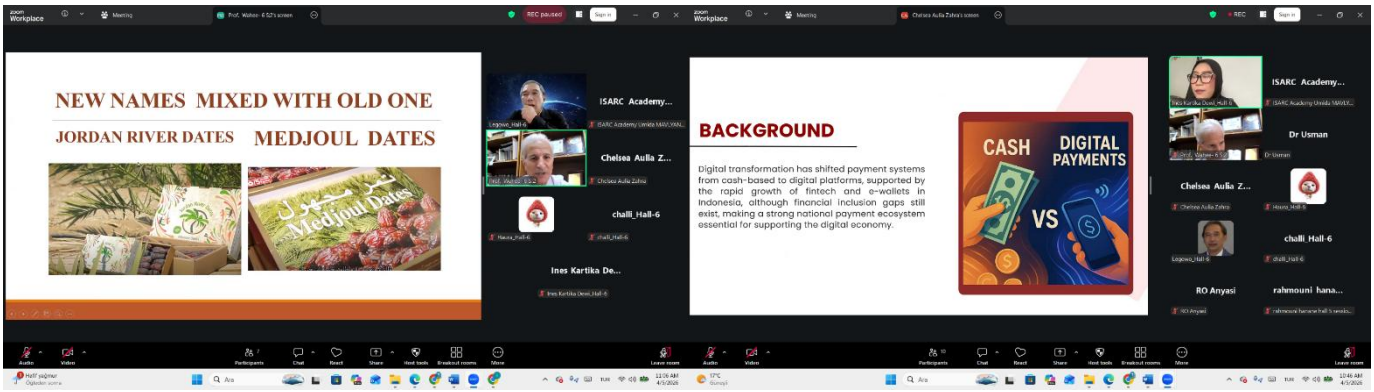
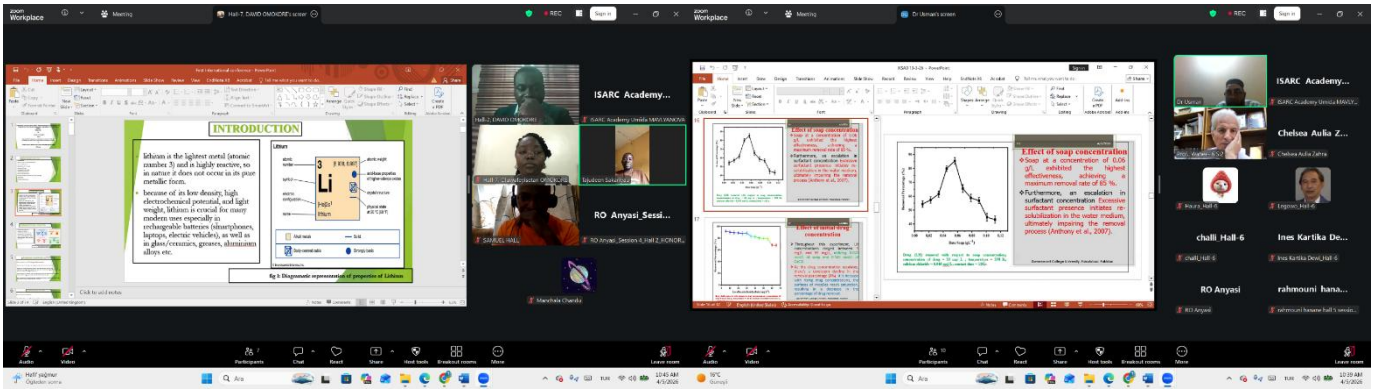
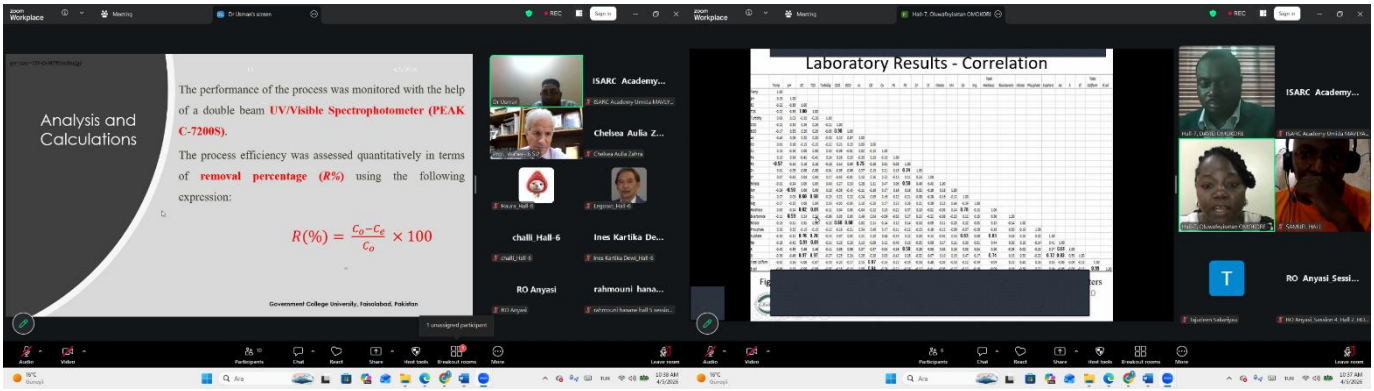
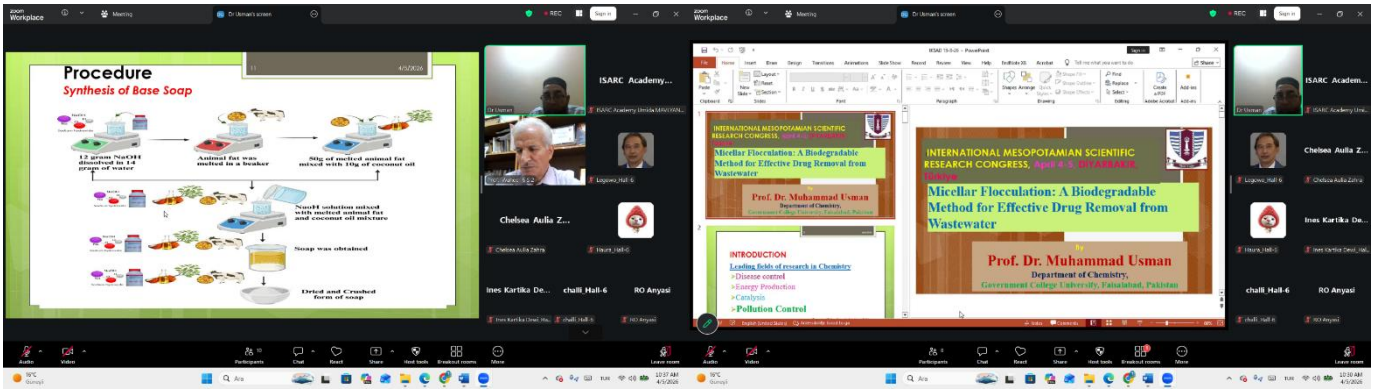
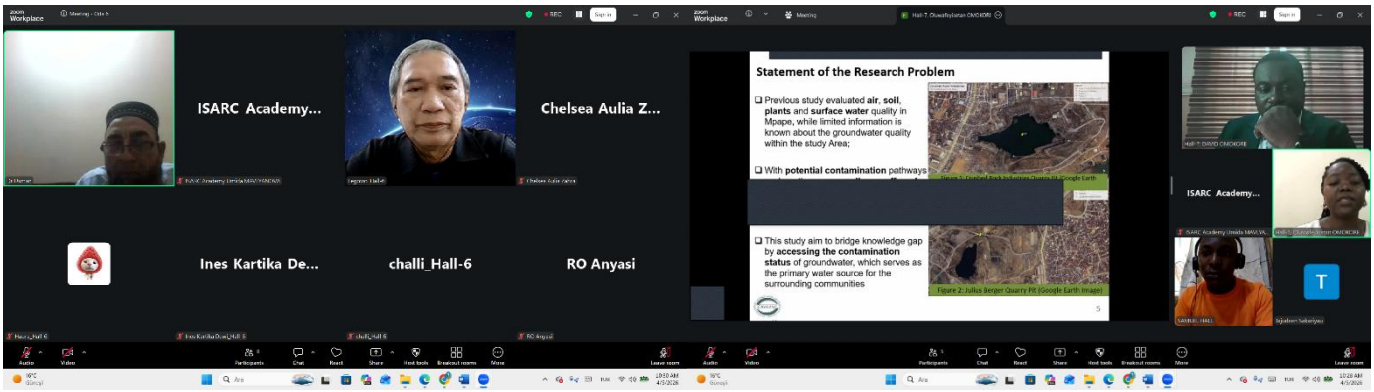

NEW NAMES MIXED WITH OLD ONE
JORDAN RIVER DATES
MEDJOUL DATES
BACKGROUND
CASH
DIGITAL PAYMENTS
VS


INTRODUCTION
Effect of soap concentration


Analysis and Calculations
Laboratory Results - Correlation


Procedure
Synthesis of Base Soap
Micellar Flocculation: A Biodegradable Method for Effective Drug Removal from Wastewater
Prof. Dr. Muhammad Usman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Ines Kartika De...
challi_Hall-6
RO Anyasi
Statement of the Research Problem
Previous study evaluated air, soil, plants and surface water quality in Mpape, while limited information is known about the groundwater quality within the study Area;
With potential contamination pathways
This study aim to bridge knowledge gap by accessing the contamination status of groundwater, which serves as the primary water source for the surrounding communities
Figure 2: Julius Berger Quarry Pit (Google Earth Image)
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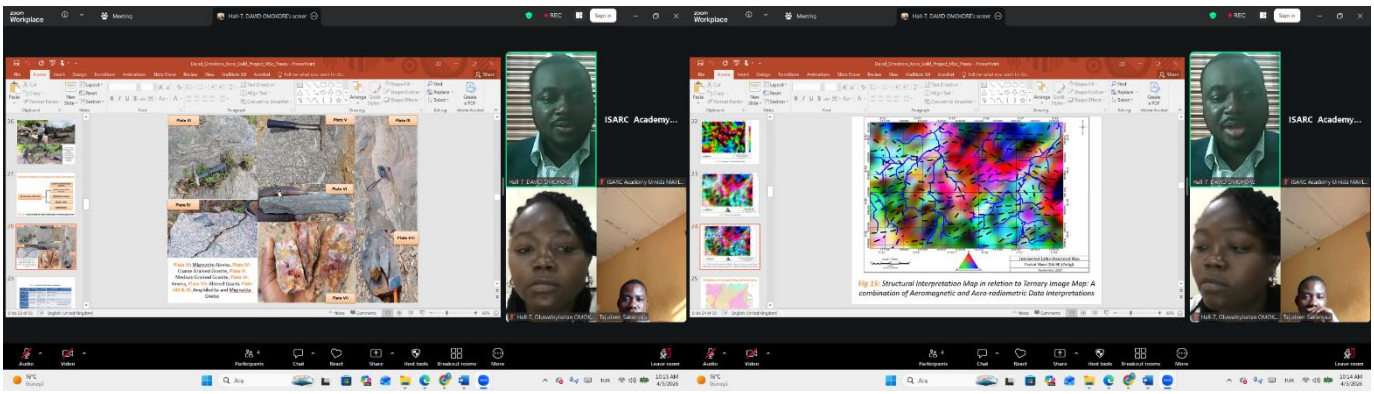
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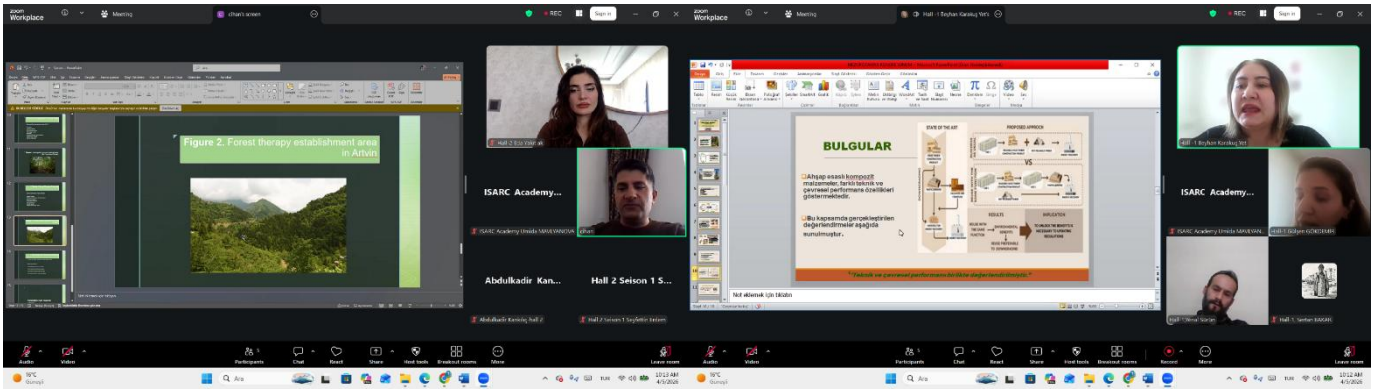
Figure 2. Forest therapy establishment area in Artvin
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Abdulkadir Kan...
Hall 2 Seison 1 S...
BULGULAR
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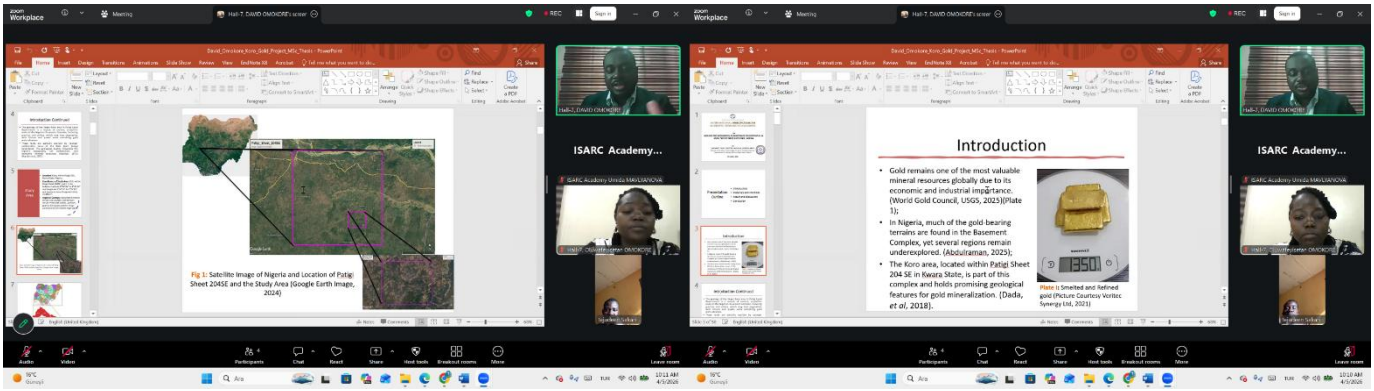
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Introduction
Gold remains one of the most valuable mineral resources globally due to its economic and industrial importance. (World Gold Council, USGS, 2023)(Plate 1);
In Nigeria, much of the gold-bearing terrains are found in the Basement Complex, yet several regions remain underexplored. (Abdulraman, 2025);
The Koro area, located within Patigi Sheet 204 SE in Kwara State, is part of this complex and holds promising geological features for gold mineralization. (Dada, et al, 2018).
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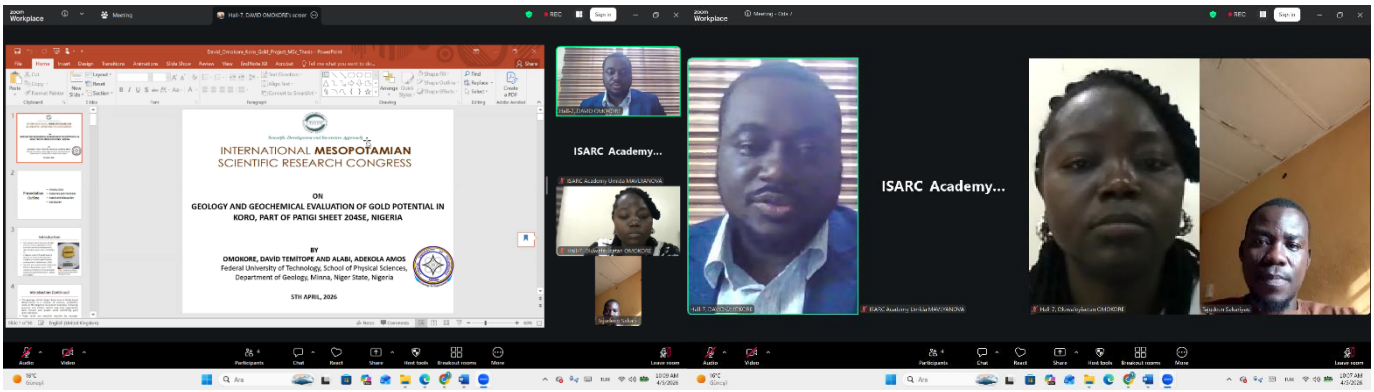
INTERNATIONAL MESOPOTAMIAN
SCIENTIFIC RESEARCH CONGRESS
ON
GEOLOGY AND GEOCHEMICAL EVALUATION OF GOLD POTENTIAL IN KORO, PART OF PATIGI SHEET 204SE, NIGERIA
BY
OMOKORE, DAVID TEMITOPE AND ALABI, ADEKOLA AMOS
Federal University of Technology, School of Physical Sciences, Department of Geology, Minna, Niger State, Nigeria
5TH APRIL, 2026
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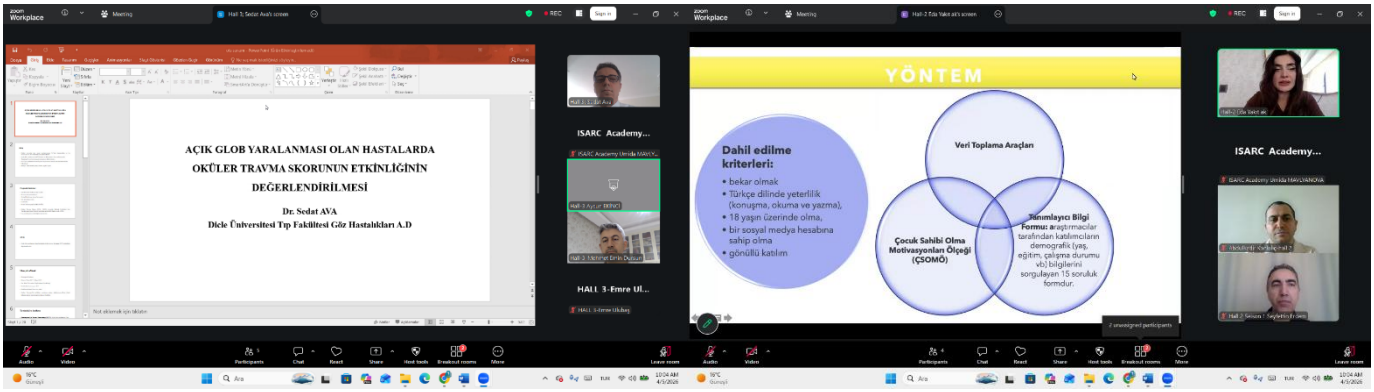
ISARC Academy...


AÇIK GLOB YARALANMASI OLAN HASTALARDA
OKÜLER TRAVMA SKORUNUN ETKİNLİĞİNİN
DEĞERLENDİRİLMESİ
Dr. Sedat AVA
Dicle Üniversitesi Tıp Fakültesi Göz Hastalıkları A.D
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YÖNTEM
Dahil edilme kriterleri:
• bekar olmak
• Türkçe dilinde yeterlilik (konuşma, okuma ve yazma),
• 18 yaşın üzerinde olma,
• bir sosyal medya hesabına sahip olma
• gönüllü katılım
Veri Toplama Araçları
Çocuk Sahibi Olma Motivasyonları Ölçeği (ÇSOMÖ)
Tanımlayıcı Bilgi Formu: araştırmacılar tarafından katılımcıların demografik (yaş, eğitim, çalışma durumu vb.) bilgilerini sorgulayan 15 soruluk formdur.
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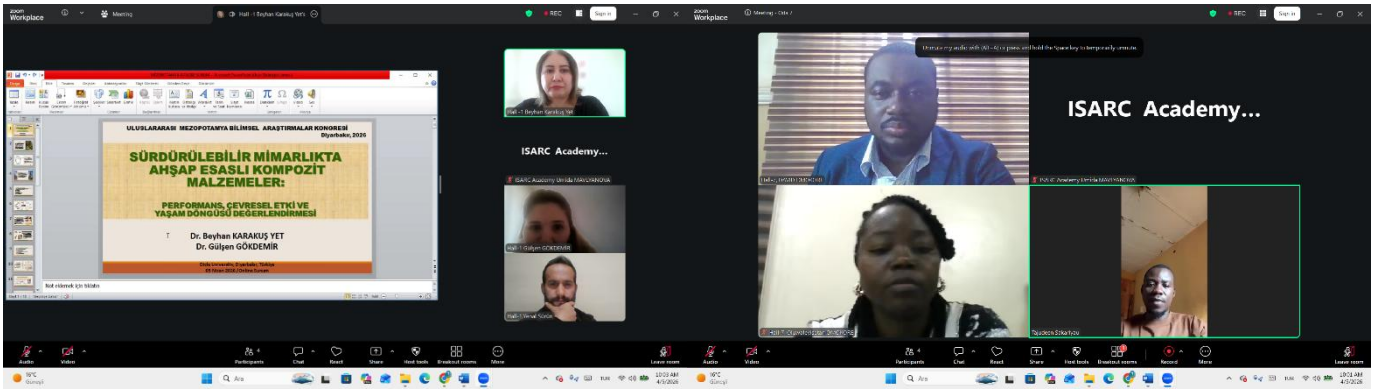
ULUSLARARASI MEZOPOTAMYA BİLİMSEL ARAŞTIRMALAR KONGRESİ
Diyarbakır, 2026
SÜRDÜRÜLEBİLİR MİMARLIKTA AHŞAP ESASLI KOMPOZİT MALZEMELER:
PERFORMANS, ÇEVRESEL ETKİ VE YAŞAM DÖNGÜSÜ DEĞERLENDİRMESİ
Dr. Beyhan KARAKUŞ YET
Dr. Gülşen GÖKDEMİR
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Scıentific Development and Innovative Approach

INTERNATIONAL **MESOPOTAMIAN** SCIENTIFIC RESEARCH CONGRESS

"Bridging Disciplines, Advancing Knowledge"

April 4-5, 2026 / Diyarbakır, Türkiye

Congress Program

Participant Countries: Algeria, India, Indonesia, Indonesia, Jordan, Kosovo, México, Morocco, Nigeria, Pakistan, Portugal, Republic of Belarus, Romania, South Africa, TRNC, Türkiye, Vietnam

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PASSCODE: 083356
https://us06web.zoom.us/j/86542191288?pwd=5jiY6aPGOfYgabaV5se6aNQT6WHYof.1

05.04.2026 / Hall-1, Session-1

ISTANBUL LOCAL TIME
10 00 : 12 00

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Dr. Gülşen Gökdemir

TOPIC TITLE	AUTHORS	AFFILIATION
WOOD-BASED COMPOSITES IN SUSTAINABLE ARCHITECTURE: PERFORMANCE, ENVIRONMENTAL IMPACT, AND LIFE CYCLE ASSESSMENT	Beyhan Karakuş Yet Gülşen Gökdemir	Dicle University, Türkiye
ANALYSIS OF BAROQUE PERIOD FURNITURE FROM A BIOMIMICRY PERSPECTIVE: A RETROSPECTIVE EVALUATION IN THE CONTEXT OF FORM, STRUCTURE, AND SYSTEM	Gülşen Gökdemir Beyhan Karakuş Yet	Dicle University, Türkiye
AGE, GENDER AND SOCIAL HIERARCHY IN THE URARTIAN URN BURIAL TRADITION: A SOCIO-CULTURAL ANALYSIS	Yenal Sürün	Van Yüzüncü Yıl University, Türkiye
TWO INTERPRETATIONS OF MODERN ARCHITECTURAL THOUGHT: A COMPARATIIVE ANALYSIS OF LE CORBUSIER AND TURGUT CANSEVER	Sertan Bakar Mehmet İnceoğlu	Kafkas University, Türkiye Eskişehir Technical University, Türkiye
A THEORETICAL EVALUATION OF THE ARCHITECT'S IDENTITY AND ROLE: THE HISTORICAL AND PHILOSOPHICAL BACKGROUND OF ARCHITECTURAL THOUGHT	Sertan Bakar Mehmet İnceoğlu	Kafkas University, Türkiye Eskişehir Technical University, Türkiye

05.04.2026 / Hall-2, Session-1

ISTANBUL LOCAL TIME
10 00 : 12 00

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Assoc. Prof. Dr. Eda Yakıt Ak

TOPIC TITLE	AUTHORS	AFFILIATION
MOTIVATION TO HAVE CHILDREN AMONG UNMARRIED YOUNG PEOPLE AND INFLUENCING FACTORS	Eda Yakıt Ak Zeynep Oğul	Dicle University, Türkiye Near East University, TRNC
FOREST THERAPY: NATURE-BASED APPROACHES IN PUBLIC HEALTH	Cihan Önen	Bitlis Eren University, Türkiye
EARLY INSTABILITY DURING CONSERVATIVE MANAGEMENT OF A REDUCED TYPE II ODONTOID FRACTURE: A CASE	Abdulkadir Kankılıç İbrahim Başar Abdurrahim Taş	Dicle University, Türkiye
CLINICAL AND PATHOLOGICAL CHARACTERISTICS OF SURGICALLY TREATED MENINGIOMAS	Abdulkadir Kankılıç İbrahim Başar Abdurrahim Taş	Dicle University, Türkiye
CENTRAL SEROUS CHORIORETINOPATHY DETECTED FOLLOWING COVID-19 DISEASE	Seyfettin Erdem	Dicle University, Türkiye

05.04.2026 / Hall-3, Session-1

ISTANBUL LOCAL TIME
10 00 : 12 00

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Assoc. Prof. Dr. Aysun Ekinci

TOPIC TITLE	AUTHORS	AFFILIATION
HYPERLIPIDEMIA AS A CAUSE OF RECURRENT ACUTE PANCREATITIS: A CASE REPORT	Ercan Gündüz	Dicle University, Türkiye
SPORADIC HYPOKALEMIC PERIODIC PARALYSIS: A CASE REPORT	Ercan Gündüz	Dicle University, Türkiye
EVALUATION OF THE EFFECTIVENESS OF THE OCULAR TRAUMA SCORE IN PATIENTS WITH OPEN GLOBE INJURIES	Sedat Ava	Dicle University, Türkiye
THE EFFECTIVENESS OF PUPILLOMETRY IN DETECTING AUTONOMIC DYSFUNCTION IN OBESE PEDIATRIC PATIENTS	Mehmet Emin Dursun	Dicle University, Türkiye
DISRUPTION OF THE NEUROMUSCULAR JUNCTION IN SARCOPENIA: DIAGNOSTIC POTENTIAL OF SERUM BIOMARKERS	Aysun Ekinci	Dicle University, Türkiye
SURGICAL MANAGEMENT AND ENDODONTIC REHABILITATION OF A RADICULAR CYST IN THE POSTERIOR MANDIBLE OF A PEDIATRIC PATIENT: CASE REPORT AND LITERATURE REVİEW	Emre Ulubaş Damla Maide Davutluoğlu İnci Rana Karaca	Gazi University, Türkiye
HORIZONTAL RIDGE AUGMENTATION USING XENOGENEIC GRAFT AND COLLAGEN MEMBRANE FOR SIMULTANEOUS IMPLANT PLACEMENT IN THE ANTERIOR MAXILLA: CASE REPORT AND REVIEW OF THE LITERATURE	Emre Ulubaş İnci Rana Karaca	Gazi University, Türkiye

05.04.2026 / Hall-4, Session-2

ISTANBUL LOCAL TIME
10 30 : 12 30

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Raymond Oriebe Anyasi

TOPIC TITLE	AUTHORS	AFFILIATION
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MICELLAR FLOCCULATION: A BIODEGRADABLE METHOD FOR EFFECTIVE DRUG REMOVAL FROM WASTEWATER	Muhammad Usman Fiza Bukhtawar Amnah Yusaf	Government College University Faisalabad, Pakistan
RISK MANAGEMENT BEHAVIORS AND PRODUCTION PERFORMANCE UNDER UNCERTAINTY: EVIDENCE FROM INTENSIVE WHITELEG SHRIMP FARMING IN THE MEKONG DELTA, VIETNAM	The Nhu Hiep Tran Le Thong Pham	Cantho University, Vietnam
SYNTHESIS AND CHARACTERIZATION OF LANTHANUM DOPED NICKEL COBALT FERRITES FOR ELECTROCATALYSIS	Amina Irshad Sania Arif Hafeez Anwar	University of Agriculture, Pakistan
PRODUCTION AND CHARACTERIZATION OF CARBON NANOTUBES FROM BIOCHAR UNDER MICROWAVE IRRADIATION	Faisal Nazir	The University Of Agriculture, Pakistan
SYSTEMATIC LITERATURE REVIEW ON PHISHING ATTACK: TYPES, CLASSIFICATION TECHNIQUES, METHODOLOGY USED AND RESEARCH DIRECTIONS	Abdulrahman Mohammed Saba Alfa Muhammad	Federal Polytechnic Bida, Nigeria

05.04.2026 / Hall-5, Session-2

ISTANBUL LOCAL TIME
10 30 : 12 30

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Mihaela-Corina Bucur

TOPIC TITLE	AUTHORS	AFFILIATION
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AGING AND GERIATRIC HEALTH	Dulce María Gerónimo Hernandez Viridiana Haizea Cruz Rangel Gloria Auristela Hernández Perez	Universidad Juárez Autónoma de Tabasco, México
THE CROSS STITCH EMBROIDERY E-LEARNING COURSE	Alesja Bajko Irina Lyubanets	Baranovichi State University, Republic of Belarus
YOUNG ENTREPRENEUR, THINK ABOUT EXPERIENCE BEFORE PRACTICE	Hanane Rahmouni	University of Oran 2 Mohamed Ben Ahmed, Algeria
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THE DIGITAL VEIL: A QUALITATIVE INVESTIGATION INTO THE ETHICAL AND PROCEDURAL CHALLENGES OF ELECTRONIC EVIDENCE IN MODERN LITIGATION	Mihaela-Corina Bucur	Asanka Sante Medical Clinic, Romania
THE HUMAN FACTOR IN HIGH-STAKES TRIAGE: A QUALITATIVE EXPLORATION OF DECISION-MAKING UNDER CRITICAL TIME CONSTRAINTS	Mihaela-Corina Bucur	Asanka Sante Medical Clinic, Romania
EFFECTS OF THE NUMBERED HEADS TOGETHER (NHT) INSTRUCTIONAL STRATEGY ON THE INTEREST AND ACADEMIC ACHIEVEMENT OF SENIOR SECONDARY SCHOOL II (SS II) STUDENTS IN GEOGRAPHY IN MANGU, PLATEAU STATE, NIGERIA	Hannah Nathaniel Shamle Nuhu Haggai	University of Jos, Nigeria

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ISTANBUL LOCAL TIME
10 30 : 12 30

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Prof Dr Mohammed Waheeb

TOPIC TITLE	AUTHORS	AFFILIATION
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THE STUDY OF THE NATIONAL PAYMENT ECOSYSTEM IN INDONESIA: DIGITAL TRANSFORMATION AND FINANCIAL INCLUSION PERSPECTIVE	Ines Kartika Dewi Chelsea Aulia Zahra Mercurius Broto Legowo	Perbanas Institute, Indonesia
THE EFFECTS OF THE PERSIAN GULF CONFLICT ON GLOBAL SUPPLY CHAINS: THE IMPORTANCE OF FLEXIBILITY AND ADAPTABILITY	Shpat Krasniqi Ismail Mehmeti Sokol Krasniqi	University of Applied Science in Ferizaj, Kosovo
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05.04.2026 / Hall-7, Session-2

ISTANBUL LOCAL TIME
10 30 : 12 30

MEETING ID: 865 4219 1288
PASSCODE: 083356

HEAD OF SESSION: Omokore, David Temitope

TOPIC TITLE	AUTHORS	AFFILIATION
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WOOD-BASED COMPOSITES IN SUSTAINABLE ARCHITECTURE: PERFORMANCE, ENVIRONMENTAL IMPACT, AND LIFE CYCLE ASSESSMENT

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ABSTRACT

Sustainable architecture is an approach that aims to reduce the environmental impacts of buildings and promote the efficient use of natural resources. In this context, wood-based composite materials are increasingly preferred in the construction sector due to their reliance on renewable resources, low carbon footprint, and ability to store carbon.

In this study, wood-based composite materials were evaluated based on the literature in terms of mechanical performance, moisture and water-related behavior, thermal and acoustic properties, and biological durability. In addition, the environmental impacts of these materials were examined within the framework of the Life Cycle Assessment (LCA) approach, considering production processes, carbon storage potential, and end-of-life options.

The findings indicate that wood-based composites offer significant advantages, including low weight, a high strength-to-weight ratio, and good dimensional stability. However, sensitivity to moisture, the risk of biological degradation, and adhesive-related emissions are among the main limitations of these materials. Therefore, appropriate material selection, proper design decisions, and the adoption of low-emission production approaches are of great importance.

In conclusion, when evaluated from a life cycle perspective, wood-based composite materials represent a strong alternative in sustainable building design in terms of both technical and environmental performance. This study emphasizes the importance of evaluating the performance and environmental impacts of these materials in an integrated manner.

Keywords: Sustainable architecture, wood-based composite materials, life cycle assessment (LCA), environmental impact, carbon storage.

SÜRDÜRÜLEBİLİR MİMARLIKTA AHŞAP ESASLI KOMPOZİTLER: PERFORMANS, ÇEVRESEL ETKİ VE YAŞAM DÖNGÜSÜ DEĞERLENDİRMESİ

ÖZET

Sürdürülebilir mimarlık, yapıların çevre üzerindeki etkilerini azaltmayı ve doğal kaynakları daha verimli kullanmayı amaçlayan bir yaklaşımdır. Bu doğrultuda, ahşap esaslı kompozit malzemeler; yenilenebilir kaynaklara dayanmaları, düşük karbon ayak izine sahip olmaları ve karbon depolayabilme özellikleri sayesinde yapı sektöründe giderek daha fazla tercih edilmektedir.

Bu çalışmada, ahşap esaslı kompozit malzemeler literatür verileri doğrultusunda; mekanik performans, nem ve suya karşı davranış, termal ve akustik özellikler ile biyolojik dayanıklılık açısından ele alınmıştır. Bunun yanı sıra, bu malzemelerin çevresel etkileri yaşam döngüsü değerlendirmesi (LCA)

yaklaşımı kapsamında incelenmiş; üretim süreçleri, karbon depolama potansiyeli ve kullanım ömrü sonu seçenekleri değerlendirilmiştir.

Elde edilen bulgular, ahşap esaslı kompozitlerin hafif olmaları, yüksek mukavemet/ağırlık oranına sahip olmaları ve boyutsal kararlılık göstermeleri gibi önemli avantajlar sunduğunu ortaya koymaktadır. Ancak, neme duyarlılık, biyolojik bozunma riski ve yapıştırıcı kaynaklı emisyonlar bu malzemelerin sınırlayıcı yönleri arasında yer almaktadır. Bu nedenle, uygun malzeme seçimi, doğru tasarım kararları ve düşük emisyonlu üretim yaklaşımlarının benimsenmesi büyük önem taşımaktadır.

Sonuç olarak, ahşap esaslı kompozit malzemeler yaşam döngüsü perspektifi ile birlikte değerlendirildiğinde, sürdürülebilir yapı tasarımında hem teknik hem de çevresel açıdan güçlü bir alternatif sunmaktadır. Bu çalışma, söz konusu malzemelerin performans ve çevresel etkilerinin birlikte ele alınmasının önemini ortaya koymaktadır.

Anahtar Kelimeler: Sürdürülebilir mimarlık, ahşap esaslı kompozit malzemeler, yaşam döngüsü değerlendirmesi (LCA), çevresel etki, karbon depolama

ANALYSIS OF BAROQUE PERIOD FURNITURE FROM A BIOMIMICRY PERSPECTIVE: A RETROSPECTIVE EVALUATION IN THE CONTEXT OF FORM, STRUCTURE, AND SYSTEM

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ABSTRACT

Biomimicry is a contemporary approach based on transferring the forms, processes, and systems found in nature into the field of design. The concept of inspiration from nature, however, has historically been utilized in various forms across many disciplines long before the formal definition of biomimicry. In this context, Baroque period furniture stands out with its fluid forms and nature-based ornamentation, offering distinctive examples of the aesthetic relationship established with nature. However, during this period, the concept of biomimicry had not yet been defined, and nature-based design was developed largely within an intuitive and aesthetic framework. The aim of this study is to retrospectively examine Baroque period furniture from a biomimicry perspective. The research was conducted using a qualitative methodology; different furniture examples were evaluated through literature review and visual analysis techniques. In this study, biomimicry is not treated as a rigid classification system, but rather as an analytical evaluation framework. Accordingly, the analysis was carried out within three main dimensions: form, process, and system. In the dimension of form, elements such as curved lines, cabriole legs, and plant-based ornamentations were evaluated in terms of their similarity to organic structures found in nature. In the process dimension, the sense of fluidity, continuity, and development observed in the formation of these forms was associated with natural growth and morphogenetic processes. In the system dimension, the harmony among furniture components, repetition of motifs, and the holistic design language were interpreted within the context of order and organizational principles observed in nature. The findings indicate that nature-inspired design in Baroque furniture is particularly evident at the formal level; however, analogical similarities can also be established at the levels of process and system. Furthermore, it is understood that this design approach has the potential to be reinterpreted within the framework of contemporary biomimicry. This suggests that Baroque furniture can be considered an early and intuitive expression of nature-based design. In conclusion, this study demonstrates that historical design practices can be reinterpreted through a biomimicry perspective and highlights the continuity of nature-based design thinking. It is expected that this approach will provide a conceptual contribution to contemporary design research.

Keywords: Biomimicry, Baroque Furniture, Form–Process–System, Retrospective Analysis, Nature-Based Design

TWO INTERPRETATIONS OF MODERN ARCHITECTURAL THOUGHT: A COMPARATİİVE ANALYSIS OF LE CORBUSIER AND TURGUT CANSEVER

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ABSTRACT

A review of architectural history suggests that architects have shaped the discipline not only through their built works but also through the theoretical positions and intellectual frameworks they have articulated. In this regard, a comparative examination of architects who represent different orientations within modern architecture offers an important basis for understanding the diversification of architectural thought.

This study aims to analyze the architectural thought of two significant figures of modern architecture, Le Corbusier and Turgut Cansever, from a comparative perspective. Rather than focusing solely on their architectural projects, the research examines their writings, interviews, and intellectual productions in order to reveal the theoretical foundations of their architectural approaches. Accordingly, the cultural, philosophical, and intellectual contexts underlying their architectural thinking are critically evaluated.

The findings indicate that Le Corbusier developed an approach representing the rational, systematic, and industrial orientation of modern architecture, whereas Cansever articulated a distinctive architectural perspective that relates architecture to cultural, ethical, and spiritual values. This comparison demonstrates how architectural thought evolves differently within diverse cultural and ideological contexts and provides an interdisciplinary perspective for architectural theory.

Within this framework, the study also discusses how the meanings attributed to the concept of modernity by these two architects are shaped by different social and cultural contexts. While Le Corbusier's approach emphasizes universality, standardization, and function-based design principles, Cansever's architectural thinking foregrounds locality, tradition, and cultural continuity.

Consequently, the research suggests that modern architecture should not be understood as a singular and homogeneous discourse; rather, it constitutes a plural field of thought that is reinterpreted through different worldviews and geographical contexts.

Keywords: Le Corbusier, Turgut Cansever, Architectural thought, Architectural theory, Modern architecture.

A THEORETICAL EVALUATION OF THE ARCHITECT'S IDENTITY AND ROLE: THE HISTORICAL AND PHILOSOPHICAL BACKGROUND OF ARCHITECTURAL THOUGHT

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ABSTRACT

Historically, the discipline of architecture has been understood not merely as a technical and artistic activity aimed at the production of physical space, but also as a cultural field of production closely related to the intellectual world of human beings. In this respect, the identity, role, and modes of production of the architect constitute one of the central debates within architectural theory. Throughout history, the concept of the architect has acquired different meanings in different periods; the social role, intellectual position, and design practices of architects have been redefined in accordance with changing cultural and ideological contexts.

This study aims to examine the historical and philosophical background of the concept of the architect and to discuss the architect's position within the process of architectural production. Within this framework, it is argued that the architect should not be considered solely as a designer possessing technical knowledge, but also as a cultural and intellectual subject engaged in the production of meaning. Accordingly, theoretical approaches within architectural history and the development of architectural thought are analyzed in order to reveal how the identity of the architect has been shaped within broader social and cultural contexts.

The findings of the research suggest that the architect cannot be confined to the role of a professional actor engaged merely in the production of buildings. Rather, the architect should be regarded as an intellectual figure who generates ideas and contributes to shaping the social world of meaning. From this perspective, architectural production can be interpreted as a process of meaning-making emerging from the interaction between the architect's individual intellectual framework and the historical and cultural conditions in which they operate.

Keywords: Architectural theory, architect identity, architectural thought, architectural history.

EARLY INSTABILITY DURING CONSERVATIVE MANAGEMENT OF A REDUCED TYPE II ODONTOID FRACTURE: A CASE

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İbrahim Başar

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ABSTRACT

Objective: To demonstrate the risk of early displacement during conservative management of reduced Type II odontoid fractures without neurological deficit and to emphasize the importance of close clinical and radiological follow-up.

Methods: A 51-year-old female patient presented with neck pain and tenderness following a motor vehicle accident. Neurological examination revealed no deficit. Initial cervical CT demonstrated a reduced Type II odontoid fracture with a distinct fracture line on the left side, while cortical continuity was preserved on the right side. The patient was treated conservatively with a cervical collar. One week later, the fracture line was reassessed using follow-up cervical CT imaging.

Results: Follow-up CT revealed significant displacement at the odontoid fracture site. In addition, progression of the fracture and separation were observed on the right side, where cortical continuity had initially been preserved. No neurological deficit developed during the follow-up period.

Conclusions / Implications: Although conservative treatment may be considered in reduced Type II odontoid fractures without neurological deficit, these injuries may demonstrate unstable behavior and early displacement. Therefore, close clinical and radiological follow-up is mandatory, and surgical stabilization should not be delayed when indicated.

Keywords: Odontoid fracture, Type II odontoid fracture, Conservative treatment, Cervical collar, Fracture displacement

CLINICAL AND PATHOLOGICAL CHARACTERISTICS OF SURGICALLY TREATED MENINGIOMAS

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ABSTRACT

Objective: The aim of this study was to evaluate the demographic characteristics, tumor localization, surgical resection grades, and histopathological WHO grades in patients diagnosed with meningioma. In addition, the distribution of tumor locations and the presence of peritumoral edema in cranial meningiomas were analyzed.

Methods: A total of 51 patients with meningioma who were treated surgically were included in the study. The age and sex distribution of the patients, cranial or spinal localization of the tumor, anatomical locations of cranial meningiomas, Simpson resection grades, WHO tumor grades, and the presence of peritumoral edema in cranial cases were evaluated retrospectively. The obtained data were analyzed using percentage distributions and mean values.

Results: Of the 51 cases, 40 were female (78.4%) and 11 were male (21.6%), with a mean age of 51.5 ± 15.9 years. Tumors were cranial in 47 patients (92.2%) and spinal in 4 patients (7.8%). According to the surgical resection grade, Simpson Grade I resection was achieved in 39.2%, Simpson Grade II in 56.9%, and Simpson Grade V in 3.9% of the cases. Histopathological evaluation revealed WHO Grade I in 80.4%, WHO Grade II in 13.7%, and WHO Grade III in 5.9% of the patients. The most common locations of cranial meningiomas were convexity (38.3%), sphenoid (19.1%), and parasagittal (12.8%) regions. Peritumoral edema was detected in 42.6% of the cranial cases.

Conclusions: The findings of this study demonstrate that meningiomas occur more frequently in women, consistent with the literature, and that the majority of cases are cranially located and low grade (WHO Grade I). Achieving a high rate of Simpson Grade I–II resections suggests that effective tumor control can be obtained with appropriate surgical technique.

Keywords: Meningioma, Simpson grading system, WHO grade , Surgical resection, Peritumoral edema

HYPERLIPIDEMIA AS A CAUSE OF RECURRENT ACUTE PANCREATITIS: A CASE REPORT

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ABSTRACT

Introduction: Acute pancreatitis is a clinical condition characterized by the activation of digestive enzymes that lead to autodigestion of pancreatic tissue. The disease may progress from a mild edematous form to hemorrhagic and severe necrotizing forms, resulting in local, regional, and systemic manifestations and complications. The most common etiological factors are biliary tract stones and alcohol consumption. Hypertriglyceridemia accounts for approximately 1.3–3.8% of acute pancreatitis attacks. In this study, we present a case of recurrent acute pancreatitis secondary to hyperlipidemia.

Case: A 40-year-old female patient presented to our emergency department with complaints of abdominal pain radiating to the back, nausea, and vomiting. The patient had a history of hypertriglyceridemia and was receiving fenofibrate therapy. She had previously experienced four episodes of acute pancreatitis. There was no history of alcohol consumption or gallstones. On physical examination, the patient's general condition was moderate and she was conscious and cooperative. There was diffuse tenderness on palpation in the epigastric region. Vital signs were as follows: blood pressure 100/80 mmHg, pulse 112 beats/min, body temperature 37.2°C, and respiratory rate 20 breaths/min. Laboratory findings were as follows: white blood cell count 13,000/mm³, hemoglobin (Hb) 13.2 g/dL, hematocrit (Hct) 39.4%, platelet count 354,000/mm³, glucose 110 mg/dL, urea 24 mg/dL, creatinine 1.1 mg/dL, amylase 881 U/L, lipase 412 U/L, triglyceride 784 mg/dL, and lactate dehydrogenase (LDH) 245 U/L. Abdominal ultrasonography revealed enlargement of the pancreatic body and mild-to-moderate peripancreatic fluid collection. Based on the clinical presentation, laboratory findings, and radiological examination, the patient was diagnosed with acute pancreatitis. She was admitted to the internal medicine department for follow-up and treatment.

Conclusion: In patients with hyperlipidemia, triglyceride levels above 500 mg/dL increase the risk of acute pancreatitis. Hyperlipidemia should also be considered in the etiology of patients presenting to the emergency department with a history of recurrent acute pancreatitis.

Keywords: Recurrent pancreatitis, hyperlipidemia, lipase

SPORADIC HYPOKALEMIC PERIODIC PARALYSIS: A CASE REPORT

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ABSTRACT

Introduction: Hypokalemic periodic paralysis (HPP) is an autosomal dominant inherited disorder characterized by intermittent attacks of muscle weakness lasting from several hours to several days, occurring a few times per day or per year. HPP may also present as sporadic cases. During an attack, potassium shifts into muscle cells, resulting in decreased serum potassium levels; these levels return to normal after the attack resolves. In this study, we present a case of hypokalemic periodic paralysis that presented to the emergency department with an attack in the absence of any identifiable triggering factor.

Case: A 45-year-old female patient presented to our emergency department with complaints of weakness in the arms and legs that had persisted for the last two days. Over the previous four months, she had experienced three to four similar episodes occurring at intervals of 45–60 days, each lasting approximately four to five hours and predominantly affecting the lower extremities. The patient had no significant past medical history. On physical examination, her blood pressure was 120/80 mmHg, body temperature was 37.9°C, and pulse rate was 76 beats per minute with a regular rhythm. Muscle strength was graded as 3–4/5 in both upper extremities, 3/5 in the left lower extremity, and 2/5 in the right lower extremity. The remainder of the physical examination findings were normal. Laboratory investigations revealed the following values: hemoglobin (Hb) 14.2 g/L, hematocrit (Hct) 43.5%, platelet count 254,000/mm³, white blood cell count 9,500/mm³, urea 45 mg/dL, creatinine 0.96 mg/dL, sodium (Na) 138 mEq/L, potassium (K) 1.8 mEq/L, and chloride (Cl) 118 mEq/L. Potassium replacement therapy was initiated in the emergency department. Following treatment, the patient's potassium level returned to normal limits, and her neurological symptoms completely resolved compared to baseline. After being informed about her condition, she was discharged.

Conclusion: In patients presenting to the emergency department with intermittent muscle weakness, serum potassium levels should be evaluated along with a thorough medical history, and hypokalemic periodic paralysis should be considered in the differential diagnosis.

Keywords: Hypokalemia, periodic paralysis

EVALUATION OF THE EFFECTIVENESS OF THE OCULAR TRAUMA SCORE IN PATIENTS WITH OPEN GLOBE INJURIES

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ABSTRACT

Purpose: This study aimed to evaluate the effectiveness of the Ocular Trauma Score (OTS) in predicting visual outcomes for patients with open globe injuries

Methods: We retrospectively reviewed the medical records of 157 patients treated at the Dicle University Faculty of Medicine Ophthalmology Clinic between April 2017 and May 2019. Data on age, gender, trauma etiology, injury zone, and best corrected visual acuity (BCVA) were analyzed. Initial OTS points were calculated, and the final visual acuity at 6 months post-injury was compared with the OTS-predicted outcomes

Results: Of the 157 patients included in the study, 107 (68.1%) were male and 50 (31.9%) were female. The average age of the patients was 22.7 years. Glass (15.2%) and metal (14.6%) were the primary causes of injury. Most injuries (52.2%) were localized to Zone 1. Comparing final visual acuity to OTS predictions revealed significant differences in Category 1 for light perception and hand motion (HM), and in Category 2 for the 1/200–20/200 and ≥ 20/40 ranges ($p < 0.0001$, $p = 0.031$, $p = 0.0009$, respectively). No significant differences were observed in other categories ($p > 0.05$).

Conclusion: The OTS demonstrated high predictive accuracy, particularly in Categories 3, 4, and 5. However, its predictive value was lower in Categories 1 and 2. For these categories, incorporating additional factors such as age, surgical timing, and lens status may improve prognostic precision**.**

Keywords: Ocular trauma, open globe injury, Ocular Trauma Score

THE EFFECTIVENESS OF PUPILLOMETRY IN DETECTING AUTONOMIC DYSFUNCTION IN OBESE PEDIATRIC PATIENTS

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ABSTRACT

Introduction and Aim: We aimed to evaluate autonomic function in obese children without any systemic diseases that could cause autonomic dysfunction by comparing static and dynamic pupillary responses with those of healthy children.

Method: The study included obese pediatric patients without any pathology detected on ophthalmological examination and without systemic diseases that could cause autonomic dysfunction, such as diabetes mellitus, as well as healthy children of similar age and gender. Static and dynamic pupillary responses were measured using an automated pupillometer. Static pupillometry measurements recorded scotopic, mesopic, low photopic, and high photopic pupil diameters. Dynamic pupillometry measurements recorded resting pupil diameter, pupil contraction amplitude, pupil contraction latency, pupil contraction duration, pupil contraction velocity, pupil dilation latency, pupil dilation duration, and pupil dilation velocity.

Results: The study included 28 obese pediatric patients and 30 healthy controls. The groups were similar in terms of age and gender. In the obese group, scotopic pupil diameter and mesopic pupil diameter, which are static pupil responses, were significantly higher compared to the control group ($p=0.002$ and $p=0.003$, respectively). There was no statistically significant difference between the obese and control groups in pupil diameters in low-photopic and high-photopic environments. While pupil dilation velocity, one of the dynamic pupillometry measurements, was statistically significantly increased in the obese group ($p=0.037$), there was no significant difference in other dynamic pupillometry measurements.

Discussion and Conclusion: In obese pediatric patients, static pupillary responses, specifically scotopic pupil diameter and mesopic pupil diameter, were significantly higher compared to the control group, while dynamic pupillometry measurements showed a statistically significant increase in pupil dilation rate. These results suggest that obesity can affect the autonomic nervous system from an early age, even without any accompanying systemic disease.

Keywords: Obesity, pediatric, static pupillometry, dynamic pupillometry

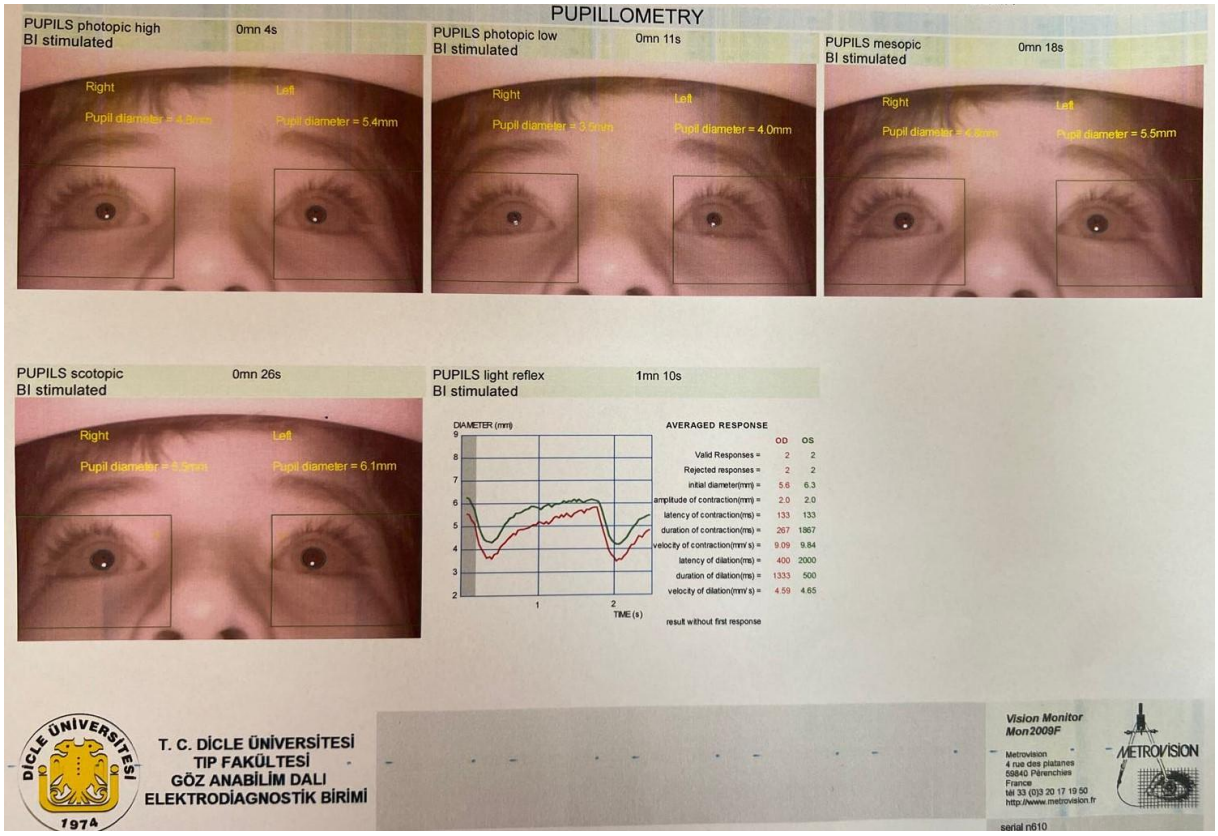

Figure: Pupillometry image of a 11-year-old male patient taken at the Ophthalmology Clinic of Dicle University Faculty of Medicine.

MICELLAR FLOCCULATION: A BIODEGRADABLE METHOD FOR EFFECTIVE DRUG REMOVAL FROM WASTEWATER

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ABSTRACT

This research work addresses removal of Levefloxacin hemihydrate from synthetic waste water employing a biodegrabale method. Micellar enhanced flocculation technique has been applied under optimized conditions for the said purpose. The mixture of anionic surfactants, obtained from a bio-degradable source (base soap), has been found to have great potential to solubilize drug molecules. The polyvalent salts are able to flocculate the micelles and help in their subsequent removal. The removal of drug was analyzed using UV/Visible spectrophotometer. Different factors such as the effect of change in concentration, pH, temperature, contact time, and electrolyte were studied to evaluate the adsorption characteristics and removal efficiency of the process. The data obtained was further used to study the mechanism of adsorption with the help of various models e.g., Langmuir, Freundlich, Temkin, and Dubinin–Radushkevich (D-R). The kinetic parameters were also calculated by employing pseudo-1st and pseudo-2nd order kinetic models. Furthermore, thermodynamic calculations were performed to determine the change in Gibb's free energy (ΔG^o), enthalpy (ΔH^o), and entropy (ΔS^o). The results make it evident that the micellar flocculation-based adsorptive removal is an excellent and sustainable approach for the treatment of wastewater.

Keywords: Surfactants, micellization, flocculation, adsorption, isotherm, Kinetics, thermodynamics

RISK MANAGEMENT BEHAVIORS AND PRODUCTION PERFORMANCE UNDER UNCERTAINTY: EVIDENCE FROM INTENSIVE WHITELEG SHRIMP FARMING IN THE MEKONG DELTA, VIETNAM

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ABSTRACT

Intensive whiteleg shrimp farming has become one of the most important aquaculture production systems in Vietnam, particularly in the Mekong Delta. However, this farming system is increasingly exposed to multiple sources of uncertainty, including disease outbreaks, environmental fluctuations, rising input costs, and unstable market conditions. Under such circumstances, farmers make production decisions that can be interpreted as farm-level risk management behaviors.

This study examines the relationship between risk management behaviors and production performance among intensive whiteleg shrimp farming households in the Mekong Delta, Vietnam. The analysis is based on a panel dataset of 360 farming households observed over two consecutive production crops, generating 720 household-crop observations. The dataset contains information on production inputs, outputs, financial outcomes, and the adoption of key farm-level risk management practices.

Eight risk management practices are considered, including pond lining, pond size management, production system configuration, stocking density control, adoption of recommended farming protocols, pond bottom sludge removal, and the use of chemical treatments for environmental management. The study employs descriptive statistical analysis and group comparison methods to identify differences in production structure and economic outcomes between households that adopt and those that do not adopt specific practices.

Preliminary evidence indicates that risk management behaviors are not adopted uniformly across households, production crops, or localities. Instead, they reflect differences in managerial orientation and farm-level adaptation strategies. This study contributes by reframing technical measures in shrimp farming as behavioral manifestations of farm-level risk management under uncertainty.

Keywords: risk management behavior; production performance; intensive whiteleg shrimp farming; Mekong Delta; Vietnam.

SYNTHESIS AND CHARACTERIZATION OF LANTHANUM DOPED NICKEL COBALT FERRITES FOR ELECTROCATALYSIS

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ABSTRACT

Electrocatalysis has emerged as an essential approach for efficient energy conversion in the transition toward sustainable energy sources, particularly in processes such as water splitting that generate clean hydrogen fuel. Owing to their excellent electrical conductivity, magnetic behavior, and chemical stability, spinel ferrites, especially nickel cobalt ferrite, have gained considerable attention. The objective of this work is to synthesize lanthanum-doped nickel cobalt ferrite nanoparticles by the co-precipitation method, an inexpensive and simple way that enables precise control over particle characteristics to enhance catalytic activity. The synthesized nanoparticles will be characterized using X-ray diffraction (XRD) to analyze crystal phases and structural modifications, scanning electron microscopy (SEM) to observe morphology and particle size, Fourier-transform infrared spectroscopy (FTIR) to identify chemical bonding and functional groups, and UV–visible spectroscopy to study optical properties. To check the catalytic activity of synthesized material by Cyclic Voltammetry (CV), Linear Sweep Voltammetry (LSV) and Electrochemical Impedance Spectroscopy (EIS). Together, these techniques will provide comprehensive insight into how lanthanum doping influences the physical and electronic structures of nickel cobalt ferrite. The electrocatalytic performance of the synthesized materials for hydrogen and oxygen evolution reactions, key steps in water splitting, will be investigated. It is anticipated that lanthanum incorporation will enhance reaction kinetics and long-term stability by facilitating electron transfer and increasing the density of active catalytic sites. This study aims to develop a cost-effective and efficient ferrite-based electrocatalyst that can contribute to advancing renewable hydrogen production and promoting sustainable energy technologies.

Keywords: Water splitting, coprecipitation, electrocatalysis, renewable energy resources

PRODUCTION AND CHARACTERIZATION OF CARBON NANOTUBES FROM BIOCHAR UNDER MICROWAVE IRRADIATION.

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ABSTRACT

Carbon nanotubes (CNTs) are widely used in a variety of fields to produce a diversity of products, including hydrogen storage systems, and field emitters. In the proposed study, CNTs synthesized via biochar under the microwave irradiation method. In this method, the combination of charcoal and ferrocene are used to synthesize CNTs from the biochar approach. Biochar samples for CNTs synthesis are made from pyrolyzed agro-industrial waste such as rapeseed cake, hazelnut hulls, wheat straw, and oat hulls at different temperatures. The biochar was produced from agro-industrial biomass. During experiments, 100g of biomass was placed in a microwave reactor. The samples were pyrolyzed at 400 °C to 600°C. SEM analysis was used to confirm the morphology of CNTs. SEM micrographs revealed the perfect structure of multiwall carbon nanotubes, while interlayers spacing was changed due to variation of catalysts and measured about 0.34nm. Further, the optical properties were examined by UV-visible spectroscopy. In the UV, one band is clear at 240 nm region due to resonance of nanotubes pi(π) electrons of carbon nanotubes. XRD was used to analyze the glassy structure of prepared CNTs under microwave revealed that the creation and growth of CNTs were mostly influenced by microwave irradiation and the ferrocene catalyst. The structure of CNTs was developed under microwave heating and in the presence of ferrocene catalyst. To research how nitrogen impurities adhere to CNTs, FTIR experiments were conducted in the 400–4000 cm^{-1} range. The sample's FTIR spectra exhibit prominent peaks that correspond to C-H and C=C, respectively.

SYSTEMATIC LITERATURE REVIEW ON PHISHING ATTACK: TYPES, CLASSIFICATION TECHNIQUES, METHODOLOGY USED AND RESEARCH DIRECTIONS

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ABSTRACT

Phishing attacks have significantly transformed the cyber security landscape, presenting both new challenges and opportunities for attackers and defenders alike. This systematic literature review explores the multifaceted role of phishing attacks, focusing on their methods, exploitation techniques, detection mechanisms, forensic analysis, threat intelligence, defensive strategies, and future research directions. Employing the PRISMA-ScR methodology, the study analyzes relevant literature from 2018 to 2025. Findings reveal that phishing techniques are increasingly sophisticated, involving automated reconnaissance, targeted social engineering, and advanced evasion tactics, while defensive strategies are evolving through intelligent detection systems capable of rapid identification and mitigation. Key challenges include ethical considerations, user susceptibility, privacy concerns, and the risks posed by highly automated and AI-enhanced phishing campaigns. The review underscores the importance of developing robust phishing detection tools, comprehensive forensic methods, and user-centric awareness programs to counteract these evolving threats. It concludes by recommending strategic investments in advanced anti-phishing technologies, improved cyber security policies, and international cooperation to effectively address the growing risks associated with phishing attacks

Keywords: phishing attacks, phishing classifications, phishing techniques, detection techniques.

ENHANCING DEEP LEARNING OF QUESTIONNAIRE CONSTRUCTION THROUGH THE FLIPPED CLASSROOM

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ABSTRACT

In healthcare education, mastering data collection tools like questionnaires is essential for future research and clinical practice. However, traditional expository methods often result in a superficial understanding of instrument design. This work describes a flipped-classroom-based pedagogical framework for a healthcare statistics course aimed at fostering critical thinking, collaborative skills, and a deep understanding of data collection tools, particularly questionnaires.

The flipped classroom approach is adaptable to different institutional contexts and levels, but its effectiveness will depend on thoughtful selection of pre-class materials, clear guidance for in-class activities, and constructive feedback on post-class assignments.

The intervention is structured into three phases. In the *pre-class* phase, students engage with theoretical materials (text and videos) via Moodle, followed by a diagnostic quiz to identify learning gaps. The *in-class* session prioritizes active learning through collaborative group work: first, a critical analysis of an existing questionnaire; second, the development of an original survey instrument where students must justify their choice of questions and response scales. The instructor acts as a facilitator throughout. The in-class phase activities selection is consistent with evidence that flipped classrooms achieve their greatest impact when face-to-face time is used for interactive problem-solving rather than repetition of pre-class content. Finally, in the *post-class* phase, students individually refine their instruments based on peer and instructor feedback.

Potential challenges include managing group dynamics, and providing sufficient support for students who are less familiar with self-directed learning. Nonetheless, the literature suggests that with careful planning and alignment, flipped classrooms can provide a powerful platform for integrating methodological rigor and higher-order skills.

By confronting the practical difficulties of questionnaire design in a guided environment, students are expected to bridge the gap between theory and application. The strategy aims to enhance the students' ability to create scientifically sound instruments while stimulating the critical judgment necessary for evidence-based practice.

The flipped classroom approach provides a dynamic framework for teaching Statistics, promoting autonomous learning and a more sophisticated grasp of data collection procedures.

Keywords: Active Learning, Flipped Classroom, Questionnaire Design, Statistics Education.

THE CROSS STITCH EMBROIDERY E-LEARNING COURSE

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ABSTRACT

An undeniable trend in the modern education is computerization and digitalization, which represents a universal desire to integrate various electronic tools used in the educational process. One such tool is the electronic learning course.

An electronic learning course is interactive educational materials in electronic format. It contains teaching materials aimed at organizing and supporting the educational process through the didactic capabilities of information and communication technologies.

The goal of an electronic learning course is to improve the quality and effectiveness of educational activities through the use of didactic tools of information and communication technologies, as well as to enhance the quality of students' self-education.

The advantages of an electronic learning course are:

- courses are available at convenient time;

- multimedia;

- mobility;

- the ability to create an individual educational trajectory for each student.

The structure of an electronic learning course includes:

1. An information and content block aimed at providing students with structured educational material.

2. A control and communication block aimed at assessing students' knowledge and promoting interaction among participants in the educational process.

3. A correction and generalization block aimed at adjusting the educational process, structuring knowledge, addressing problem areas, and analyzing learning outcomes.

The main functions of the e-learning course are reference, information, training, control, simulation, modeling, visual demonstration, management, stimulation, optimization, and communication.

The purpose of the original e-learning course "Cross Stitch Embroidery" is to create conditions for students to master cross-stitch techniques (single cross stitch, double cross stitch, straight cross stitch, star cross stitch, Bulgarian cross stitch, half cross stitch, and fractional cross stitch).

The objectives of the original e-learning course "Cross Stitch Embroidery" are:

- Educational: to promote students' knowledge of the history of embroidery, tools and materials for embroidery, workspace organization, the stages of working with embroidery patterns, and finishing the finished embroidered piece.
- Developmental: to foster the development of memory, imagination, creative and critical thinking, and motor skills.
- Nurturing: to foster aesthetic taste, accuracy, diligence, patience, and responsibility.

The original e-learning course "Cross Stitch Embroidery" includes 9 modules:

1. "History of Embroidery. Cross Stitch Basics."

2. "Single Cross Stitch."

3. "Double-Sided Cross Stitch."

4. "Straight Cross Stitch."

5. "Star Cross Stitch."

6. "Bulgarian Cross Stitch."

7. "Half Cross Stitch."

8. "Cross Stitch Embroidery."

9. "Using Cross Stitch in a Creative Project."

The use of the original e-learning course "Cross Stitch Embroidery" will increase students' motivation to master cross stitch techniques.

Key words: the computerization, digitalization, the electronic course, content-based, Cross Stitch.

YOUNG ENTREPRENEUR, THINK ABOUT EXPERIENCE BEFORE PRACTICE.

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ABSTRACT

Every university student wants to have their own business, wants to create their own business as soon as they obtain their university degree.

The student's business is shaped by her own research at the university, in the research laboratory, and by her engagement with various societal issues. While creating a business is certainly a valuable theoretical concept, gaining practical professional experience is crucial for achieving the business's objective.

A student or aspiring young entrepreneur should understand that starting a business is not simply the realization of their idea. While the recent graduate's idea may be found in their thesis or research, the business idea itself is rooted in the scientific, administrative, and legal environment. A business is purely an economic and legal entity; it is not merely an idea. The idea resides in the university, but the business exists within the broader context.

A recent graduate or student should first consider acquiring valuable experience in all areas, because running a business begins with mastering the professional environment, not just academics.

Understanding the principles and definition of the professional environment is essential for a young student.

The ultimate goal of starting a business for a young entrepreneur is to achieve their dream of success, but this success will not materialize without experience and mastery of the business.

Therefore, initially, while still at university, a student must consider how to gain experience to begin understanding the concept of mastering their idea. Experience in all aspects and mastery are essential for success.

Ultimately, the goal is to gain experience to practice mastery in order to validate the creation of their business or the achievement of their objective.

Keywords: young student, young entrepreneur, company, experience, mastery.

BRIDGING THE THEORY-PRACTICE GAP: THE EFFICACY OF CLINICAL SIMULATION IN POST-SECONDARY NURSING EDUCATION

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ABSTRACT

In the specialized field of post-secondary nursing education, the transition from classroom theory to clinical practice represents a significant emotional and professional threshold. While traditional pedagogical methods focus on the acquisition of technical knowledge, the psychological and cognitive preparedness of the student at the bedside remains an area requiring deeper investigation. This study adopts a qualitative research design to explore how clinical simulation influences the perception of professional competence and clinical readiness among nursing students.

The theoretical framework is grounded in Phenomenology and Reflective Practice, aiming to capture the "lived experience" of students during high-fidelity simulation encounters. The research methodology involved a series of semi-structured interviews and focus-group discussions with second-year students from a post-secondary sanitary program. Participants were encouraged to reflect on their experiences during simulated scenarios involving critical patient care, such as acute cardiac events and post-operative complications. The qualitative data were analyzed using Thematic Analysis, allowing for the emergence of recurring patterns related to clinical anxiety, decision-making confidence, and the internalization of the nursing role.

The findings highlight three primary thematic pillars: first, the role of simulation in transforming "abstract fear" into "managed professional awareness"; second, the critical importance of the debriefing phase as a safe space for the deconstruction of errors and the construction of professional identity; and third, the shift from mechanical task performance to holistic patient care. Participants consistently reported that the simulated environment allowed them to "feel like a nurse" before entering the hospital ward, thereby reducing the reality shock associated with clinical rotations.

The study concludes that qualitative insights into student experiences are vital for refining nursing curricula. Beyond mere technical proficiency, simulation-based pedagogy serves as a profound developmental tool that fosters resilience and ethical sensitivity. The research suggests that post-secondary sanitary institutions should prioritize the integration of reflective, qualitative feedback loops within their instructional design to better prepare graduates for the human and emotional complexities of the healthcare profession.

Keywords: Clinical Simulation, Professional Identity, Thematic Analysis, Reflective Practice, Clinical Judgment

THE DIGITAL VEIL: A QUALITATIVE INVESTIGATION INTO THE ETHICAL AND PROCEDURAL CHALLENGES OF ELECTRONIC EVIDENCE IN MODERN LITIGATION

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ABSTRACT

The rapid proliferation of encrypted communication and cloud-based data storage has fundamentally altered the landscape of modern judicial proceedings. As traditional physical evidence is increasingly replaced or augmented by digital artifacts, legal practitioners face unprecedented challenges in maintaining the integrity of the chain of custody while balancing the fundamental right to privacy. This research adopts a strict qualitative methodology to explore the subjective experiences and professional dilemmas of legal assistants and forensic investigators operating within the contemporary judicial framework.

The study is grounded in a Constructivist Grounded Theory approach, aiming to understand how legal professionals navigate the "gray zones" of digital discovery and electronic surveillance. Data collection was conducted through in-depth, semi-structured interviews with senior judicial clerks and specialized legal investigators. The research focused on the cognitive and ethical processes involved when handling metadata, social media footprints, and encrypted logs as primary evidence in both civil and criminal litigation.

The findings, derived through Thematic Analysis, reveal three critical professional tensions. First, the "Authenticity Crisis": participants expressed deep-seated concerns regarding the malleability of digital data and the increasing difficulty of verifying the "unaltered state" of evidence in an era of deepfakes and advanced cyber-manipulation. Second, the "Intrusion Paradox": a recurring theme highlighting the struggle to define the boundaries of "reasonable expectation of privacy" when dealing with cross-border data seizures and private digital spheres. Third, the "Translation Gap": the qualitative data underscores a significant disconnect between the technical complexity of digital forensics and the ability of the court to interpret these findings without bias or over-simplification.

The research concludes that the legal system is currently undergoing a "paradigm shift" where procedural law is often outpaced by technological capabilities. The study suggests that the future of judicial administration depends not just on technical tools, but on the development of a robust, human-centered ethical framework that can interpret digital footprints through the lens of fundamental human rights. By documenting these professional anxieties and strategies, this paper provides a nuanced understanding of the hidden complexities behind the "digital veil" of modern evidence.

Keywords: Cyber-Forensics, Chain of Custody, Electronic Discovery, Privacy Rights, Metadata

THE HUMAN FACTOR IN HIGH-STAKES TRIAGE: A QUALITATIVE EXPLORATION OF DECISION-MAKING UNDER CRITICAL TIME CONSTRAINTS

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ABSTRACT

In the hyper-dynamic environment of Emergency Departments, the process of clinical triage constitutes the most critical juncture for patient outcomes and institutional efficiency. As modern emergency medicine increasingly integrates algorithmic scoring systems and digital monitoring, the subjective experience of the practitioner navigating these "golden moments" of decision-making remains a vital area of study. This research utilizes a qualitative, descriptive design to investigate the cognitive and emotional processes of emergency medical personnel when faced with complex, multi-victim scenarios or ambiguous clinical presentations.

The study is framed within the Naturalistic Decision-Making theory, seeking to understand how experts use situational cues and pattern recognition rather than linear protocols. Data collection was performed through in-depth, semi-structured interviews and critical incident technique sessions with experienced paramedics and emergency room specialists. The focus was on the "lived experience" of triage—specifically the moments where clinical intuition contradicts automated protocols or where resource scarcity forces profound ethical trade-offs. The narratives were analyzed using Thematic Analysis to identify the latent structures of professional judgment in high-stress environments.

The findings reveal three significant thematic clusters. First, the "Heuristic Leap": participants described a reliance on rapid, experience-based mental simulations that often bypass formal digital checklists in unstable clinical situations. Second, the "Shadow of Accountability": a recurring qualitative theme regarding the psychological burden of "exclusionary decisions" (deciding who is not a priority), which persists despite the presence of standardized triage scales. Third, the "Temporal Distortions": the data highlights how perceived time pressure alters the practitioner's ability to process non-verbal patient cues, potentially leading to a "tunnel vision" effect that favors physiological metrics over holistic assessment.

The research concludes that the resilience of emergency medical systems is fundamentally tied to the "adaptive expertise" of the human practitioner. The study suggests that future clinical protocols must account for these qualitative psychological dimensions, moving toward a model of Cognitive Ergonomics that supports, rather than dictates, the expert's judgment. By articulating these internal processes, the paper provides a crucial perspective on maintaining the "human-in-the-loop" during the digital transformation of emergency care.

Keywords: Emergency Medicine, Clinical Triage, Situational Awareness, Cognitive Ergonomics, Medical Ethics

EFFECTS OF THE NUMBERED HEADS TOGETHER (NHT) INSTRUCTIONAL STRATEGY ON THE INTEREST AND ACADEMIC ACHIEVEMENT OF SENIOR SECONDARY SCHOOL II (SS II) STUDENTS IN GEOGRAPHY IN MANGU, PLATEAU STATE, NIGERIA

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ABSTRACT

This study investigated the effects of the Numbered Heads Together (NHT) instructional strategy on the interest of Senior Secondary School II (SS II) students towards Geography in Mangu Local Government Area of Plateau State, Nigeria. Three objectives were achieved by answering three corresponding research questions and testing three corresponding hypotheses. A quasi-experimental pre-test, post-test non-equivalent control group design was adopted for the study. Data were collected sample of 111 students from the two randomly selected secondary schools were used for the study using a Geography Interest Questionnaire (GIQ). The instrument was validated by experts, and the reliability was established using appropriate Cronbach Alpha with a coefficient of 7.91. Data were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA) at 0.05 level of significance. The findings revealed that students taught Geography using the Numbered Heads Together strategy recorded significantly higher mean scores in the post-test interest than those taught using the conventional teaching method. Gender had no significant influence on students' interest towards Geography. The interaction effect of treatment and gender on interest was not significant, indicating that the effectiveness of the Numbered Heads Together strategy is not gender-dependent. The study concluded that the Numbered Heads Together instructional strategy is an effective, learner-centered approach for improving students' interest in Geography. It was therefore recommended that Geography teachers should adopt the strategy in classroom instruction and that educational stakeholders should organize training programs to enhance teachers' competence in cooperative learning strategies.

Key words: Numbered Heads Together (NHT) Strategy, Students' Interest, Gender Geography

BORDER MARGINALISATION AND SPATIAL PLANNING: UNLOCKING WEALTH POTENTIAL IN YEWA NORTH BORDER COMMUNITIES, OGUN STATE, NIGERIA

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ABSTRACT

Border studies and spatial planning increasingly conceptualise borderlands not as peripheral voids but as dynamic socio-economic spaces shaped by flows of people, goods, and governance practices. Nevertheless, in many developing contexts, these regions remain marginalised within formal planning systems. This paper examines the marginalisation of border communities through the lens of territorial governance and inclusive planning, focusing on border communities in Yewa North Local Government Area of Ogun State, Nigeria. Despite their strategic location along the Nigeria–Benin Republic corridor, these communities experience fragmented infrastructure, weak institutional presence, and a heavy reliance on informal cross-border trade. Adopting a qualitative, planning-oriented approach, the study analyses the interaction between informal economic networks, land-use dynamics, and governance gaps in shaping development outcomes. It demonstrates how the absence of coordinated spatial planning frameworks constrains the transformative potential of these settlements. The paper argues for the deliberate integration of border communities into national and regional planning agendas through strengthened cross-border cooperation, improved service delivery, and context-responsive policy design. Repositioning these areas as strategic growth nodes can enhance connectivity, stimulate local economies, and promote more balanced territorial development.

Keywords: Border studies, spatial planning, borderlands, territorial governance, cross-border development.

THE STUDY OF THE NATIONAL PAYMENT ECOSYSTEM IN INDONESIA: DIGITAL TRANSFORMATION AND FINANCIAL INCLUSION PERSPECTIVE

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ABSTRACT

The rapid development of information and communication technology has significantly transformed financial transactions worldwide. Payment systems are evolving from traditional cash-based mechanisms toward electronic and digital platforms that offer greater efficiency, security, and accessibility. In Indonesia, the development of the national payment ecosystem has been strongly supported by regulatory frameworks and technological innovation led by Bank Indonesia. The implementation of the Quick Response Code Indonesian Standard (QRIS) has facilitated the adoption of digital payments and promoted financial inclusion, particularly among Micro, Small, and Medium Enterprises (MSMEs). This study aims to evaluate the structural configuration, stakeholder involvement, and the developmental dynamics of Indonesia's national payment ecosystem. A qualitative descriptive method is employed in this study, relying on a literature review of scholarly publications, regulatory frameworks, and industry reports. The findings reveal that multiple stakeholders are involved in the national payment ecosystem, such as regulators, banks, fintech firms, merchants, and consumers. Digital payment innovations, including e-wallets, mobile banking, and payment gateways, play a significant role in enhancing transaction efficiency, interoperability, and financial inclusion. The study concludes that strengthening collaboration among stakeholders, improving digital infrastructure, and enhancing financial literacy are critical factors in developing a sustainable and inclusive national payment ecosystem.

Keywords: Digital transformation, Financial inclusion, MSMEs, National payment ecosystem, QRIS

THE EFFECTS OF THE PERSIAN GULF CONFLICT ON GLOBAL SUPPLY CHAINS: THE IMPORTANCE OF FLEXIBILITY AND ADAPTABILITY

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Abstract

The Persian Gulf region remains a pivotal hub in the global energy market, and conflicts in this area continue to expose vulnerabilities within international supply chains. This study investigates the effects of the Persian Gulf conflict on global supply chains, focusing on disruptions in oil and gas supply, shipping routes, and interconnected industries. Geopolitical tensions can trigger sudden fluctuations in energy prices, delays in transportation, and interruptions in production, generating widespread ripple effects across global markets.

While such disruptions present substantial challenges, they also underscore the critical importance of supply chain resilience. Flexibility and adaptability are essential strategic responses for organizations navigating uncertain geopolitical landscapes. Approaches such as supplier diversification, alternative logistics pathways, adaptive inventory management, and real-time risk monitoring enable companies to anticipate and respond effectively to sudden shocks.

This research integrates both quantitative and qualitative methods, analyzing historical data on energy price volatility, trade flow disruptions, and shipping delays, alongside case studies of firms that have successfully maintained operational continuity during regional conflicts. Findings indicate that organizations emphasizing operational flexibility and adaptive capacity are better positioned to minimize losses and sustain global operations amid uncertainty.

In conclusion, the Persian Gulf conflict exemplifies the dual nature of geopolitical disruptions: while posing significant risks to global supply chains, they also drive innovation in supply chain management. By prioritizing flexibility and adaptability, organizations can not only mitigate the adverse effects of instability but also enhance competitive advantage in an increasingly volatile global market. These insights are valuable for policymakers, industry leaders, and researchers seeking to strengthen supply chain resilience in the context of geopolitical risk.

Keywords: Persian Gulf conflict; Global supply chains; Supply chain resilience; Flexibility; Adaptability; Geopolitical risk

SMART CITY DEVELOPMENT IN INDONESIA: OPPORTUNITIES AND CHALLENGES

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ABSTRACT

The Smart City concept has become a global trend aimed at improving citizens' quality of life and increasing the efficiency of urban management. A Smart City represents the integration of digital technologies to optimize the delivery and efficiency of urban services. While many cities in Indonesia can develop smart cities, they still face various challenges. This study examines the opportunities and challenges of Smart City development in Indonesia. This study explores the opportunities and challenges of Smart City development in Indonesia. This research is a descriptive study with a qualitative approach. Data were collected through a literature review and interviews with experts in the field of Smart City. The results show that the opportunities for implementing Smart City in Indonesia include improving urban management efficiency, enhancing the quality of life, and increasing cities' competitiveness. However, several challenges remain, including limited technological infrastructure, a shortage of skilled human resources, and weak coordination among government agencies. This study is expected to contribute to Smart City development in many Indonesian cities by encouraging investment in technological infrastructure, strengthening human resource capacity, and improving coordination among government institutions.

Keywords: Challenges, Development, Indonesia, Opportunities, Smart City

FROM NIQLAWI TO MEDJOOL: RE-ENGINEERING THE HISTORICAL AND DIGITAL NARRATIVE OF DATES IN JORDAN AND THE ARAB WORLD

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ABSTRACT

This research aims to catalyze a paradigm shift in the Jordanian date sector by reclaiming the lost historical identity of the "Medjool" date and re-establishing its roots as the "Niqlawi Date." The project is grounded in a historical fact dating back to the 7th century AD, linking this unique variety to the Baptism Site (Al-Maghtas). It was the sacred sustenance for pilgrims, nourished by the region's distinctive fresh water springs.

The authenticity of this research lies in dismantling the traditional narrative of the Medjool as a "modern arrival" and proving its deep-seated roots in Jordanian heritage. Innovation is manifested in the creation of an integrated "Digital Storytelling" framework. By linking laboratory-verified quality (derived from spring water) with its historical saga via Smart Tracking (QR Codes), the fruit is transformed from a mere agricultural commodity into a "Civilizational Experience."

The project offers unconventional solutions to enhance value-added benefits, potentially increasing farmers' income by an estimated 30% while integrating the agricultural sector with religious tourism. To ensure sustainability, the project relies on strategic public-private partnerships, transforming the "Niqlawi" into a Geographically and Historically Protected Brand (GI Status), securing Jordan's global leadership in the agricultural knowledge economy.

The essence of this work is its status as the first agro-historical study to re-identify and re-authenticate the Medjool variety by its ancient name, "Niqlawi." The innovation lies in merging the "Sanctity of Place" and "Ancient History" with "Modern Digital Marketing Tools" to create a unique visual and informational identity that cannot be replicated globally.The "Niqlawi" project is not merely about palm cultivation; it is the reclamation of cultural and technical sovereignty, positioning Jordanian dates within the global "Ultra-Premium Heritage Products" category. We are not just documenting a crop; we are recovering intellectual and historical property lost through the centuries. By connecting the sanctity of the Baptism Site, 7th-century heritage, and the purity of Jordanian springs, we are not selling dates—we are offering the world a "Piece of History" wrapped in digital innovation.

The Proposed Concept: "The Living Digital Museum"

As a culmination of this research, the study proposes the establishment of a "Living Digital Museum" at the Baptism Site on the East Bank of the Jordan River. This will feature a Niqlawi/Medjool palm grove irrigated by the same historical springs. It will serve as a destination where tourists can savor the "Niqlawi Date" while experiencing its story through Augmented Reality (AR) technology.

Keywords: Agriculture, Date, Excavations, Archaeology, South Levant.

THE SKY REVEALS THE SECRETS OF THE EARTH IN THE ZARQA BADIA KITES AND STRUCTURES IN THE SOUTHERN LEVANT THAT MYSTIFY SCIENTISTS AND ATTRACT VISITORS

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ABSTRACT

Desert archaeological sites often suffer from documentation and study challenges due to vast areas, site isolation, and the difficulty of observing spatial patterns from ground level. Consequently, there is a pressing need for aerial imaging technologies as modern tools to study these sites and analyze their relationship with the surrounding environment.

The lenses and aerial photography techniques employed by the scientific research team at the Hashemite University which documented the architecture of the Jordanian Badia hold within their archives a magnificent wealth of global cultural heritage. In the eastern Zarqa Badia, we were not merely looking at an empty void, but at an open book of stone, meticulously inscribed by ancient humans. Long lines, stone circles, precise corridors, and silent installations appeared at first glance as mysterious geometric shapes; however, they soon revealed one of the greatest collective hunting systems in human history: the "Stone Kites." These structures, with their superior engineering and designs that evolved over time from early prototypes to sophisticated and "smart" systems, represent a distinct art of desert architectural engineering.

Continuous field monitoring in the Zarqa Badia ranging from the Hallabat area, which hosts some of the world's most significant early kites, to the Qusayr 'Amra region and its surroundings shows that nearly every square kilometer contains a kite with an architectural style adapted to the geographical landscape. These kites, numbering over 135 in the Zarqa Badia alone and dating back more than 4,000 years, demonstrate the extraordinary intelligence of our ancestors in identifying the gathering points of animals such as Oryx, Reem gazelles, and various birds. These animals are depicted on desert rocks through engravings and carvings, serving as physical evidence of the early techniques used by the ancient inhabitants of Jordan.

Assessments of the current state of these kites confirm that what was observed from the sky is not merely scattered ruins, but an integrated socio-economic and engineering system spanning hundreds of kilometers. These kites, along with nearby associated structures such as circular buildings, hunters' quarters, enclosures, hides, and installations linked to religious, social, and economic functions—reflect the deep relationship between humans and the natural desert environment. This is in addition to the "Mysterious Structures" whose functions and reasons for construction continue to baffle scientists.

These aerial discoveries confirm the grandeur of the Badia's geography, not as a barren space, but as a landscape of production, knowledge, and intelligent adaptation. Our ancestors understood animal migration, wind patterns, and topography, transforming them into sustainable hunting tools and advanced living systems.

Delving into the Zarqa Badia is a journey into both mystery and knowledge, inviting visitors and tourists to penetrate this stony silence and discover endless scientific and human narratives. It is a desert of adventure and the thrill of discovery. The study highlights significant differences between ground-based and aerial perspectives; while ground observation struggles with the camouflage of black basalt stones, aerial photography provides a holistic view that reveals the full geometric patterns and topographical contexts.

We must recognize that Jordan has entered a new era of utilizing sky and space technologies to accelerate discovery in the Badia. There is an urgent need for a comprehensive strategy to protect these treasures and repurpose them as global points of interest through scientific research and

cultural/exploratory tourism. The Zarqa Badia is not a forgotten past, but a promising future a global destination for discovery and an open laboratory for science.

Keywords: Badia, Archaeology, Kites, Stone Ages, Zarqa, Southern Levant.

RETOS Y AVANCES DE LAS DEFENSORAS DE TERRITORIOS CHALLENGES AND ADVANCES OF WOMEN DEFENDERS OF TERRITORIES

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RESUMEN

Las prácticas jurídicas, políticas y comunitarias desplegadas por mujeres defensoras del territorio en contextos indígenas, problematizan la centralidad del derecho estatal occidental como único marco legítimo de justicia, se pretende analizar los mecanismos alternos y en muchos casos extra estatales que estas mujeres activan para la defensa territorial y para su propia protección frente a procesos de criminalización, despojo y violencia estructural. Dichos mecanismos incluyen sistemas normativos comunitarios, asambleas, acuerdos colectivos, prácticas de justicia restaurativa, redes de cuidado y saberes ancestrales que operan como tecnologías jurídicas situadas, así como las tensiones que atraviesan las defensoras, frente al Estado que recurre a la judicialización, la vigilancia y la violencia simbólica para neutralizar su acción política como al interior de sus comunidades, donde persisten jerarquías patriarcales que cuestionan su autoridad y participación, no obstante, se argumenta que la respuesta a estas violencias no se produce de manera individual, sino desde procesos colectivos entre mujeres, mediante la articulación de redes solidarias comunitarias e intercomunitarias que sostienen la defensa del territorio y de la vida. Estas redes constituyen espacios de acompañamiento, formación política y producción de conocimiento jurídico desde abajo, finalmente, el artículo sostiene que las prácticas de las mujeres defensoras abren fisuras en el orden jurídico hegemónico, resignificando nociones como justicia, legalidad y autoridad, al hacerlo, no solo disputan el monopolio estatal del derecho, sino que habilitan horizontes políticos y jurídicos para las nuevas generaciones de mujeres, desde perspectivas feministas comunitarias y decoloniales orientadas a la reproducción ampliada de la vida.

Palabras claves: defensoras, territorios, mecanismos, indígenas.

ABSTRAC

The legal, political, and community practices employed by women land defenders in Indigenous contexts challenge the centrality of Western state law as the sole legitimate framework for justice. This study aims to analyze the alternative, and in many cases extra-state, mechanisms these women activate for territorial defense and their own protection against criminalization, dispossession, and structural violence. These mechanisms include community normative systems, assemblies, collective agreements, restorative justice practices, care networks, and ancestral knowledge that operate as situated legal technologies. It also examines the tensions these defenders face, both from the state, which resorts to judicialization, surveillance, and symbolic violence to neutralize their political action, and within their own communities, where patriarchal hierarchies persist, questioning their authority and participation. However, it is argued that the response to this violence does not occur individually, but rather through collective processes among women, by articulating community and inter-community solidarity networks that sustain the defense of territory and life. These networks constitute spaces for accompaniment, political training, and the production of legal knowledge from below. Finally, the article argues that the practices of women defenders open fissures in the hegemonic legal order, redefining notions such as justice, legality, and authority. In doing so, they not only challenge the state

monopoly of law but also enable political and legal horizons for new generations of women, from community-based and decolonial feminist perspectives oriented towards the expanded reproduction of life.

Keywords: women defenders, territories, mechanisms, indigenous peoples

NUMERICAL INVESTIGATION OF MHD NANOFLUID FLOW OVER A STRETCHING/SHRINKING SHEET VIA HAAR WAVELET METHOD

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ABSTRACT

The present study focuses on the boundary-layer flow of an electrically conducting nanofluid induced by a stretching sheet in the presence of a transverse magnetic field. The mathematical formulation is based on the continuity and momentum equations, which account for viscous effects, nanoparticle properties, and magnetic resistance. By introducing appropriate similarity transformations, the governing partial differential equations are transformed into a nonlinear ordinary differential equation. The resulting nonlinear problem is solved numerically using the Haar Wavelet Quasi-Linearization Method (HWQLM), yielding accurate, rapidly convergent solutions. The influence of key physical parameters, such as nanoparticle volume fraction, magnetic parameter, etc., on the flow characteristics is examined. Numerical results obtained through HWQLM are utilized to analyse the behaviour of the velocity profile and the skin friction coefficient. The study reveals that an increase in magnetic and nanoparticle volume fraction parameters significantly suppressed the fluid velocity due to enhanced resistive forces, while variations in nanofluid properties play a crucial role in controlling the boundary layer structure.

Keywords: MHD, Nanofluid, Haar Wavelet Transform, Numerical method.

DESIGN AND SIMULATION OF A CUSTOMIZED SOLAR PHOTOVOLTAIC POWER SYSTEM FOR WEATHER STATION APPLICATIONS IN MINNA, NIGER STATE

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ABSTRACT

Missing data in atmospheric and meteorological studies pose significant challenges to the reliability and accuracy of research outputs derived from such datasets. These missing values often result from intermittent or prolonged power failures at weather monitoring stations, especially in remote locations. This study addresses the issue by assessing the electrical load demand of a standalone weather station and designing a customized solar photovoltaic power system capable of ensuring continuous operation.The methodology involved a detailed evaluation of the station's electrical load requirements, followed by the design of an optimized photovoltaic system comprising appropriately selected solar modules, battery storage, charge controller, and voltage regulation components. The proposed system was further analyzed and its performance simulated using PVsyst software to validate its efficiency and reliability under local environmental conditions.The results demonstrated that the designed photovoltaic system can sustainably meet the energy demands of the weather station, thereby minimizing data loss caused by power interruptions. It is therefore concluded that the integration of a properly designed and simulated solar power system significantly enhances the operational reliability of standalone weather stations.

Keywords: Missing Meteorological Data, Standalone Weather Station Power System, Solar Photovoltaic System Design, PV System Simulation (PVsyst)

SYNTHESIS, DFT-BASED ELECTRONIC CHARACTERIZATION AND EGFR DOCKING STUDIES OF BENZENE-1,3-DIAMINE-1,3,4-OXADIAZOLE DERIVATIVES WITH POTENTIAL ANTICANCER ACTIVITY

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ABSTRACT

This study presents the synthesis and characterization of benzene-1,3-diamine-1,3,4-oxadiazole derivatives using ^{1}H NMR, ^{13}C NMR, mass spectrometry and FTIR-ATR infrared spectroscopy. In addition to the experimental study, detailed theoretical studies were conducted using density functional theory (DFT) to better understand the electronic structure and reactivity of the synthesized Novel compounds. Frontal molecular orbital analysis (HOMO-LUMO), global reactivity descriptors, density of states (DOS), and Parr functions were analyzed to evaluate the electronic properties and local reactive sites of the molecules. The outcomes revealed that compounds 5b, 5c, and 5f display favorable electronic characteristics and balanced reactivity. Molecular docking simulations were performed on the Epidermal Growth Factor Receptor (EGFR) in order to explore their potential anticancer activity. Results from the docking showed promising binding affinities, particularly for compound 5f, which displayed stronger interaction with the active site compared to the reference inhibitor, thus suggesting that these derivatives may represent promising candidates for further biological investigations.

Keywords: 1,3,4-oxadiazole; Synthesis; Characterization; Density Functional Theory; Frontier molecular orbitals; Parr functions; Molecular docking; EGFR inhibition**.**

EFFICIENT CORROSION INHIBITION PERFORMANCE OF MILD STEEL IN HYDROCHLORIC ACID (1M HCL) BY 5,5'-(1,3-PHENYLENEBIS(1,3,4-OXADIAZOLE-5,2-DIYL)) BIS (BENZENE-1,3-DIAMINE): THEORETICAL AND ELECTROCHEMICAL STUDY

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ABSTRACT

This work presents the synthesis and characterization of the compound 5,5'-(1,3-phenylenebis(1,3,4-oxadiazole-5,2-diyl)) bis (benzene-1,3-diamine) (PhOx-BBD). The structure of the synthesized molecule was confirmed by a variety of analytical methods, including ^{1}H NMR, ^{13}C NMR, FTIR-ATR spectroscopy, and mass spectrometry. To this end, Density Functional Theory (DFT) calculations were performed to investigate the electronic structure, frontier molecular orbitals, and global reactivity descriptors. This approach was taken to elucidate the nucleophilic/electrophilic character of the oxadiazole derivative. Molecular docking studies revealed strong interactions between PhOx-BBD and the Fe-solvation cluster, suggesting favorable adsorption behavior on the iron surface. Predictions derived from the ADMET model indicated the presence of encouraging pharmacokinetic properties and acceptable safety profiles. The corrosion inhibition performance of PhOx-BBD for mild steel in a 1 M HCl medium was evaluated through experimental electrochemical measurements. The experimental findings demonstrated a substantial decline in corrosion current density with an increase in inhibitor concentration, thereby substantiating the efficacy of the inhibitor in safeguarding the metal surface. The inhibitory effect exhibited a pronounced concentration-dependent protective effect, with its efficacy increasing from 60.21% to 94.15% across a range of concentrations from 10^{-6} to 10^{-3} M. Electrochemical analysis indicated that the inhibitor reduced both anodic metal dissolution and cathodic hydrogen evolution reactions, suggesting a mixed-type inhibition mechanism. Moreover, Monte Carlo and molecular dynamics simulations corroborated the experimental findings by demonstrating the strong adsorption of PhOx-BBD molecules on the Fe surface and the formation of a stable protective film. The amalgamation of experimental and theoretical findings reveals consistent trends in stability, reactivity, and adsorption behavior, underscoring the efficacy of PhOx-BBD as a corrosion inhibitor for steel protection in acidic environments and as a promising candidate for applications in surface protection and materials chemistry.

Keywords: Synthesis, Characterization, 1,3,4-oxadiazole, DFT, Reactivity, RDG, ELF, Molecular Docking, Monte Carlo, MD, Inhibitor, Corrosion

AGE, GENDER AND SOCIAL HIERARCHY IN THE URARTIAN URN BURIAL TRADITION A SOCIO-CULTURAL ANALYSIS

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ABSTRACT

The Urartians employed two primary burial practices: Inhumation (unburned or primary interment) and cremation (by burning). Following cremation, the surviving bone fragments and ashes were deposited within vessels of varying forms known as urns. A wide array of socio-cultural factors chiefly social status, age, and gender can be examined through analyses of urn morphology, urn grave typology, and associated funerary offerings. The age or gender of the deceased can be inferred not only from anthropological examinations but also, to a certain extent, from the grave goods. In particular, the urn burials documented at the Urartian necropolis of Çavuştepe Fortress, as well as at the Van-Altıntepe, Van-Kalecik, and Dedeli necropolises and the Iğdır-Melekli site, have furnished significant data on this subject. Furthermore, it has been established that infants, children, adolescents, adult females, and adult males were all interred in urn graves. The principal determinants of social status in urn burials include grave type, associated artifacts, and the urn vessel itself. Vessels classified as ―palace pottery,‖ along with metal containers such as those attested at Erzincan-Altıntepe when employed as urns, are consistently associated with the royal family, nobility, and administrative elite. Such high-quality urns occur only rarely in communal cemeteries, whereas in simpler urn forms status is expressed primarily through the quantity and quality of grave goods. In female urns, ornaments predominate, including bracelets, earrings, rings, decorative pins, amulets, spindle whorls, and seals; these assemblages attest to women's possession of administrative and social status. Male urns, by contrast, are characterized by weapons such as daggers, swords, arrowheads, and spearheads. In urns of indeterminate gender, the co-occurrence of jewelry and weaponry suggests considerable flexibility in gender roles within Urartian society. Taken as a whole, Urartian urn burials reflect a familyoriented, religiously tolerant, and socially hierarchical yet flexible social structure.

Keywords: Urartian, cremation, urn, age, gender, status

Introduction

The Urartian Kingdom was established between the 9th and 7th centuries BCE, with its capital at Tuşpa (Van Fortress). Centered in the Lake Van Basin, the kingdom expanded significantly as a result of the successful military and political policies pursued by the Urartian kings. Its borders extended as far as the Zagros Mountains to the south, the mountains of northern Armenia to the north, the Salavan Mountains in Iran to the east, and the Euphrates River to the west (Figure 1) (Salvini, 2006: 7; Salvini, 2011: 74; Çavuşoğlu, 2012: 80). The growing power of the kingdom and its expanding territory brought about important developments in Urartian socio-cultural life. The region's richness in raw material resources, in particular, made advanced metallurgy one of the most significant features of Urartu. It is also noted that Urartian society was composed of peoples of different origins, referred to as Uruadri and Nairi. The expansion of the borders further increased the diversity within the social structure. The Urartian Kingdom operated under a theocratic system of governance. The Urartians adopted a tolerant policy by incorporating the gods of the conquered lands into their own pantheon. This moderate approach and the heterogeneous nature of their society were also reflected in their religious practices. Urartian religion developed through the interaction of its own indigenous beliefs with the religions of contemporary states both within and beyond Anatolia. Consequently, influences from the Hittites, Assyrians, Hurrians, and Babylonians can be observed in Urartian religion (Belli, 1982; Çilingiroğlu, 1997; Sevin, 2003; Çavuşoğlu, 2014). The beliefs shaped by these factors led to various practices

concerning death and the afterlife among the Urartians. The Urartians believed in life after death, and this belief is clearly evident in their burial traditions. They interred their dead either by cremation (burning the body) or inhumation (burying the body unburned) in various types of tomb structures. The inhumation-type graves include simple pit graves, rock-cut tombs, chamber tombs, cist graves, and jar (pithos) burials (Çevik, 2000; Konyar, 2004; Konyar, 2011a; Konyar, 2011b).

Figure 1. Map of the Urartian Kingdom (Çavuşoğlu, 2019: 165).

Among the Urartians, the cremation tradition was practiced in two main forms. In the first type, after the body was cremated, the remaining bones and ashes were buried directly in a pit dug into the ground. This practice was more common in the early periods of Urartu, although it was not widely preferred. The second type of cremation burial consists of urn burials. An urne refers to a vessel into which the burnt bones and ashes of the deceased — and sometimes personal belongings — were placed. Urn vessels were mostly made of terracotta (fired clay), although bronze examples are also known. While a small number of urns without holes have been found, the majority feature between one and five holes (Özgüç, 1969: 27; Öğün, 1974: 443-444; Öğün, 1978: 639-678; Derin, 1993: 110). The types of graves used for urn burials show parallels with those used for inhumation burials. Among the urn burial types are: burials placed directly into pits dug into the ground, urn burials placed in niches or on the floors of chamber tombs, urn burials in stone cist graves, and urn burials deposited in rock crevices (Figure 2) (Öğün, 1978: 672; Derin, 1993; Sürün, 2024).

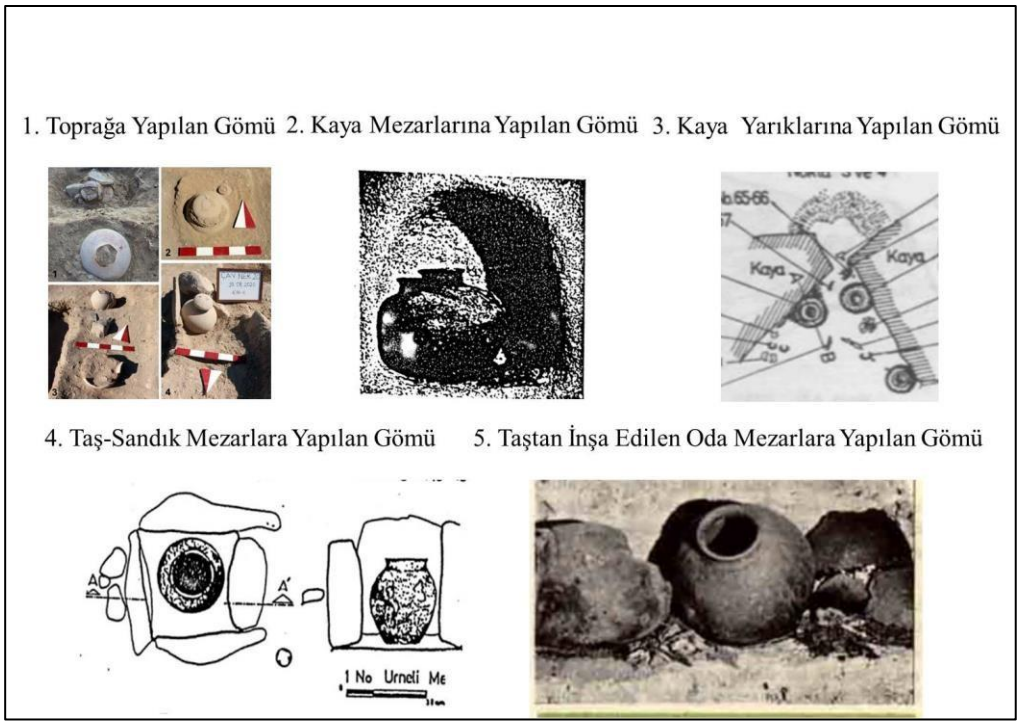

Figure 2. Urartian Urn Burial Types.

The urns could contain not only the burnt bone and ash remains but also personal belongings of the deceased, depending on the individual's social status. The artifacts recovered from these graves may have belonged to the deceased or may have been placed as offerings during the funeral ceremony. Urn vessels provide valuable information regarding the social status of the deceased. In addition, the burnt bone remains found inside the urns allow for the analysis of the age and gender of the individual. The artifacts recovered from urn burials also offer preliminary information about the deceased's age and gender. Furthermore, they provide insights into the deceased's position within the social hierarchy. Beyond these, the type of grave in which the urns were buried also yields important clues about social status.

Materials and Methods

In this study, urn burials — one of the burial traditions of the Urartian Kingdom — have been examined in terms of age, gender, and social hierarchy. Only the finds dated to the Urartian Kingdom that have been published and provide relevant data on the subject were included in the study. The age and gender determination analyses for the urn burials were obtained from paleoanthropological studies and the associated finds. The social status of the deceased was determined based on the type of urn grave, the urn vessel, and the accompanying artifacts. In light of this information, some inferences have been made regarding Urartian socio-cultural life.

Findings and Discussion

Extensive archaeological excavations in Urartian settlements have revealed a significant number of urn burials and diverse grave types. Nevertheless, analyses aimed at determining the age and gender of the deceased are relatively scarce. In this section, the role of urn finds in identifying social status is presented, drawing upon data from Urartian centers where age and gender determinations have been performed.

Age and Gender Analysis of Urn Burials in Light of Paleoanthropological Studies

In determining the age and gender of individuals from Urartian urns, both direct analyses and information obtained from the associated finds have been utilized. In this context, the centers evaluated include the Çavuştepe Fortress Urartian Necropolis (Çavuşoğlu et al., 2019a; Çavuşoğlu et al., 2019b; Çavuşoğlu et al., 2022), Van-Kalecik (Çavuşoğlu & Biber, 2006; Çavuşoğlu & Biber, 2007; Çavuşoğlu & Biber, 2008; Çavuşoğlu et al., 2009), Van-Altıntepe (Yiğit et al., 2005), and Dilkaya (Çilingiroğlu, 1985; Çilingiroğlu, 1986; Çilingiroğlu, 1987; Çilingiroğlu, 1988; Çilingiroğlu, 1990; Çilingiroğlu, 1991).

Çavuştepe Fortress Urartian Necropolis

At the Çavuştepe Fortress Urartian Necropolis, data regarding age and gender were obtained from 25 urns excavated between 2017 and 2020. Among the urns uncovered in 2017, eight contained cremated bone remains of children, while one belonged to a baby (newborn). Of these child urns, three were identified as belonging to female children. The age range could be determined for six of the urns, varying between 5, 6, 10, 11, and 12 years (Çavuşoğlu et al., 2019a: 287). In the 2018 excavations, eight urns were identified, four of which were reported to contain cremated bone remains of adult females (Çavuşoğlu et al., 2019b: 20). During the 2019 fieldwork, 14 urns were uncovered, and the gender and, in some cases, the partial age range of six of them could be determined. Five of these urns belonged to adult females, while the remaining one belonged to an adult male (Çavuşoğlu et al., 2022: 70-72). In the 2020 investigations, the age range of one out of five urns was determined, and it was reported to belong to a baby (newborn?) (Figure 3) (Çavuşoğlu et al., 2022: 72-75).

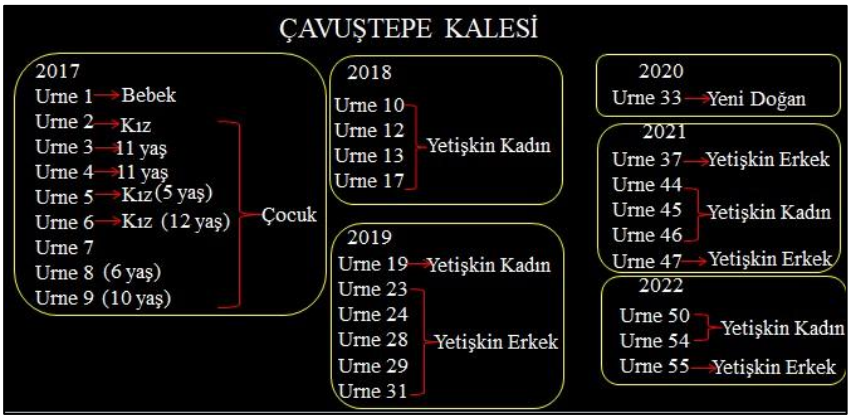

Figure 3. Age and Gender Distribution of Individuals from the Çavuştepe Fortress Urartian Necropolis.

Melekli Settlement Mound

At the Iğdır-Melekli Höyük, studies have revealed age and gender information for 11 of the excavated urns. According to the findings, three urns (Urn 55, 57, and 84) contained the cremated remains of adult males, one urn (Urn 131) belonged to an adult female, and two urns (Urn 111 and 149) contained the cremated bone remains of children. For the remaining five urns, no gender determination could be made; however, they were identified as belonging to adults (Barnett, 1963).

Van-Altıntepe Necropolis

A paleoanthropological study was conducted on the inhumation and cremation remains uncovered at the Van-Altıntepe Necropolis. In this study, 152 individuals identified from 38 graves dating to the years

1997–1999 were evaluated. Within this scope, results were obtained from eight urns. According to these data, one urn contained the remains of a child, one belonged to a female, and three urns contained the remains of males. The gender of the individuals in the other three urns could not be determined. In addition, the analysis of cremation burials conducted alongside the inhumation graves provided data on the stature of the individuals. Accordingly, the average stature was reported as approximately 1.61–1.65 m for males and 1.52–1.53 m for females (Figure 4) (Yiğit et al., 2005: 79 ff.).

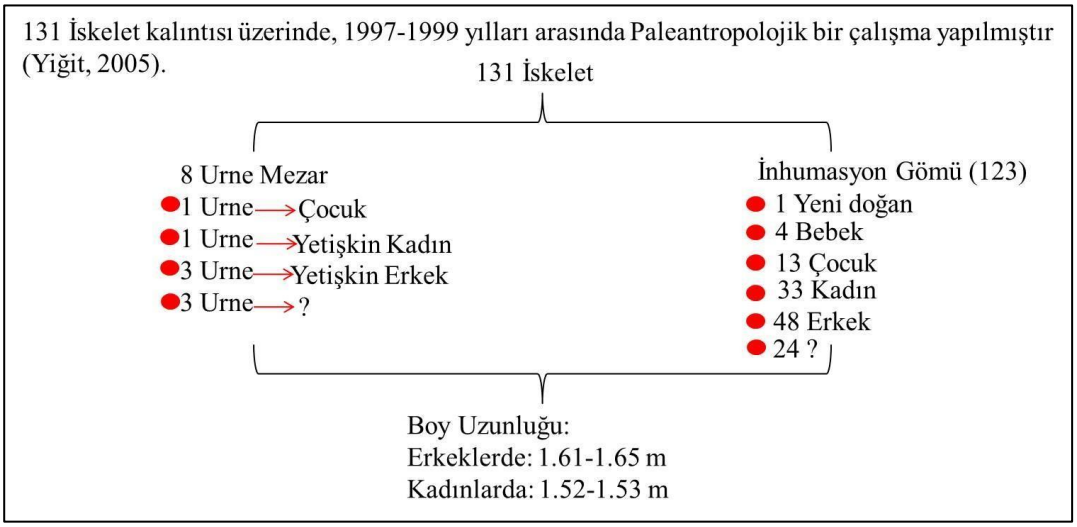

Figure 4. Age, gender and stature analysis form the Van-Altıntepe Necropolis (Based on Yiğit et al., 2005).

Van-Kalecik Nekropolis

Although no intact urns were identified at the Van-Kalecik Necropolis, fragments of urns were recovered. During the excavations carried out between 2004 and 2007, 25 graves were examined (Çavuşoğlu & Biber, 2005: 23-24; Çavuşoğlu & Biber, 2009: 275; Çavuşoğlu et al., 2009: 289). A paleoanthropological study was conducted on the skeletal remains from the necropolis. This study focused primarily on the inhumation burials. Although no direct data on cremation were available, the results provide an opportunity to make general inferences about age and gender within the same community, given that these represent different burial practices in the same society.

In the graves examined, 107 individuals were identified. According to the analysis, adults aged 30–45 constituted 43% of the burials, representing the largest group. This was followed by young adults aged 18–30, accounting for 33.6%. Children (aged 2.5–15 years) comprised 13.1% of the sample, while individuals over 45 years old represented only 2.8%. The numerical breakdown of the 107 individuals is as follows: 5 infants, 14 children, 3 adolescents, 36 young adults, 46 adults, and 3 older adults. Among the 85 adult individuals,

36.4% were female and 45.8% were male (Figure 5) (Yılmaz et al., 2009: 29-31).

In addition to the centers mentioned above, urns have also been identified at ErzincanAltıntepe (Özgüç, 1969), Van Fortress (Sevin, 1980), Kayalıdere (Burney, 1966), Dilkaya (Çilingiroğlu, 1989), Ayanis (Çilingiroğlu & Kozbe, 1994), Adilcevaz (Bilgiç & Öğün, 1974), Karmir Blur (Piotrovskii, 1952; Piotrovskii, 1966), Arin Berd (Karapetyan & Yengibaryan, 2010), and the Liç Necropolis (Öğün, 1978). However, no detailed studies focusing on age and gender determination have yet been conducted on the cremation remains from these urns. Nevertheless, the published data indicate that the cremation remains generally belong to adult individuals.

Figure 5. Age and gender distribution with percentages from the Van-Kalecik Necropolis (Yılmaz et al., 2009: 29-31).

Age and Gender Analysis Based on Urn Finds

In urn burials, personal belongings of the deceased or grave goods thought to have been placed beside the individual during the funeral ceremony are commonly found. The artifacts recovered from Urartian graves are closely related to the Urartians' beliefs about life after death. Many of these objects were burned together with the body during the cremation process. The majority of the artifacts identified in urn burials are in a burnt condition (Sürün, 2024: 119, 133). These finds were recovered primarily inside the urn, in the immediate vicinity of the urn, or beneath the base of the urn. The artifacts include terracotta pottery such as jars, bowls, cups, plates, oil lamps, spindle whorls, and seals, as well as metal objects such as jewelry and weapons (Barnett, 1963: 154; Derin, 1993: 130-142; Sürün, 2024: 22).

The finds from urn burials provide valuable information about the social, cultural, military, and economic life of the Urartians. In addition, they offer data concerning the age, gender, and social status of the deceased. Jewelry constitutes the most common category of finds in Urartian urns. Jewelry appears to have been used for various purposes, including adornment, display, beautification, demonstrating wealth, bringing luck, and healing. Bronze was the primary material used for jewelry, along with gold and silver. In the head region, pins, diadems, and earrings were worn. Around the neck and chest, necklaces made of beads, torcs, amulets, amulet-seals, pendants, medallions, and pectorals were used (Belli, 1989: 16-41; Kurtis, 1996: 118-136; Belli, 2004; Sevin, 2005: 108-109; Belli, 2010; Çavuşoğlu, 2014).

The finds from urn burials show a correlation with the age, gender, and social status of the deceased. In baby urns, no artifacts other than the cremated bone remains were identified (Çavuşoğlu et al., 2019a: 285). In child urns, the recovered artifacts mainly consist of necklaces and bracelets made of beads. Such finds have been reported from the Çavuştepe Fortress Necropolis (Çavuşoğlu et al., 2019a: 285-286) and Melekli Höyük (Barnett, 1963: 263). Among the artifacts found in female urns are earrings, rings, bracelets, decorative pins, beads, seals, spindle whorls, armbands, tweezers, amulets, and terracotta vessels (Barnett, 1963: 261-262; Çavuşoğlu et al., 2019b: 20-21; Çavuşoğlu et al., 2022: 71-72). In male urns, daggers, arrowheads, swords, knife tips, spearheads, armbands, pins, and bronze vessels are known to have been recovered (Barnett, 1963: 257-259; Çavuşoğlu et al., 2022: 71-73). From these data, it can be observed that jewelry items predominantly appear in female urns, weapons in male urns, and bracelets and beads in child urns. However, archaeological evidence indicates that jewelry was also commonly and willingly used by men in the Urartian Kingdom. Furthermore, the presence of knife and dagger tips in some female urns suggests that these items had a shared area of use. At this stage, it appears possible to conduct an analysis of gender and age only on the basis of numerical values and the relative frequency of these artifact groups (Figure 6).

Figure 6. Age and gender differentation based on urn finds.

The Relationship Between Urn Burials and Social Hierarchy

In the Urartian Kingdom, it is known that different burial practices and grave types were used depending on the age, gender, and social status of the deceased. Burial customs were practiced in two main forms: inhumation and cremation. Although grave types show parallels in both burial practices, they generally consist of simple pit graves, chamber tombs, stone cist graves, and rock-cut tombs (Barnett, 1963; Çevik, 2000; Konyar, 2004; Konyar, 2010; Konyar, 2011). In urn burials, certain key elements emphasize social hierarchy. The type of urn grave, the urn vessel itself, and the grave goods serve as the primary data sources in this analysis.

Among the metal finds recovered from urn graves, jewelry items such as diadems, earrings, pins, torcs, bead necklaces, amulets, pendants, amulet-seals, and pectorals provide important insights into the deceased's social status and economic level. It has been suggested that pectorals, medallions, pendants, and amulet-seals, in particular, are status indicators (Belli, 1989: 16-41; Belli, 2004; Sevin, 2005: 108-109; Belli, 2010; Çavuşoğlu, 2011: 250-251; Çavuşoğlu, 2014).

Another important source of information regarding social hierarchy is the urn vessel itself. In the Urartian Kingdom, there existed a type of pottery known as ―palace ware,‖ characterized by a lustrous red slip, well-burnished surface, thin walls, and fine clay. This ware is thought to have been used primarily by the ruling and elite classes (Çilingiroğlu, 1990: 273; Sevin et al., 1999: 421-425; Yiğit et al., 2005: 86). The fact that such vessels are rarely or never found in simple pit graves, which are generally regarded as ―commoners' cemeteries,‖ suggests that they were specially produced. In contrast, urn vessels are usually made of brown or brick-red slipped, thick-walled coarse ware. However, evaluating social status based solely on the urn vessel is insufficient. In some cases, palace-ware-type urns contained no grave goods, while coarse-ware urns were found with rich assemblages. Therefore, the urn vessel and the accompanying finds must be evaluated together. Although most urn vessels were made of terracotta, a small number of bronze examples, considered to be of special production, are also known. These bronze urns are documented from Erzincan-Altıntepe (Barnett & Gökçe,

1953: 124; Öğün, 1974: 59). A hieroglyphic inscription has been reported on one bronze urn (Steinherr, 1958: 97; Özgüç, 1969: 26). The material of the urn, the presence of an inscription, and the type of grave in which it was found strongly suggest that bronze urns belonged to the noble or ruling class.

Another indicator of social hierarchy in urn burials is the type of grave in which the urn was deposited. A status difference can be observed between urns placed in simple pit graves, rock crevices, or stone cist graves and those deposited in niches within chamber tombs. Chamber tombs are generally considered to be royal or elite burials (Çilingiroğlu, 1990: 273; Sevin et al., 1999: 421-425; Yiğit et al., 2005: 86). Other grave types appear to have been used by individuals from various social classes. In these graves, both rich and poor (or even empty) urn burials are known. While it is difficult to draw a clear distinction, an evaluation based on the grave goods is possible. However, in rock-cut tombs, it can be argued that the presence of an urn burial is directly related to high status.

In addition to the factors mentioned above, it has also been suggested that the practice of cremation was a distinguishing feature between the elite/ruling class and the common people. Özgüç stated that ―the noble and ruling class in Urartu were buried without cremation, while commoners were buried after cremation‖ (Özgüç, 1969: 27). In contrast, Öğün argued that ―the urn burial tradition was not exclusive to commoners and that noble individuals may also have been buried in urns‖ (Öğün, 1974: 447). The discovery of urns at Van Fortress, Adilcevaz, Dilkaya, Patnos, Dönertaş, Atabindi, and Şirinkale I-II indicates that this burial practice was also employed by the ruling and noble classes (Figure 7) (Sevin, 1980: 151-158).

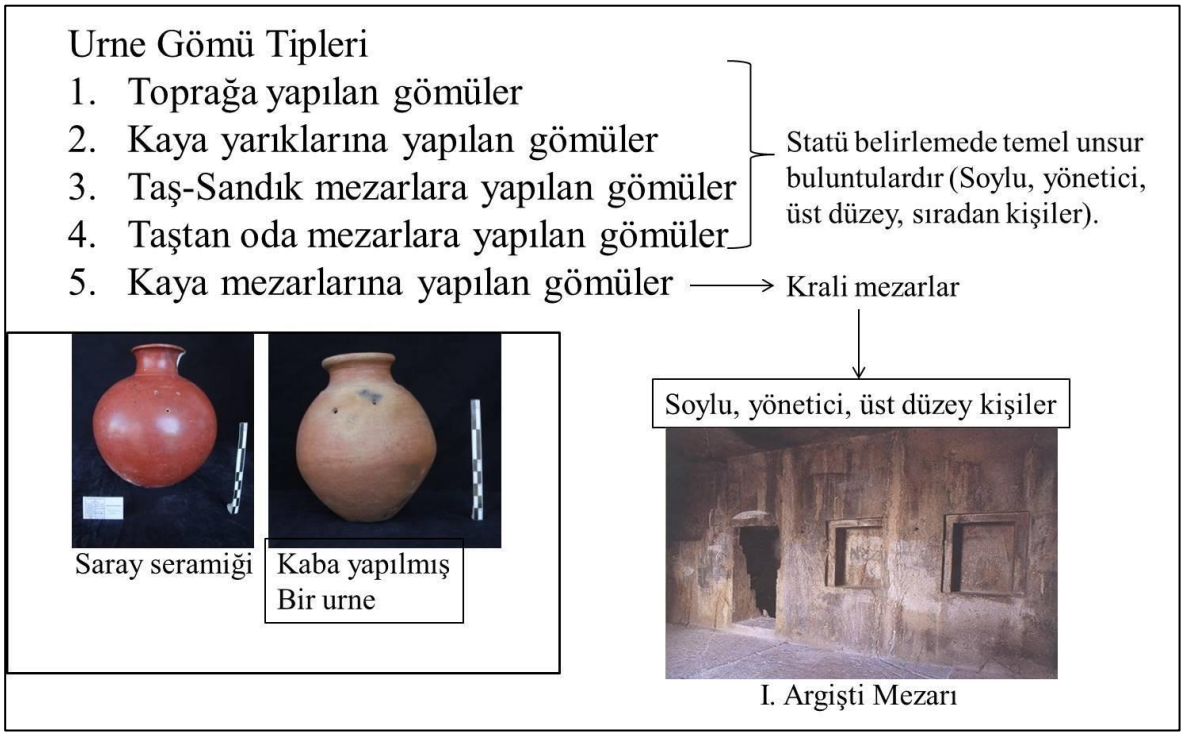

Figure 7. The role of urn grave types and urn vessels in determining social hierarchy.

Conclusion and Recommendations

It is observed that Urartian urn burials provide significant information about socio-cultural, economic, military, and social aspects of Urartian society through the grave type, vessel form, and the personal belongings or gifts placed within them. Age and gender in urn burials are determined through osteological analyses and associated finds. The data indicate that ―adult‖ individuals, particularly males, constitute the majority of the urn burials. Child and infant burials are also important as they demonstrate that cremation was practiced across all age groups. According to the analyses, the average age at the Çavuştepe Fortress Urartian Necropolis was determined as 35 years for males and 25 years for females, while the age range for children was 6–12 years (Çavuşoğlu et al., 2019a: 287). The analysis of remains from chamber tombs at Van-Kalecik also yielded data on age and gender. At Van-Kalecik,

the age range was 30– 45 years for both adult males and females, 18–30 years for young adults, and 2.5–15 years for children. A small number of individuals over 45 years of age were also identified (Yılmaz et al., 2009: 29-31). At Van-Altıntepe, the analyses provided information on stature according to gender. The average height was measured as 1.61–1.65 m for males and 1.52–1.53 m for females (Yiğit et al., 2005: 79).

The analyses from Patnos-Dedeli are particularly important for understanding the socioeconomic conditions of the Urartians. These analyses were conducted on inhumation burials.

The study revealed the presence of ―Harris Lines‖ on the bones, which are indicators of growth arrest caused by stress and nutritional deficiencies (Deniz, 1986: 119-122; Uysal, 2005: 92). This situation can be seen as a reflection of the relatively low average age at death observed in centers such as Çavuştepe and Van-Altıntepe. It is therefore possible to speak of intense nutritional stress and related short life expectancy and lower stature, particularly among the common people, as evidenced in the Dedeli sample. Furthermore, the data suggest that male burials in urns are more numerous than female burials and that males generally lived longer than females. However, it is clear that more data are needed to make these generalizations reliably.

Another factor in determining the gender of the deceased in urn burials is the grave goods. Beads, bracelets, and seals were used regardless of gender. However, it is evident that weapons and weapon-related items are more frequently found in male urns. In female urns, jewelry is more common, with earrings, diadems, medallions, and pectorals serving as particularly diagnostic items. In addition, bronze belts are an important element in gender determination. Male belts tend to be wider, while female belts are narrower (Çavuşoğlu, 2014). Urn finds can also be associated with social status in addition to age and gender. Urns containing rich assemblages, such as seals, can be linked to the noble or ruling class. The type of urn vessel and the type of grave in which the urn was buried also show parallels with social hierarchy. Urns found in rock-cut tombs can be associated with the ruling elite. Urns discovered in commoners' cemeteries can be categorized as belonging to merchants or nobles depending on the richness of their grave goods. In this sense, it is possible to classify royal chamber tomb urns as belonging to the ruling class and richly furnished urns as belonging to merchants or nobles. In terms of metal artifacts, jewelry constitutes the most common group. Bronze was the most preferred material due to its affordability and ease of workmanship. Iron was rarely used because of the difficulty in processing it. Gold, being a precious metal, appears in very limited quantities. This indicates that gold objects played a significant role in determining high social status. Seals are considered to have served functions such as protection, luck, belonging, guarantee, approval, and prestige. Therefore, seals also appear to have functioned as status indicators. It is known that seals were found in both male and female urns. This suggests that women in Urartian society held a position of influence comparable to that of men. Some urn finds provide information not only about gender but also about social structure. At Iğdır-Melekli Höyük, weapons were found together with personal belongings in more than fifteen urns. These weapons, consisting of arrowheads, spearheads, daggers, and knife blades, were recovered from male urns. This evidence allows us to interpret the Melekli community as having a strong military or warrior character.

In conclusion, the cremation or urn burial tradition in Urartu was practiced by individuals from all social classes (ruling elite, nobles, commoners, etc.) within the society that adopted cremation. Furthermore, urn burials contain remains of individuals of all ages and both genderes, regardless of age or gender. Although there is no strict status differentiation in the burial custom itself, significant differences related to age, gender, and status are evident in the grave types and urn finds. More osteological and archaeological analyses are needed to make comprehensive evaluations regarding these concepts.

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BEKAR GENÇLERDE ÇOCUK SAHİBİ OLMA MOTİVASYONU VE ETKİLEYEN FAKTÖRLER

MOTIVATION TO HAVE CHILDREN AMONG UNMARRIED YOUNG PEOPLE AND INFLUENCING FACTORS

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ABSTRACT

Objective: This study aimed to determine the motivation for having children and the factors affecting this motivation among single young individuals.

Methods: This descriptive and cross-sectional study was conducted between February and March 2026 using an online survey. The sample consisted of 185 single individuals aged 18 and over who were able to read and write in Turkish and actively use at least one social media platform. Data were collected using a Descriptive Information Form and the Childbearing Motivation Scale (CMS). Statistical analyses were performed using SPSS 22.0, including descriptive statistics, independent samples t-test, ANOVA, Pearson correlation, and binary logistic regression analysis.

Results: The mean age of participants was 20.00±1.74, and the majority were female (79.5%), university students (84.9%), and had a university-level education (91.4%). While 44.9% of participants reported willingness to have children in the future, 55.1% did not. The most frequently reported reasons for not wanting children were economic difficulties (65.9%), future anxiety (41.1%), and perceived burden of child responsibility (31.4%). There were no statistically significant differences in CMS scores according to sociodemographic characteristics ($p>0.05$). However, individuals who perceived child-rearing as highly burdensome and those with career plans had significantly lower CMS scores ($p<0.05$). Correlation analysis revealed a strong positive relationship between positive motivation and total CMS score ($r=.828$, $p<.001$). Logistic regression analysis showed that positive motivation significantly increased the likelihood of intending to have children (OR=1.026, $p=.004$), whereas negative motivation significantly decreased it (OR=0.953, $p<.001$).

Conclusion: Childbearing motivation among single young individuals is influenced more by psychological and attitudinal factors than sociodemographic characteristics. Increasing positive perceptions and reducing perceived barriers may play a key role in shaping future fertility intentions.

Keywords: single, child, motivation, young

Özet

Amaç: Bu çalışma, bekar genç bireyler arasında çocuk sahibi olma motivasyonunu ve bu motivasyonu etkileyen faktörleri belirlemeyi amaçlamıştır.

Yöntem: Bu tanımlayıcı ve kesitsel çalışma, Şubat ve Mart 2026 tarihleri arasında çevrimiçi bir anket kullanılarak gerçekleştirilmiştir. Örneklem, Türkçe okuma-yazma bilen ve en az bir sosyal medya platformunu aktif olarak kullanan 18 yaş ve üzeri 185 bekar bireyden oluşmuştur. Veriler, Tanımlayıcı Bilgi Formu ve Çocuk Sahibi Olma Motivasyonu Ölçeği (CMS) kullanılarak toplanmıştır. İstatistiksel

analizler, SPSS 22.0 kullanılarak yapılmış olup, tanımlayıcı istatistikler, bağımsız örneklemler t-testi, ANOVA, Pearson korelasyonu ve ikili lojistik regresyon analizi içermektedir.

Bulgular: Katılımcıların ortalama yaşı 20,00±1,74 idi; katılımcıların çoğunluğu kadın (%79,5) ve üniversite öğrencisiydi (%84,9) ve üniversite düzeyinde eğitim almıştı (%91,4). Katılımcıların %44,9'u gelecekte çocuk sahibi olma isteğini belirtirken, %55,1'i böyle bir isteği olmadığını belirtti. Çocuk istememe nedenleri arasında en sık bildirilenler ekonomik zorluklar (%65,9), gelecek kaygısı (%41,1) ve çocuk sorumluluğunun algılanan yükü (%31,4) idi. Sosyodemografik özelliklere göre CMS puanlarında istatistiksel olarak anlamlı bir fark yoktu ($p>0,05$). Ancak, çocuk yetiştirmeyi oldukça yük olarak algılayan ve kariyer planları olan bireylerin CMS puanları anlamlı olarak daha düşüktü ($p<0,05$). Korelasyon analizi, pozitif motivasyon ile toplam CMS puanı arasında güçlü bir pozitif ilişki olduğunu ortaya koydu ($r=0,828$, $p<0,001$). Lojistik regresyon analizi, olumlu motivasyonun çocuk sahibi olma niyetini önemli ölçüde artırdığını (OR=1,026, $p=0,004$), olumsuz motivasyonun ise önemli ölçüde azalttığını (OR=0,953, $p<0,001$) göstermiştir.

Sonuç: Bekar genç bireyler arasında çocuk sahibi olma motivasyonu, sosyodemografik özelliklerden çok psikolojik ve tutumsal faktörlerden etkilenmektedir. Olumlu algıların artırılması ve algılanan engellerin azaltılması, gelecekteki doğurganlık niyetlerinin şekillenmesinde önemli bir rol oynayabilir.

Anahtar Kelimeler; bekar, çocuk, motivasyon, genç

Giriş

Son yıllarda dünya genelinde doğurganlık oranlarında belirgin bir düşüş yaşanmaktadır. Bu durum sadece demografik değil, aynı zamanda sosyal, ekonomik ve kültürel boyutları olan önemli bir halk sağlığı sorunu olarak ele alınmaktadır. Genç yetişkinlerin çocuk sahibi olma niyetleri, bireysel üreme davranışlarının en güçlü belirleyicilerinden biri olarak kabul edilmekte ve toplumların gelecekteki nüfus yapısını doğrudan etkilemektedir (Liu et al., 2026).

Bekar gençlerde çocuk sahibi olma motivasyonu, biyolojik bir tercih olmanın yanı sıra bireysel, kişilerarası ve toplumsal düzeyde çok boyutlu faktörlerden etkilenen karmaşık bir süreçtir. Ebeveynliğe yönelik tutumlar, doğurganlık bilgisi, yaşam beklentileri ve psikolojik iyi oluş gibi bireysel faktörlerin yanı sıra sosyal normlar, ekonomik koşullar ve kültürel değerler tarafından şekillenmektedir (Shin et al., 2025). Diğer taraftan sosyal destek varlığı, yaşam doyumu ve olumlu ebeveynlik algıları doğurganlık niyetini artırırken; ekonomik belirsizlik, kariyer kaygısı ve iş-aile çatışması gibi faktörler bu niyeti azaltabilmektedir (Zhang et al., 2024).

Psikososyal faktörlerin yanı sıra bilgi düzeyi ve doğurganlığa ilişkin farkındalık da çocuk sahibi olma motivasyonu üzerinde önemli rol oynamaktadır. Özellikle genç bireylerde üreme sağlığına ilişkin bilgi eksiklikleri ve yanlış inanışlar, doğurganlık niyetlerini olumsuz yönde etkileyebilmektedir. Türkiye'de üniversite öğrencileri ile yapılan bir çalışmada, gençlerin üreme sağlığına ilişkin bilgi düzeylerinin yetersiz olduğu ve yanlış inanışların yaygın olduğu belirtilmiştir (Güngör et al., 2013).

Türkiye özelinde doğurganlık eğilimleri incelendiğinde, ideal çocuk sayısı ile gerçekleşen doğurganlık arasında bir farklılık olduğu ve doğurganlık niyetlerinin zaman içerisinde değişim gösterdiği görülmektedir. Bireylerin ideal çocuk sayısının yüksek olmasına rağmen doğurganlık niyetlerinin azalma eğiliminde olduğu bilinmektedir (Abbasoğlu Özgören & Türkyılmaz, 2023). Ayrıca yaş, bölge, dil ve doğum deneyimi gibi değişkenlerin doğurganlık niyetleri üzerinde belirleyici olduğu ifade edilmektedir. Bununla birlikte, toplumsal cinsiyet rolleri ve aile içi iş bölümü gibi faktörlerin de doğurganlık kararları üzerinde etkili olduğu, ancak bu etkinin kültürel bağlama göre değişkenlik gösterebildiği bildirilmektedir (Kavas, 2021).

Tüm bu bulgular birlikte değerlendirildiğinde, bekar gençlerde çocuk sahibi olma motivasyonunun; bireysel tutumlar, bilgi düzeyi, psikolojik faktörler, sosyodemografik özellikler ve kültürel bağlamın etkileşimiyle şekillenen çok boyutlu bir yapı olduğu görülmektedir. Bu nedenle, özellikle bekar genç bireylerde çocuk sahibi olma motivasyonunun ve bunu etkileyen faktörlerin kapsamlı biçimde

incelenmesi, hem akademik literatüre katkı sağlamakta hem de üreme sağlığı politikalarının geliştirilmesi açısından önemli veriler sunmaktadır.

Materyal ve Metot

Bu tanımlayıcı ve kesitsel çalışma, Şubat-Mart 2026 tarihleri arasında çevrimiçi bir anket yoluyla gerçekleştirilmiştir. Basit rastgele örnekleme yöntemi ile ilgili tarihler arasında erişilebilen tüm bireyler dahil edilmiştir. Maksimum çeşitliliği sağlamak amacıyla, çalışma toplam 185 bekar birey ile tamamlanmıştır. Hedef popülasyon, Türkçe okuma-yazma bilen ve en az bir sosyal medya platformu kullanan 18 yaş ve üzeri bireylerden oluşmuştur. Çalışma için etik kurul onayı alınmıştır (Numara:E-14679147-663.05-1112304). Çalışma ayrıca Helsinki Bildirgesi ilkelerine uygun olarak yürütülmüştür.

Dahil edilme kriterleri:

Çalışmanın dahil edilme kriterleri şunlardır: (a) bekar olmak (b) Türkçe dilinde yeterlilik (konuşma, okuma ve yazma), (c) 18 yaşın üzerinde olma, (d) bir sosyal medya hesabına sahip olma (e) gönüllü katılım

Veri Toplama Araçları

Tanımlayıcı Bilgi Formu: Araştırmacılar tarafından katılımcıların demografik (yaş, eğitim, çalışma durumu vb) bilgilerini sorgulayan 15 soruluk formdur.

Çocuk Sahibi Olma Motivasyonları Ölçeği (ÇSOMÖ): Guedes ve ark., (2015) tarafından bireylerin çocuk sahibi olmaya ilişkin gerekçelerini değerlendirmek amacıyla geliştirilmiş, Şimşek (2017) tarafından Türkçeye uyarlanarak geçerlik ve güvenirlik çalışması yapılmış bir ölçektir. Ölçek, bireylerin çocuk sahibi olma gerekçelerini değerlendirmek amacıyla geliştirilmiş olup olumlu çocuk sahibi olma motivasyonları ve olumsuz çocuk sahibi olma motivasyonları olmak üzere iki alt boyuttan oluşmaktadır. Olumlu motivasyonlar; ekonomik görüşler, kişisel tatmin ve çift ilişkileri gibi çocuk sahibi olmayı destekleyen nedenleri kapsarken, olumsuz motivasyonlar; evlilik stresi, finansal problemler ve sosyal/ekolojik endişeler gibi çocuk sahibi olmaya yönelik olumsuz gerekçeleri içermektedir. Ölçek toplam 35 maddeden oluşmakta ve 5'li Likert tipi derecelendirme sistemi ile yanıtlanmaktadır. Maddeler 1=Hiç ile 5=Tamamen arasında puanlanmaktadır. Ölçekte olumlu motivasyonlar alt boyutunda 22 madde, olumsuz motivasyonlar alt boyutunda ise 13 madde yer almaktadır. Olumlu motivasyonlar alt boyutundan alınan yüksek puan, bireyin çocuk sahibi olmaya ilişkin olumlu gerekçelerini daha güçlü benimsediğini; olumsuz motivasyonlar alt boyutundan alınan yüksek puan ise çocuk sahibi olmaya ilişkin olumsuz gerekçelerinin daha belirgin olduğunu göstermektedir. Ölçeğin Cronbach alfa katsayısı 0.91 olarak hesaplanmıştır. Bu çalışmada ölçeğin iç tutarlılık katsayısı Cronbach alfa ile değerlendirilmiş ve α=0.91 olarak bulunmuştur. Bu değer, ölçeğin iç tutarlılığının sınırda kabul edilebilir düzeyde olduğunu göstermektedir.

Verilerin Analizi

Araştırma verileri SPSS (22.0) paket programı ile analiz edildi. Tanımlayıcı analizlerde nicel değişkenler ortalama±standart sapma ve minimum-maksimum değerlerle, kategorik değişkenler ise sayı ve yüzde ile sunuldu. Sürekli değişkenlerin normal dağılıma uygunluğu Kolmogorov-Smirnov testi ile değerlendirildi. Normal dağılım gösteren değişkenlerde iki grup karşılaştırmalarında bağımsız örneklem t testi, üç ve daha fazla grup karşılaştırmalarında tek yönlü varyans analizi kullanıldı. Sürekli değişkenler arasındaki ilişkiler Pearson korelasyon analizi ile incelendi. Ölçeklerin iç tutarlılığı Cronbach alfa katsayısı ile değerlendirildi. Gelecekte çocuk sahibi olmayı isteme durumunun yordayıcılarını belirlemek amacıyla ikili lojistik regresyon analizi yapıldı. Tüm analizlerde anlamlılık düzeyi $p<0.05$ olarak kabul edildi.

Bulgular ve Tartışma

Katılımcıların sosyodemografik özellikleri ile çocuk sahibi olma niyetlerine ilişkin bulgular Tablo 1'de sunulmuştur. Katılımcıların yaş ortalaması 20.00±1.74 olup yaşlar 18 ile 26 arasında değişmektedir. Çoğunluğunu kadınlar (%79.5), üniversite ve üzeri eğitim düzeyine sahip bireyler (%91.4) ve öğrenciler (%84.9) oluşturmaktadır. Gelir düzeyi açısından en yüksek oran orta gelir grubunda (%53.5) yer almaktadır.

Tablo 1. Katılımcıların sosyodemografik özellikleri ve çocuk sahibi olmaya ilişkin özelliklerinin dağılımı

Nicel değişkenler	**Mean ± SD**		**Min–Max**
Yaş	20 ± 1.74		18–26
Kategorik değişkenler	**Kategori**	**n**	**%**
Cinsiyet	Erkek	38	20.5
	Kadın	147	79.5
Eğitim durumu	Lise	16	8.6
	Üniversite ve üzeri	169	91.4
Çalışma durumu	Çalışmıyor	18	9.7
	Çalışıyor	10	5.4
	Öğrenci	157	84.9
Gelir Düzeyi	Düşük	50	27.0
	Orta	99	53.5
	Yüksek	3	1.6
	Çok düşük	33	17.8
Yakın gelecekte evlilik düşüncesi	Evet	40	21.6
	Hayır	143	77.3
Gelecekte çocuk sahibi olmayı isteme	Evet	83	44.9
	Hayır	102	55.1
Çocuk sahibi olmak istememenin nedenleri			
Ekonomik zorluk	Evet	122	65.9
	Hayır	63	34.1
İşsizlik	Evet	24	13.0
	Hayır	161	87.0
Gelecek kaygısı	Evet	76	41.1
	Hayır	109	58.9
İklim kaygısı	Evet	12	6.5

	Hayır	173	93.5
Çocuklar özgürlüğü kısıtlar	Evet	25	13.5
	Hayır	160	86.5
Çocukların sorumluluğu fazladır	Evet	58	31.4
	Hayır	127	68.6
Kariyer planları	Evet	33	17.8
	Hayır	152	82.2
Yeterli ebeveynlik becerilerine sahip olmama	Evet	49	26.5
	Hayır	136	73.5

Katılımcıların %21.6'sı yakın gelecekte evlenmeyi düşündüğünü, %77.3'ü ise düşünmediğini belirtmiştir. Gelecekte çocuk sahibi olmayı isteyenlerin oranı %44.9, istemeyenlerin oranı ise %55.1'dir.

Çocuk sahibi olmak istememe nedenleri arasında en sık ekonomik zorluklar (%65.9) bildirilmiştir. Bunu gelecek kaygısı (%41.1), çocukların sorumluluğunun fazla olması (%31.4), yeterli ebeveynlik becerilerine sahip olmama (%26.5), kariyer planları (%17.8), çocukların özgürlüğü kısıtlaması (%13.5), işsizlik (%13.0) ve iklim kaygısı (%6.5) izlemektedir.

Tablo 2. Katılımcıların bazı özelliklerine göre ÇSOMÖ puanları ortalamalarının dağılımı

Kategorik değişkenler	**Kategori**	**n**	**%**	**ÇSOMÖ $\bar{x}$±SD**	**Test ve p**
Cinsiyet	Erkek	38	20.5	94.89±24.56	t=1.315 p=.190
	Kadın	147	79.5	89.37±22.71	
Eğitim durumu	Lise	16	8.6	95.25±17.85	t=0.858 p=.392
	Üniversite ve üzeri	169	91.4	90.05±23.57	
Çalışma durumu	Çalışmıyor	18	9.7	84.89±20.99	F=0.786 p=.457
	Çalışıyor	10	5.4	95.60±23.32	
	Öğrenci	157	84.9	90.82±23.38	
Gelir Düzeyi	Düşük	50	27.0	92.88±23.60	F=0.543 p=.653
	Orta	99	53.5	90.77±22.76	
	Yüksek	3	1.6	87.67±15.01	
	Çok düşük	33	17.8	86.36±24.46	
Yakın gelecekte evlilik düşüncesi	Evet	40	21.6	94.20±23.32	t=1.067 p=.287
	Hayır	143	77.3	89.78±23.08	
Gelecekte çocuk sahibi olmayı isteme	Evet	83	44.9	92.43±24.85	t=1.574 p=.117
	Hayır	102	55.1	88.93±21.65	
Çocuk sahibi olmak istememenin nedenleri*					
Ekonomik zorluk	Evet	63	34.1	94.11±22.12	t=-1.530

					p=.128
	Hayır	122	65.9	88.64±23.52	
İşsizlik	Evet	24	13.0	94.88±20.71	t=-0.992 p=.322
	Hayır	161	87.0	89.85±23.47	
Gelecek kaygısı	Evet	76	41.1	92.30±23.34	t=-0.883 p=.378
	Hayır	109	58.9	89.25±23.02	
İklim kaygısı	Evet	12	6.5	84.83±12.35	t=0.877 p=.382
	Hayır	173	93.5	90.90±23.68	
Çocuklar özgürlüğü kısıtlar	Evet	25	13.5	83.12±17.26	t=1.725 p=.086
	Hayır	160	86.5	91.66±23.76	
Çocukların sorumluluğu fazladır	Evet	58	31.4	83.91±21.34	t=2.660 p=.008
	Hayır	127	68.6	93.51±23.38	
Kariyer planları	Evet	33	17.8	78.03±23.46	t=3.520 p< .001
	Hayır	152	82.2	93.21±22.24	
Yeterli ebeveynlik becerilerine sahip olmama	Evet	49	26.5	85.18±20.31	t=1.890 p=.060
	Hayır	136	73.5	92.42±23.85	

Katılımcıların sosyodemografik özellikleri, çocuk sahibi olmaya ilişkin görüşleri ve çocuk sahibi olmak istememe nedenlerine göre ÇSOMÖ puan ortalamaları Tablo 2'de sunulmuştur. Analiz sonucunda ÇSOMÖ puan ortalamalarının cinsiyet, eğitim durumu, çalışma durumu, gelir düzeyi, yakın gelecekte evlilik düşüncesi ve gelecekte çocuk sahibi olmayı isteme durumuna göre istatistiksel olarak anlamlı farklılık göstermediği belirlenmiştir (p>0.05). Benzer şekilde ekonomik zorluk, işsizlik, gelecek kaygısı, iklim kaygısı ve çocukların özgürlüğü kısıtladığı düşüncesine göre de ÇSOMÖ puan ortalamaları arasında anlamlı fark saptanmamıştır (p>0.05).

Buna karşın, çocukların sorumluluğunun fazla olduğunu düşünen katılımcıların ÇSOMÖ puan ortalamasının, bu görüşe katılmayanlara göre anlamlı düzeyde daha düşük olduğu bulunmuştur (83.91±21.34'e karşı 93.51±23.38; t=2.660, p=0.008). Ayrıca kariyer planlarını çocuk sahibi olmama nedeni olarak belirten katılımcıların ÇSOMÖ puan ortalaması da bu nedeni belirtmeyenlere göre anlamlı düzeyde daha düşüktür (78.03±23.46'ya karşı 93.21±22.24; t=3.520, p<0.001). Yeterli ebeveynlik becerilerine sahip olmama değişkeninde ise fark sınırda anlamlı bulunmuştur (p=0.060).

Tablo 3. Yaş, olumlu motivasyonlar, olumsuz motivasyonlar ve ÇSOMÖ toplam puanı arasındaki korelasyonlar

Değişkenler	**1**	**2**	**3**	**4**
1. Yaş	—			
2. Olumlu Motivasyonlar Alt Boyutu	-.098	—		
3. Olumsuz Motivasyonlar Alt Boyutu	.013	-.153*	—	
4. ÇSOMÖ Toplam Puan	-.082	.828***	.427***	—

Not: Değerler Pearson korelasyon katsayısını (r) göstermektedir. *p < .05, ***p < .001.

Yaş ile olumlu motivasyonlar alt boyutu, olumsuz motivasyonlar alt boyutu ve ÇSOMÖ toplam puanı arasında istatistiksel olarak anlamlı bir ilişki saptanmamıştır (p > .05). Olumlu motivasyonlar alt boyutu ile olumsuz motivasyonlar alt boyutu arasında zayıf düzeyde, negatif yönlü ve istatistiksel olarak

anlamlı bir ilişki belirlenmiştir (r = -.153, p = .037). Buna göre olumlu çocuk sahibi olma motivasyonları arttıkça, olumsuz çocuk sahibi olma motivasyonlarının azalma eğiliminde olduğu söylenebilir. Ayrıca olumlu motivasyonlar alt boyutu ile ÇSOMÖ toplam puanı arasında güçlü düzeyde pozitif yönlü (r = .828, p < .001), olumsuz motivasyonlar alt boyutu ile ÇSOMÖ toplam puanı arasında ise orta düzeyde pozitif yönlü (r = .427, p < .001) anlamlı ilişki bulunmuştur.

Tablo 4. Katılımcıların çocuk sahibi olmayı isteme durumunu etkileyen faktörlere ilişkin ikili lojistik regresyon analizi

Değişken	**B**	**OR**	**p**
Olumlu motivasyonlar alt boyutu	0.025	1.026	.004
Olumsuz motivasyonlar alt boyutu	-0.049	0.953	<.001

Not: Model genel olarak anlamlı bulunmuştur ($\Delta\chi^2$ = 38.726, p < .001; Nagelkerke R^2 = 0.255). Diğer değişkenler istatistiksel olarak anlamlı değildir (p > .05).

Katılımcıların çocuk sahibi olmayı isteme durumunu etkileyen faktörleri belirlemek amacıyla yapılan ikili lojistik regresyon analizi sonucunda kurulan modelin genel olarak anlamlı olduğu saptanmıştır ($\Delta\chi^2$=38.726, p<.001). Modelin açıklayıcılık düzeyi Nagelkerke R²'ye göre %25.5'tir. Analizde, olumlu motivasyonlar alt boyutu toplam puanının çocuk sahibi olmayı isteme olasılığını anlamlı düzeyde artırdığı belirlenmiştir (OR=1.026, p=.004). Buna göre olumlu motivasyon puanındaki her 1 puanlık artış, çocuk sahibi olmayı isteme olasılığını yaklaşık %2.6 artırmaktadır. Buna karşılık, olumsuz motivasyonlar alt boyutu toplam puanının çocuk sahibi olmayı isteme olasılığını anlamlı düzeyde azalttığı bulunmuştur (OR=0.953, p<.001). Olumsuz motivasyon puanındaki her 1 puanlık artış, çocuk sahibi olmayı isteme olasılığında yaklaşık %4.7 azalma ile ilişkilidir.

Yakın gelecekte evlenmeyi düşünme durumu, cinsiyet, eğitim durumu, çalışma durumu, gelir düzeyi ve yaş değişkenlerinin çocuk sahibi olmayı isteme durumu üzerinde istatistiksel olarak anlamlı etkisinin olmadığı belirlenmiştir (p>.05).

Sonuç ve Öneriler

Bu çalışmada, bekar genç bireylerde çocuk sahibi olma motivasyonu ve etkileyen faktörler incelenmiştir. Elde edilen bulgular, katılımcıların yarısından fazlasının gelecekte çocuk sahibi olmayı istemediğini ve bu durumun en çok ekonomik zorluklar, gelecek kaygısı ve çocuk bakımına ilişkin sorumluluk algısı ile ilişkili olduğunu göstermektedir.

Araştırmada sosyodemografik değişkenlerin çocuk sahibi olma motivasyonu üzerinde anlamlı bir etkisinin bulunmaması, bu kararın daha çok bireylerin algıları, tutumları ve psikolojik değerlendirmeleri ile şekillendiğini düşündürmektedir. Özellikle çocuk sahibi olmanın yüksek sorumluluk gerektirdiği algısı ve kariyer planlarının önceliklendirilmesi, motivasyonu azaltan önemli faktörler olarak öne çıkmıştır.

Ayrıca, olumlu çocuk sahibi olma motivasyonlarının artmasının çocuk sahibi olma isteğini artırdığı, olumsuz motivasyonların ise bu isteği azalttığı belirlenmiştir. Bu durum, doğurganlık niyetlerinin yalnızca dışsal koşullarla değil, bireylerin içsel değerlendirmeleri ve algılarıyla da yakından ilişkili olduğunu ortaya koymaktadır.

Öneriler

- Genç bireylerde çocuk sahibi olmaya ilişkin olumlu algıları güçlendirmeye yönelik psikoeğitim programları geliştirilmelidir.
- Üreme sağlığı ve doğurganlık farkındalığını artırmaya yönelik eğitimler özellikle üniversite düzeyinde yaygınlaştırılmalıdır.

- Ekonomik kaygıların çocuk sahibi olma kararları üzerindeki etkisini azaltmak amacıyla gençlere yönelik sosyal destek ve aile politikaları güçlendirilmelidir.
- Kariyer ve ebeveynlik rollerinin dengelenmesini destekleyen esnek çalışma modelleri ve sosyal politikalar geliştirilmelidir.
- Gelecek kaygısı ve ebeveynlik yeterliliği algısını azaltmaya yönelik danışmanlık ve rehberlik hizmetleri sunulmalıdır.
- İlerleyen çalışmalarda daha geniş ve farklı sosyodemografik gruplarla araştırmalar yapılarak bulguların genellenebilirliği artırılmalıdır.
- Nitel araştırmalar ile genç bireylerin çocuk sahibi olma konusundaki derinlemesine algı ve deneyimleri incelenmelidir.

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FOREST THERAPY: NATURE-BASED APPROACHES IN PUBLIC HEALTH

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ABSTRACT

Forest bathing, which is considered a component of a healthy lifestyle in Japan, has gradually spread worldwide and gained acceptance. However, for a long time, it did not receive sufficient attention in many parts of the world and was not fully understood. Today, the positive effects of forest therapy on public health have been demonstrated, and the number of studies on this topic is steadily increasing. The importance of nature and forest therapy is growing due to its ability to support both physical and mental health, as well as its stress- and anxiety-reducing effects.

In Europe and the United States, forest therapy practices are attracting attention in terms of public health and well-being; in Germany, Heringsdorf therapy walks are conducted under the guidance of therapists, while in the United States, programs such as ParkRx Day integrate nature-based health approaches into daily life. In Türkiye, examples from Europe and the United States can serve as useful models. The forested areas along the Black Sea coastline also hold similar potential.

Therapeutic Forest Park projects carried out in the Artvin and Marmara regions aim to explore the therapeutic potential of forests and natural areas and highlight their value for public health. These initiatives demonstrate that natural environments not only offer visual aesthetic benefits but also serve as valuable resources that support public health.

Keywords: Public health, Nature-based health, Forest therapy

Introduction

Shinrin-yoku, known as “forest bathing,” is a practice recognized in Japan as a component of a healthy lifestyle. This approach has subsequently spread and been adopted in many parts of the world (Ergüven, 2019). Forest bathing is a traditional practice that involves visiting forests and breathing in the forest air. The positive contributions of forests to public health are based on scientific evidence; however, the therapeutic and healing aspects of forests were largely overlooked for a long time (Kur- und Heilwald Heringsdorf, 2026). Today, there is a growing body of research worldwide demonstrating the beneficial effects of forests and natural environments on health (Antonelli, Barbieri, & Donelli, 2019).

Due to its positive effects on physical and mental well-being, forest therapy is gaining increasing attention in Europe as a means of supporting public health and well-being. Moreover, a comprehensive body of research, predominantly conducted in Asian countries, indicates that nature-based practices such as walking, observation, and mindfulness in natural environments can produce beneficial therapeutic effects on hypertension as well as mental health problems such as stress, depression, and anxiety. These practices may reduce stress in the short term and lead to changes in cortisol levels (Antonelli, Barbieri, & Donelli, 2019; Stier-Jarmer et al., 2021). However, research in this field is still insufficient, and more comprehensive scientific studies are needed.

Materials and Methods

The study was conducted based on a literature review and comparative analysis of forest therapy practices in Japan, Europe, the United States, and Türkiye. Data were collected from the Web of Science (WOS), TR Dizin, and official websites, focusing on forest bathing, therapeutic forest parks, and nature-based health interventions. Articles examining the physiological and psychological effects of forest

therapy were reviewed. Programs such as ParkRx Day in the United States and Heringsdorfer therapy walks in Germany were also analyzed. Additionally, the potential for implementing forest therapy in Türkiye was assessed using data from the Terapi Orman Parkı project in Camili Valley and ongoing studies in the Marmara region.

Findings

- ✓ **Healthy Parks, Healthy People**

In the United States, parks and natural areas play a central role within the National Park Service's health promotion programs. A vision and objective have been established to utilize both urban and natural park spaces to support individuals' mental, physical, and emotional health, as well as their social well-being. In line with this approach, nature- and outdoor-based activities are presented as an alternative lifestyle option for American citizens (Kondo, Oyekanmi, Gibson, South, Bocarro, & Hipp, 2020; National Park Service, 2024).

- ✓ **ParkRx Day**

ParkRx Day is celebrated as a special day encouraging people to go outdoors and experience the healing power of parks and nature. Healthcare providers direct their patients to natural areas and parks to support their health. Various activities are organized in natural settings under the guidance of park staff and healthcare professionals, promoting public health (National Park Service, 2024).

- ✓ **Heringsdorfer Therapy Walks**

Heringsdorfer, opened in 2017, is Europe's first spa and therapeutic forest. Visitors of all ages can participate in activities such as therapy walks, exercise sessions, and moonlight walks offered free of charge. The combination of oxygen-rich forest air and salty sea breeze can provide beneficial effects on cardiovascular and respiratory conditions. During therapist-guided walks, simple exercises tailored to the individual help participants make more effective use of the forest environment. This approach supports the immune system, enhances metabolism, and promotes inner calm (Kur- und Heilwald Heringsdorf, 2026).

Figure 1. Heringsdorf spa and healing forest (MV Tourismus GmbH)

✓ **Forest Therapy in Türkiye**

In Türkiye, forested areas along the Black Sea coast hold significant potential for forest therapy. As seen in Germany and other global examples, local guides and experts trained under university supervision can lead such initiatives. These applications not only contribute to public health but also support regional development (Ergüven, 2019). The Terapi Orman Parkı project in Camili Valley, covering 30 hectares, emphasizes the calming effects of the forest (Orman Genel Müdürlüğü, 2023). Additionally, studies on the therapeutic potential of forests in the Marmara region are being conducted by the General Directorate of Forestry.

Figure 2. Forest therapy establishment area in Artvin

Table 1. Forest Therapy Programs and Their Benefits in Different Countries/Regions

Country / Region	Program / Application	Benefits
USA	ParkRx Day	Stress reduction, immune support, improved physical and mental health
Germany	Heringsdorfer Therapy Walks	Improved cardiovascular and respiratory health, increased inner peace
Turkey (Black Sea)	Therapy Forest Park , Camili Valley	Calming effect, contribution to public health, support for regional development
Turkey (Marmara)	Forest therapy studies	Assessment of the therapeutic potential of forests

Discussion

Examples from the United States and Europe demonstrate that the structured use of natural areas provides significant benefits for physical, mental, and social well-being. Guided interactions with nature, combined with simple exercises and mindfulness practices, can strengthen the immune system, reduce stress, and improve cardiovascular and respiratory health. In this regard, programs such as ParkRx Day and Heringsdorfer therapy walks can be considered good examples. Adapting these

practices to Türkiye, particularly in the Black Sea and Marmara regions, offers advantages for both public health and regional development. For the successful implementation and broad acceptance of such programs, the following points should be considered:

- Training qualified personnel,
- Conducting scientific monitoring to evaluate the program and its framework,
- Collaborating with universities and local authorities,
- Integrating the local cultural context and community participation,
- Ensuring the sustainability of forest therapy initiatives.

Conclusion and Recommendations

Conclusion:

Practices in Europe and the United States demonstrate that natural areas are no longer viewed merely as scenic environments but as important resources that support public health.

Recommendations:

- Areas in Türkiye with forest therapy potential should be effectively utilized to enhance both public health and tourism benefits.
- Short-term pilot forest therapy programs can be implemented in selected regions to evaluate their health impacts.
- Training programs can be developed to certify guides who will lead forest therapy practices.

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CENTRAL SEROUS CHORIORETINOPATHY DETECTED FOLLOWING COVID-19 DISEASE

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ABSTRACT

Purpose: We aimed to present two central serous chorioretinopathy (CSCR) cases that developed after COVID-19.

Materials and Methods: Case 1, A 41-year-old man complained of blurred vision and seeing objects darker in his right eye since about 3 weeks. His history revealed that he had been diagnosed with COVID-19 32 days ago. Case 2, A 35-year-old man complained of blurred and dark vision and of seeing distorted objects from his left eye since about 4 weeks. His history revealed a diagnosis of COVID-19 40 days ago. Both patients underwent comprehensive anterior and posterior segment examinations, including assessments of best corrected visual acuity, and optical coherence tomography (OCT) scans.

Results: Case 1, serous retinal detachment was observed in the fovea centre in the left eye. On spectral domain enhanced depth imaging optical coherence tomography scan (EDI-OCT), hyper-reflective dots were detected in the ganglion cell layer, inner plexiform and inner nuclear layers in the right eye; while hyper-reflective dots were detected in all layers of the retina with increased sub-foveal choroidal thickness, subretinal fluid and retinal pigment epithelial detachment in the left eye. Case 2, serous retinal detachment was observed in the fovea centralis of the left eye. On EDI-OCT, hyper-reflective dots were detected in the ganglion cell layer, inner plexiform, inner nuclear and outer plexiform layers in the right eye; while hyper-reflective dots were detected in all layers of the retina with increased sub-foveal choroidal thickness, subretinal fluid and retinal pigment epithelial detachment in the left eye.

Conclusions: Coexistence of COVID-19 and CSCR, both of which are thought to have autonomic dysfunction, may explain the CSCR we detected in 2 patients with COVID-19 in our study.

Keywords Central serous chorioretinopathy, COVID-19, autonomic dysfunction

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that causes coronavirus disease (COVID-19) has been spread worldwide and was declared a pandemic by the World Health Organization (Epidemiology Unit, 2020; WHO, 2020). COVID-19 is thought to be transmitted mainly through droplets in the environment as a result of contact with infected patients (Fan *et al.*, 2020; Van Doremalen *et al.*, 2020). It has been reported that COVID-19, caused by SARS-CoV-2, which infects host cells using renin-Angiotensin-Converting Enzyme-2 (ACE2) receptors expressed in many tissues, causes endothelial cell inflammation and dysfunction, causing tissue hypoperfusion and thrombosis (Becker, 2020; Carnevale, Beretta and Morbini, 2020; Casagrande *et al.*, 2020a; Varga *et al.*, 2020). The presence of the ACE2 receptor has been reported in many ocular tissues, including choroid and retinal vascular endothelial cells (Choudhary *et al.*, 2017).

Central serous chorioretinopathy (CSCR), with central vision loss and central scotoma, is a disease that is characterized by serous neuroretinal detachment due to subretinal fluid accumulation and involves the macular region, and its pathogenesis is not fully understood. In CSCR, factors such as endogenous or exogenous corticosteroids, increased sympathetic activity and stress are blamed in the etiology, and vascular factors are reported to be prominent in pathogenesis (Gelber and Schatz, 1987; Bouzas, Karadimas and Pournaras, 2002; Michael *et al.*, 2003; Tewari *et al.*, 2006). Dysfunction of the retinal pigment epithelium (RPE) and hyperpermeability of the vessels of the choroid are blamed in CSCR,

which is a pachycoroid disease. In the disease, due to the dysfunction of choroidal capillaries and the compensatory mechanism that develops after ischemia, excessive permeability in the vascular structures causes leakage between vascular structures and subretinal fluid accumulation (Baran, Gürlü and Esgin, 2005; Imamura *et al.*, 2009; Cheung *et al.*, 2019).

Retinal changes such as hyperreflective lesions, cotton wool spots and microhemorrhage have been described in association with COVID-19 (Marinho *et al.*, 2020a). However, to our knowledge, this study is the first CSCR report reported after COVID-19.

Materials and Methods

Case 1, A 41-year-old man complained of blurred vision and seeing objects darker in his right eye since about 3 weeks. His history revealed that he had been diagnosed with COVID-19 32 days ago. Case 2, A 35-year-old man complained of blurred and dark vision and of seeing distorted objects from his left eye since about 4 weeks. His history revealed a diagnosis of COVID-19 40 days ago. Both patients underwent comprehensive anterior and posterior segment examinations, including assessments of best corrected visual acuity, and optical coherence tomography (OCT) scans.

Results:

Case 1: A 41-year-old man complained of blurred vision and seeing objects darker in his right eye since about 3 weeks. His history revealed that he had been diagnosed with COVID-19, through reverse transcriptase-polymerase chain reaction analysis, 32 days ago. On examination, the best corrected visual acuity was 20/20 and 20/40 in the right and left eye, respectively. Both anterior segments were unremarkable. Intraocular pressure in both eyes was 14 mmHg. While the right eye was unremarkable in fundus examination, serous retinal detachment was observed in the fovea centre in the left eye. On spectral domain enhanced depth imaging optical coherence tomography scan (Heidelberg Engineering, Inc., Heidelberg, Germany), hyper-reflective dots were detected in the ganglion cell layer, inner plexiform and inner nuclear layers in the right eye; while hyper-reflective dots were detected in all layers of the retina with increased sub-foveal choroidal thickness, subretinal fluid and retinal pigment epithelial detachment in the left eye. (Fig. 1a, b).

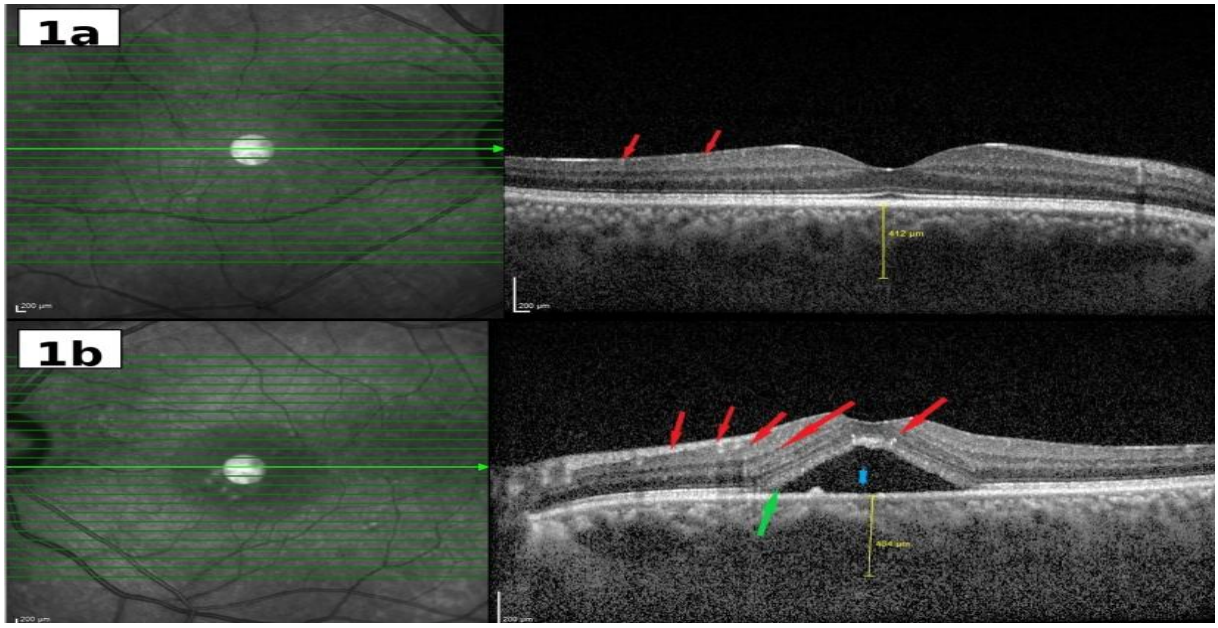

Figure 1. Optical coherence tomography image from patient 1. Hyper-reflective dots were detected in the ganglion cell layer, inner plexiform and inner nuclear layers in the right eye (red arrows) (**1a),**,

while hyper-reflective dots were detected in all layers of the retina (red arrows) with increased sub-foveal choroidal thickness, subretinal fluid (blue star) and retinal pigment epithelial detachment (green arrow) in the left eye (**1b)**.

Case 2: A 35-year-old man complained of blurred and dark vision and of seeing distorted objects from his left eye since about 4 weeks. His history revealed a diagnosis of COVID-19 by reverse transcriptase-polymerase chain reaction analysis, 40 days ago. On examination, the best corrected visual acuity was 20/20 and 20/50 in the right and left eye, respectively. Both anterior segments were unremarkable. Intraocular pressure was 16 mmHg in both eyes. While the fundus examination of the right eye revealed no abnormalities, serous retinal detachment was observed in the fovea centralis of the left eye. On enhanced depth imaging optical coherence tomography, hyper-reflective dots were detected in the ganglion cell layer, inner plexiform, inner nuclear and outer plexiform layers in the right eye; while hyper-reflective dots were detected in all layers of the retina with increased sub-foveal choroidal thickness, subretinal fluid and retinal pigment epithelial detachment in the left eye. (Figure 2a,b)

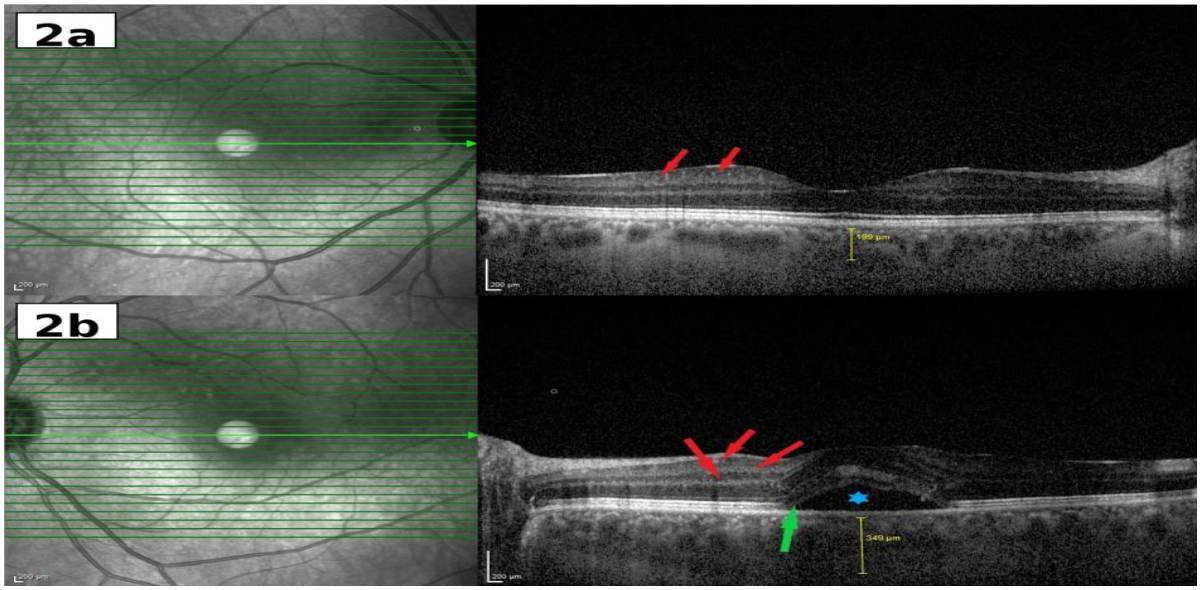

Figure 2. Optical coherence tomography image from patient 2. Hyper-reflective dots were detected in the ganglion cell layer, inner plexiform, inner nuclear and outer plexiform layers in the right eye (red arrows) (**2a)**, while hyper-reflective dots were detected in all layers of the retina (red arrows) with increased sub-foveal choroidal thickness, subretinal fluid (blue star) and retinal pigment epithelial detachment (green arrow) in the left eye (**2b)**.

Both patients were diagnosed with CSCR associated with COVID-19. Thereafter, the patients were scheduled for follow-up visits at the retina unit of our clinic.

Discussion

Although, ocular symptoms seen in COVID 19 patients have mostly been reported as anterior segment disorders such as conjunctival congestion and conjunctivitis, studies have reported that viral RNA was detected in retina and corneal biopsies of COVID-19 patients. (Casagrande *et al.*, 2020b; Sawant *et al.*, 2020; Xia *et al.*, 2020) Angiotensin-Converting Enzyme-2, the cellular receptor of SARS-CoV-2, has been reported to exist in ocular tissues such as the retina. (Casagrande *et al.*, 2020a) Additionally, experimental studies have reported that the virus can cause retinitis, while clinical studies have shown the presence of fine cotton-wool stains and micro-haemorrhages in the retina.(Wang *et al.*, 2000; Marinho *et al.*, 2020b) It has been reported that hypercoagulation, which occurs due to the hyperinflammatory response caused by SARS-CoV-2, causes retinal vascular occlusion and

ophthalmoplegia, and that ophthalmoparesis may also be observed in these patients.(Acharya *et al.*, 2020; Panigada *et al.*, 2020; Sheth *et al.*, 2020).

Autonomic (sympathetic and parasympathetic) disorders such as orthostatic intolerance, postural tachycardia and episodic hyperadrenergic fluctuations have been reported in COVID-19 patients.(Miglis *et al.*, 2020) In addition, autonomic dysfunction has been reported in up to 50% of patients after SARS.(Lo *et al.*, 2005) Similarly, abnormal choroidal blood flow secondary to autonomic nervous system dysfunction has been reported in patients with CSCR.(Tewari *et al.*, 2006) According to the results of these studies, the existence of autonomic dysfunction in both CSCR and COVID-19 patients may explain the CSCR we detected in 2 patients with COVID-19 in our study.

In our study, hyper-reflective lesions were detected in the ganglion cell layer, inner plexiform and inner nuclear layers of the eyes of the patients. Similarly, in a study examining COVID-19 patients with normal visual acuity, hyper-reflective lesions in the ganglion cells and inner plexiform layers in both eyes of all patients were reported.(Marinho *et al.*, 2020c)

In conclusion, the CSCR we detected in 2 patients in the early period after COVID-19 may have been due to the autonomic dysfunction that may develop due to the disease. Therefore, this study may be important in terms of its potential to contribute to a better understanding of the systemic effects of COVID-19.

Declaration of conflicting interests

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DISRUPTION OF THE NEUROMUSCULAR JUNCTION IN SARCOPENIA: DIAGNOSTIC POTENTIAL OF SERUM BIOMARKERS

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ABSTRACT

Objective: Sarcopenia is a skeletal muscle disorder associated with aging and characterized by a progressive decline in muscle mass, muscle strength, and physical performance, representing a significant public health concern. Increasing evidence suggests that structural and functional alterations occurring at the neuromuscular junction (NMJ) contribute substantially to the pathogenesis of sarcopenia. The aim of this review is to evaluate serum biomarkers that may reflect NMJ integrity and to particularly assess the potential diagnostic relevance of the C-terminal agrin fragment (CAF) in relation to sarcopenia.

Methods: This review evaluated recent literature concerning sarcopenia, the neuromuscular junction, and related biomarkers. A comprehensive search of the PubMed database was conducted using the keywords “sarcopenia,” “neuromuscular junction,” “agrin,” “C-terminal agrin fragment,” and “biomarkers.” The retrieved studies were analyzed with respect to their findings on NMJ function and their association with muscle loss.

Results: The neuromuscular junction plays a critical role in maintaining muscle function by enabling synaptic communication between motor neurons and muscle fibers. Age-related alterations in this structure have been reported to contribute to reductions in both muscle mass and strength. Neurotrophic factors and synaptic regulatory proteins are essential for preserving NMJ stability. Molecules such as brain-derived neurotrophic factor (BDNF), calcitonin gene-related peptide (CGRP), and growth-associated protein-43 (GAP-43) have been implicated in these processes. In addition, proteolytic cleavage of agrin by the enzyme neurotrypsin produces the C-terminal agrin fragment (CAF), which can be detected in circulation. Elevated serum levels of CAF have been reported in individuals with sarcopenia, suggesting that this fragment may reflect NMJ degeneration and muscle deterioration.

Conclusion: Current evidence indicates that biomarkers associated with the neuromuscular junction may contribute to a better understanding of the biological mechanisms underlying sarcopenia. In particular, molecules related to NMJ integrity—especially CAF—may serve as promising biomarkers for the early detection of sarcopenia and for monitoring muscle loss. However, further large-scale and prospective studies are required to clarify their clinical applicability.

Keywords: Sarcopenia, neuromuscular junction, agrin, C-terminal agrin fragment (CAF), biomarkers.

Introduction

Sarcopenia is an age-related skeletal muscle disorder characterized by the progressive loss of muscle mass, strength, and physical performance, and it is increasingly recognized as a major contributor to frailty, disability, and mortality in older adults (Cui et al., 2025; Kupriyanova et al., 2025). Recent advances in the understanding of sarcopenia have shifted the focus from purely muscular mechanisms to include neural components, particularly the role of the neuromuscular junction (NMJ) in disease onset and progression (Pratt et al., 2020; Liu et al., 2025).

The NMJ is a specialized synapse that enables communication between motor neurons and skeletal muscle fibers. Its structural and functional integrity is essential for maintaining muscle contraction and motor unit stability. Emerging evidence suggests that NMJ dysfunction is an early and critical event in sarcopenia, often preceding detectable muscle atrophy and functional decline (Pratt et al., 2020; Cui et al., 2025). Age-related alterations in NMJ morphology—including synaptic fragmentation, reduced

acetylcholine receptor density, and impaired synaptic transmission—have been shown to contribute to motor unit loss and ineffective reinnervation.

Recent studies utilizing electrophysiological and omics-based approaches further support the concept of neurogenic sarcopenia, highlighting that denervation, impaired neuromuscular signaling, and disruption of trophic support pathways play a central role in muscle degeneration (Cui et al., 2025; Kupriyanova et al., 2025). These findings indicate that sarcopenia is not solely a muscle disease but rather a neuromuscular disorder involving complex interactions between the nervous system and skeletal muscle.

In parallel with these mechanistic insights, there has been increasing interest in identifying circulating biomarkers that reflect NMJ integrity. Among these, the C-terminal agrin fragment (CAF), a product of agrin cleavage by neurotrypsin, has emerged as one of the most promising candidates. CAF is released into circulation following NMJ degradation and has been shown to correlate with muscle weakness, reduced physical performance, and sarcopenia severity (Pratt et al., 2021; Qaisar et al., 2024).

Recent clinical and translational studies have demonstrated that CAF levels increase with age and are associated with impaired muscle health across different populations. Moreover, CAF has been shown to respond to interventions such as exercise and rehabilitation, suggesting its potential utility not only as a diagnostic biomarker but also as a tool for monitoring therapeutic outcomes (Soendenbroe et al., 2025). In addition, elevated CAF levels have been observed in neurodegenerative conditions such as Parkinson's and Alzheimer's diseases, further supporting its role as a marker of neuromuscular integrity (Karim et al., 2022).

Beyond CAF, other NMJ-related biomarkers, including neurofilament light chain (NfL), brain-derived neurotrophic factor (BDNF), and glial cell line-derived neurotrophic factor (GDNF), have been investigated for their potential role in reflecting neuromuscular health. These biomarkers provide complementary information regarding axonal integrity, synaptic stability, and neurotrophic signaling, reinforcing the concept that sarcopenia involves a complex network of neuro-muscular interactions (Karim et al., 2022; Liu et al., 2025).

Materials and Methods

This study was conducted as a narrative review to synthesize current knowledge regarding neuromuscular junction dysfunction and serum biomarkers in sarcopenia.

A comprehensive literature search was performed using PubMed and related databases. The search strategy included combinations of the following keywords: "sarcopenia," "neuromuscular junction," "agrin," "C-terminal agrin fragment," "CAF," "biomarkers," and "denervation."

Inclusion criteria were:

- Studies investigating NMJ structure or function in aging or sarcopenia
- Studies evaluating circulating biomarkers related to NMJ integrity
- Clinical, experimental, and review articles

Exclusion criteria included:

- Irrelevant studies not addressing NMJ or sarcopenia
- Non-English publications without accessible data

Both original research articles and review studies were included to provide a comprehensive overview. Special emphasis was placed on studies investigating CAF and multi-marker approaches.

Findings and Discussion

1. Neuromuscular Junction Dysfunction in Sarcopenia

The NMJ plays a central role in maintaining skeletal muscle function. Age-related degeneration of this synapse is now recognized as a key contributor to sarcopenia.

Morphological changes include fragmentation of postsynaptic structures, reduced acetylcholine receptor density, and degeneration of presynaptic terminals. These structural alterations result in impaired synaptic transmission and reduced muscle activation (Pratt et al., 2020). Denervation of muscle fibers is a hallmark of NMJ dysfunction. Although compensatory reinnervation occurs through collateral sprouting, this process becomes less efficient with aging. Consequently, muscle fibers undergo atrophy and eventual loss.

Electrophysiological studies demonstrate increased neuromuscular transmission instability and reduced motor unit numbers, suggesting that NMJ dysfunction precedes measurable muscle loss (Cui et al., 2025).

2. Molecular Mechanisms of NMJ Degeneration

NMJ stability is regulated by a complex interplay of neurotrophic factors, synaptic proteins, and extracellular matrix components.

Neurotrophic factors such as BDNF and GDNF are essential for synaptic maintenance. Reduced levels of these molecules have been associated with impaired NMJ integrity and decreased muscle function (Karim, Iqbal, Muhammad, & Qaisar, 2022).

Agrin plays a key role in clustering acetylcholine receptors at the postsynaptic membrane. Its cleavage by neurotrypsin produces CAF, which serves as an indicator of NMJ degradation (Monti et al., 2021).

Chronic inflammation also contributes to NMJ deterioration. Elevated levels of inflammatory cytokines, including IL-6 and TNF-α, promote catabolic pathways and exacerbate muscle loss (Liu, Chen, & Cui, 2025). Additionally, recent omics-based studies highlight the importance of neurogenic mechanisms, including gene expression changes and epigenetic regulation, in NMJ dysfunction (Kupriyanova et al., 2025).

3. C-Terminal Agrin Fragment (CAF) as a Biomarker

CAF has emerged as one of the most promising biomarkers of NMJ degradation. The ilSIRENTE study demonstrated that elevated serum CAF levels are significantly associated with reduced muscle mass and physical performance in older adults (Landi et al., 2016).

Similarly, the GenoFit study identified CAF as an early biomarker capable of detecting subclinical sarcopenia before overt functional decline (Pratt et al., 2021). Population-based studies show that CAF levels increase with age and are inversely correlated with muscle strength and lean mass (Qaisar et al., 2024).

Moreover, CAF has been shown to reflect NMJ damage in other conditions, such as myasthenia gravis, supporting its role as a general biomarker of neuromuscular integrity (Yasuda et al., 2017).

4. CAF in Disease States and Clinical Context

CAF levels are elevated in various pathological conditions associated with neuromuscular dysfunction. In Alzheimer's disease, CAF concentrations correlate with sarcopenia severity and functional dependency (Karim et al., 2022). Similarly, in Parkinson's disease, elevated CAF levels are associated with reduced muscle strength and physical performance.

Interestingly, interventions such as exercise have been shown to modulate CAF levels, suggesting its potential utility in monitoring therapeutic responses (Soendenbroe et al., 2025).

5. Other NMJ-Related Biomarkers

In addition to CAF, several biomarkers have been investigated:

- Neurofilament light chain (NfL): indicator of axonal damage
- BDNF and GDNF: markers of neurotrophic support
- Inflammatory cytokines: IL-6, TNF-α
- Muscle-related proteins: myostatin, GDF-15

Multi-marker approaches have demonstrated improved diagnostic accuracy. The BIOSPHERE study identified a panel of biomarkers associated with physical frailty and sarcopenia (Calvani et al., 2020).

Another mediator upregulated upon denervation is growth-associated protein 43 (GAP-43), which is found in almost all neurons during axonal growth and is particularly abundant in axonal growth cones. GAP-43 is widely expressed in the central nervous system during the perinatal period and its levels decrease with aging. However, GAP-43 increases following denervation, contributing to the muscle regeneration process (Yuan et al., 2024).

6. Clinical Implications and Limitations

Serum biomarkers offer several advantages:

- Non-invasive and easily measurable
- Potential for early detection
- Utility in monitoring disease progression

However, limitations include:

- Lack of standardized reference values
- Variability in assay methods
- Influence of comorbid conditions

Therefore, further validation is required before routine clinical implementation.

Conclusion and Recommendations

Taken together, current evidence strongly supports the hypothesis that NMJ disruption is a key driver of sarcopenia and that circulating biomarkers—particularly CAF—may provide valuable tools for early diagnosis and disease monitoring. However, despite promising findings, further research is needed to standardize measurement methods, establish reference ranges, and validate these biomarkers in large-scale clinical studies.

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ÇOCUK HASTADA POSTERİOR MANDİBULADA RADİKÜLER KİSTİN CERRAHİ YÖNETİMİ VE ENDODONTİK REHABİLİTASYONU: OLGU SUNUMU VE LİTERATÜR DERLEMESİ

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Özet

Radiküler kist, nekrotik pulpa ile ilişkili periapikal inflamasyonun periodontal ligamentte yer alan Malassez epitel artıkları üzerinde proliferatif etki oluşturması sonucunda gelişen ve odontojenik kistlerin en sık görülen inflamatuar alt tipini temsil eden patolojik bir oluşumdur [1-3,7].

Pediatrik yaş grubunda ve özellikle daimi dentisyonda görülme sıklığı daha düşüktür; bu nedenle çocuk hastalarda posterior mandibulada daimi molarlarla ilişkili radiküler kist olguları klinik açıdan dikkat çekicidir [4-7,19,20].

Bu makalede sağ posterior mandibular bölgede ağrı şikâyeti ile başvuran 12 yaşındaki kız çocuğunda 46 ve 47 numaralı daimi dişlerin apeksleri ile ilişkili radiküler kistin tanı ve tedavi süreci, güncel literatür eşliğinde sunulmaktadır.

Radyografik incelemede 46 ve 47 numaralı dişlerin kök apekslerini içeren, sınırları belirgin radyolüsent lezyon saptanmış; üç boyutlu anatomik değerlendirme amacıyla gerçekleştirilen konik ışınlı bilgisayarlı tomografi incelemesinde lezyonun sağ posterior mandibulada yaklaşık 15 x 10 x 6 mm boyutlarında olduğu belirlenmiştir.

Pedodonti kliniğine konsültasyonu sonrası yapılan elektrikli pulpa testinde her iki daimi moların devital olduğu görülmüş; primer enfeksiyon kaynağının ortadan kaldırılması amacıyla 46 ve 47 numaralı dişlere endodontik tedavi uygulanmıştır.

Endodontik rehabilitasyonu takiben lokal anestezi altında vestibüler insizyonla flep kaldırılmış, bukkal kortikal kemik üzerinden lezyona ulaşılarak enükleasyon gerçekleştirilmiş ve materyal histopatolojik incelemeye gönderilmiştir.

Histopatolojik değerlendirme radiküler kist tanısını doğrulamış, postoperatif dönemde hastanın semptomları tamamen gerilemiş ve hasta kemik rejenerasyonu ile tedavi edilen dişlerin uzun dönem stabilitesinin izlenmesi amacıyla düzenli kontrole alınmıştır.

Bu olgu, çocuk hastalarda daimi dişlerde posterior mandibulada yer alan inflamatuar periapikal lezyonlarda yalnızca cerrahi eksizyonun değil, enfeksiyon kaynağını ortadan kaldıran endodontik yaklaşımın da tedavi başarısında belirleyici olduğunu göstermekte; ayrıca uygun olgu seçimi ile daimi dişlerin korunmasının mümkün olduğunu vurgulamaktadır.

Anahtar kelimeler: Radiküler kist, Mandibula,Çocuk hasta,Enükleasyon

Giriş

Radiküler kist, pulpal nekroz ve buna sekonder gelişen periapikal inflamatuar yanıt sonucunda periodontal ligament içindeki Malassez epitel artıkları kaynaklı gelişen inflamatuar odontojenik bir kist olarak tanımlanır ve oral ve maksillofasiyal bölgedeki en yaygın kistik lezyonudur[1,2,7].Patogenezde intraradiküler enfeksiyon, bakteriyel toksinlerin ve inflamatuar mediyatörlerin periapikal dokulara yayılması, epitel-stroma etkileşimi ve kistik boşluk içindeki ozmotik-hidrostatik basınç değişiklikleri birlikte rol oynar [2,3,9,19].Nair, apikal periodontitisin esas olarak endodontik kökenli mikrobiyal uyarana bağlı olduğunu ve radiküler kistlerin bu inflamatuar spektrum içerisinde değerlendirilmesi gerektiğini vurgulamıştır[2,3].

Radiküler kistler daimi dentisyonda daha sık gözlenirken, süt dişlerinde ve genel olarak çocuk yaş grubunda daha nadir rapor edilmektedir; bu durumun kısa fizyolojik diş ömrü, aksesuar kanallar aracılığıyla daha kolay drenaj, lezyonların spontan gerileme potansiyeli ve patolojik inceleme için yeterince gönderilmemesi gibi nedenlerle ilişkili olduğu ileri sürülmektedir [4-6,8,19].Lustmann ve Shear, 1985 tarihli klasik derlemelerinde süt dişlerinden kaynaklanan radiküler kistlerin nadir olduğuna dikkat çekmiş; buna karşın Mass ve arkadaşları, primer molarlarla ilişkili radyolüsent lezyonların histopatolojik incelemesinde radiküler kist oranının düşünüldüğünden daha yüksek olabileceğini göstermiştir [4,5].Grundy ve arkadaşlarının pulpa tedavisi uygulanmış süt molarlarla ilişkili kistik lezyonlara dikkat çeken çalışması da, pediatrik hastalarda periapikal radyolüsensilerin rutin olarak granülom kabul edilmemesi gerektiğini ortaya koymuştur [6].

Daha güncel epidemiyolojik veriler de odontojenik çene kistleri içinde radiküler kistin en sık görülen tip olduğunu göstermektedir; Du ve arkadaşlarının 1.038 olguluk serisinde radiküler kistler tüm odontojenik çene kistlerinin yaklaşık %58,96'sını oluşturmaktadır[7].

Bununla birlikte pediatrik popülasyonda görülen radiküler kistlerin büyük çoğunluğu süt mandibular molarlarla ilişkilidir; daimi dentisyonda, özellikle çocuk yaş grubunda posterior mandibular molarlarla ilişkili olgular daha sınırlı sayıdadır ve bu nedenle ayırıcı tanı ve tedavi planlaması ayrı bir önem taşır [4,5,8,19,20].

Klinik olarak bu lezyonlar uzun süre asemptomatik seyredebilir ve çoğu zaman rutin radyografilerde tesadüfen saptanır; ancak lezyon hacminin artması durumunda ağrı, kortikal ekspansiyon, şişlik, diş mobilitesi, komşu anatomik yapılarda bası ve sürmekte olan veya sürecek daimi dişlerde pozisyon değişikliği ortaya çıkabilir [4,7-9,15,19].

Radyografik olarak tipik görünüm, ilgili dişin apeksinde yer alan, iyi sınırlı, çoğunlukla uniloküler radyolüsent alan şeklindedir; enfeksiyonun aktif olduğu durumlarda sklerotik sınırların silikleşmesi, çevre kortikal kemikte incelme ve komşu diş ya da diş germlerinde yer değişikliği izlenebilir [1,8,11,12].Bu noktada dentigeröz kist, periapikal granülom ve diğer odontojenik radyolüsent lezyonlarla ayırıcı tanı kritik önem taşır; özellikle çocuklarda gelişmekte olan daimi diş germinin radyolüsent alan tarafından çevrelenmesi dentigeröz kisti düşündürebileceğinden, iki boyutlu görüntüleme her zaman yeterli olmayabilir [1,8,12,17].

Konik ışınlı bilgisayarlı tomografi, lezyonun gerçek üç boyutlu uzanımını, kortikal kemik ilişkisini, komşu dişlerdeki etkisini ve cerrahi planlamaya esas anatomik ayrıntıları ortaya koyması bakımından seçilmiş olgularda önemli üstünlük sağlar [8].

Tedavi planlamasında temel amaç enfeksiyon kaynağının ortadan kaldırılması, lezyonun histopatolojik doğrulanması, çevre sert ve yumuşak dokuların korunması ve mümkünse daimi dentisyonun sürdürülmesidir [1,2,9,15].

Küçük ve sınırlı lezyonlarda endodontik tedavi ile birlikte izlem veya gerekli durumlarda enükleasyon tercih edilebilirken, daha büyük ve komşu anatomik yapılar açısından risk taşıyan kistik oluşumlarda marsupyalizasyon ya da dekompresyon gibi daha konservatif seçenekler gündeme gelebilir [3,9,14-16].

Pei ve arkadaşlarının çocuklarda süt dişleri ile ilişkili radiküler kistlerde dekompresyonu değerlendirdikleri retrospektif çalışmada, lezyonların tamamında boyutsal küçülme elde edilmiş ve bu yaklaşımın daha az invaziv bir seçenek olduğu bildirilmiştir [9].

Buna karşılık literatürde Ramakrishna ve Verma, Gandhi ve Franklin ile Narsapur ve arkadaşları gibi yazarlar, belirli olgularda total enükleasyonun tanısal ve terapötik açıdan etkili olduğunu ve uygun seçilmiş hastalarda başarılı sonuçlar verdiğini göstermiştir [10-12].

Son yıllarda Sevekar ve arkadaşları, Talukdar ve arkadaşları, Kajjari ve arkadaşları, Bane ve arkadaşları, Goswami ve Chauhan ile Deshpande ve arkadaşlarının yayımladığı pediatrik olgu sunumları, çocuklarda radiküler kistlerin nadir olmakla birlikte klinik olarak anlamlı morbidite oluşturabildiğini ve tedavi kararının dişin restore edilebilirliği, lezyon boyutu, daimi diş germleri ve cerrahi erişim gibi çok sayıda değişkene bağlı olarak verilmesi gerektiğini ortaya koymuştur [13,16-20].

Bu olgu sunumunun amacı, 12 yaşındaki bir çocuk hastada daimi mandibular birinci ve ikinci molarlarla ilişkili radiküler kistin tanı, endodontik rehabilitasyon ve cerrahi yönetim sürecini sunmak; ayrıca mevcut literatür ışığında, pediatrik daimi dentisyonda koruyucu ve rasyonel tedavi yaklaşımını tartışmaktır [1-3,8-10,19,20].

Olgu sunumu

On iki yaşındaki çocuk hasta, sağ posterior mandibular bölgede devam eden ağrı şikâyeti ile kliniğimize başvurdu ve klinik değerlendirme sonrası lezyonun diş kaynaklı inflamatuar bir periapikal patoloji olabileceği düşünüldü.

İlk radyografik incelemede 46 ve 47 numaralı daimi mandibular sağ birinci ve ikinci molar dişlerin kökleriyle ilişkili, sınırları belirgin bir radyolüsent alan saptandı; bu görünüm, nekrotik dişlerle ilişkili radiküler kist olasılığını güçlü biçimde düşündürdü(Şekil 1).

Lezyonun komşu anatomik yapılarla ilişkisini daha net değerlendirmek ve cerrahi yaklaşımı planlamak amacıyla konik ışınlı bilgisayarlı tomografi incelemesi yapıldı ve sağ posterior mandibulada yaklaşık 15 x 10 x 6 mm boyutlarında lezyon izlendi.

Üç boyutlu görüntüleme, lezyonun apikal yerleşimini, bukkal kortikal kemik ile ilişkisini ve ilgili dişlerin korunabilirliğinin değerlendirilmesini kolaylaştırarak tedavi planının netleştirilmesine katkı sağladı.

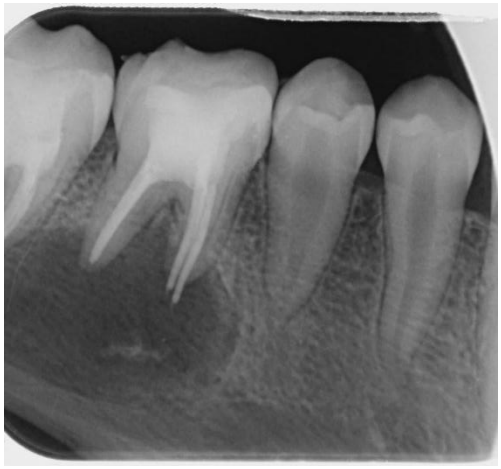
Pedodonti bölümünden alınan konsültasyon sonrasında yapılan elektrikli pulpa testinde 46 ve 47 numaralı dişlerin devital olduğu belirlendi ve lezyonun primer enfeksiyon kaynağının bu dişlerle ilişkili olduğu kanaatine varıldı.

Daimi dişlerin korunmasının mümkün olduğu düşünüldüğünden, cerrahi girişimden önce enfeksiyon odağının ortadan kaldırılması amacıyla her iki dişe endodontik tedavi başlandı ve tedavi başarıyla tamamlandı(Şekil 2).

Endodontik rehabilitasyonu takiben, lokal anestezi altında cerrahi aşamaya geçildi ve yeterli görüş sağlamak için bukkal vestibül boyunca yapılan insizyonla flep kaldırılarak işleme başlandı(Şekil 3).

Patolojik boşluğa ulaşmak amacıyla bukkal kortikal kemik plağı kontrollü şekilde uzaklaştırıldı ve lezyon tamamen enükle edildi(Şekil 4)

Şekil 1 Lezyonu gösteren panoramik radyografi



Şekil 2 Lezyonla ilişkili dişlere endodontik tedavi yapılması sonrasındaki periapikal radyografisi

Şekil 3 Vestibüler insizyonla tam kalınlık flep kaldırılması

Şekil 4 Bukkal kortikal kemikte pencere açılması

Cerrahi işlem sırasında elde edilen doku örneği kesin tanının konulabilmesi amacıyla histopatolojik incelemeye gönderildi; değerlendirme sonucunda radiküler kist ön tanısı doğrulandı.

Postoperatif dönemde hastanın ağrı başta olmak üzere mevcut klinik semptomlarının tamamen gerilediği gözlendi ve erken iyileşme süreci sorunsuz seyretti.

Hasta, kemik rejenerasyonunun izlenmesi ve endodontik tedavi uygulanmış 46 ve 47 numaralı dişlerin uzun dönem prognozunun değerlendirilmesi amacıyla düzenli klinik ve radyografik takibe alındı.

Bu tedavi akışı, çocuk hastada daimi posterior dişlerin çekimden korunabildiği, enfeksiyon kaynağının önce endodontik olarak kontrol altına alındığı ve ardından cerrahi olarak kesin tanı ve lezyon eliminasyonunun sağlandığı kombine bir yaklaşım olarak şeklinde gerçekleştirildi.

Tartışma

Radiküler kistler çocuk yaş grubunda genel olarak nadir kabul edilmekle birlikte, literatürdeki birikmiş veriler bu nadirliğin kısmen tanısal eksiklikten ve histopatolojik doğrulama oranlarının düşüklüğünden kaynaklanabileceğini düşündürmektedir [4-6].

Lustmann ve Shear'ın derlemesinde süt dişlerinden gelişen radiküler kistlerin sınırlı sayıda rapor edilmiş olması, uzun yıllar bu lezyonların istisnai kabul edilmesine yol açmış; ancak Mass ve arkadaşlarının histopatolojik serisi, primer molarlarla ilişkili radyolüsent lezyonlarda radiküler kistin beklenenden daha sık saptanabileceğini göstermiştir [4,5].

Bu durum, çocuk hastalarda periapikal radyolüsensilerin yalnızca granülomatöz lezyon olarak değerlendirilmemesi ve özellikle nekrotik diş varlığında kistik patolojinin de göz önünde bulundurulması gerektiğini ortaya koymaktadır [1,5,6].

Pediatrik olguların çoğunun süt mandibular molarlarda bildirilmiş olması nedeniyle[4,7,19,20], bu olguda olduğu gibi 12 yaşındaki bir çocukta daimi mandibular posterior bölgede iki komşu moların köklerini ilgilendiren radiküler kist varlığı dikkat çekicidir ve klinisyenin yaşa bağlı önyargılarla tanıyı daraltmaması gerektiğini göstermektedir.

Ramakrishna ve Verma, Gandhi ve Franklin, Narsapur ve arkadaşları ile Sevekar ve arkadaşlarının olgularında lezyonların çoğu süt molarlarla ilişkili olup belirgin kemik ekspansiyonu veya diş germi yer değişikliği ile seyretmiştir[10-13].; buna karşılık mevcut olguda lezyon daimi ve restoratif olarak korunabilir iki posterior dişle ilişkili olduğundan tedavi planı farklı bir koruyucu mantıkla şekillendirilmiştir.

Bu farklılık, pediatrik radiküler kistlerin yönetiminde tedavi kararının yalnızca lezyonun histolojik tipine değil, ilgili dişin dentisyon tipine, restore edilebilirliğine ve fonksiyonel değerine de bağlı olduğunu göstermektedir [1,9,16,19].

Ayırıcı tanı açısından değerlendirildiğinde, çocuk hastalarda gelişmekte olan daimi diş germlerinin periapikal radyolüsent alanla komşuluğu dentigeröz kist ile radiküler kist arasında tanısal güçlük yaratabilir ve bu sorun özellikle mandibular posterior bölgede daha belirgin hale gelebilir [1,8,12,17].

Mahesh ve arkadaşları, konvansiyonel iki boyutlu görüntülemenin bazı olgularda lezyonun hangi dişle ilişkili olduğunu açık olarak gösteremediğini, konik ışınlı bilgisayarlı tomografinin ise lezyonun apeksle mi yoksa kronla mı ilişkili olduğunu ve kortikal kemikteki etkisini net biçimde ortaya koyabildiğini bildirmiştir [8].

Sunulan olguda da konik ışınlı bilgisayarlı tomografi kullanımı, lezyon boyutunun ve uzanımının doğru değerlendirilmesini sağladığı gibi cerrahi erişimin planlanması, bukkal kortikal yaklaşımın belirlenmesi ve dişlerin korunabilirliğine yönelik kararın desteklenmesi açısından yararlı olmuştur.

Patogenez bakımından bu olgu, endodontik enfeksiyon ile periapikal inflamatuar yanıt arasındaki ilişkinin klinik bir yansımasıdır; pulpal nekroz giderilmeden yalnızca cerrahi eksizyon yapılmasının biyolojik kaynağı ortadan kaldırmayacağı düşünüldüğünden, öncelikle 46 ve 47 numaralı dişlerde endodontik tedavi uygulanması rasyonel bir yaklaşımdır [2,3].

Nair'in radiküler kistlerin biyolojisine ilişkin değerlendirmeleri, periapikal lezyonların bir bölümünün enfeksiyon kontrolü ile gerileyebileceğini, ancak gerçek kistik yapının özellikle yerleşik olgularda cerrahi müdahale gerektirebileceğini göstermektedir[3].

Bu nedenle mevcut olguda tedavi planlamasının endodontik tedavinin lezyonun biyolojik kaynağını ortadan kaldırmayı, enükleasyonun ise hem patolojik kaviteyi elimine etmeyi hem de histopatolojik kesin tanıyı sağlamayı hedefleyen tamamlayıcı iki basamak olarak kurgulanması uygun görülmüştür.

Çocuk hastalarda konservatif cerrahi alternatifleri tartışılırken marsupyalizasyon ve dekompresyon özellikle büyük hacimli lezyonlarda önem kazanır; Johann ve arkadaşları ile Penumatsa ve arkadaşları konservatif yaklaşımın kalıcı diş germlerinin korunmasına katkı sağlayabileceğini göstermiş, Pei ve arkadaşları ise dekompresyon ile yüksek oranda boyutsal küçülme bildirerek bu yaklaşımın daha az invaziv bir seçenek olduğunu ortaya koymuştur [9,14,15].

Bununla birlikte, konservatif yöntemler uzun takip süresi, hasta ve ebeveyn uyumu gereksinimi, drenaj yolunun açık tutulması zorunluluğu ve rezidüel patolojik dokunun yerinde bırakılması gibi sınırlılıklar da taşımaktadır [9,14,15].

Talukdar, Kajjari, Bane ve Goswami tarafından bildirilen olgularda enükleasyonun özellikle cerrahi olarak ulaşılabilir, semptomatik veya dişin yer değiştirmesine neden olan lezyonlarda etkili olduğu ve uygun seçilmiş olgularda iyi iyileşme sağladığı bildirilmiştir [16-19].

Mevcut olguda lezyon boyutunun sınırlı olması, ilgili daimi dişlerin endodontik olarak rehabilite edilebilmesi ve histopatolojik doğrulama gerekliliği birlikte değerlendirildiğinde enükleasyonun uygun seçenek olduğu kanaatine varılmıştır.

Histopatolojik inceleme, radiküler kistin periapikal granülomdan ve radyografik olarak benzer görünebilen diğer odontojenik kistik lezyonlardan ayırt edilmesinde temel belirleyici aşamadır; bu nedenle çocuk hastalarda yapılan cerrahi işlemlerde çıkarılan dokunun patolojik değerlendirmeye gönderilmesi standart yaklaşım olarak benimsenmelidir [1,5,8,17,19].

Güncel olgu serileri, tedavi sonrasında iyi kemik iyileşmesi ve sürmekte olan daimi dişlerin korunmasının mümkün olabildiğini göstermekle birlikte, özellikle çocuk yaş grubunda çene gelişimi ve diş sürme dinamikleri devam ettiği için uzun dönem klinik ve radyografik takip zorunludur [7,9,15-19].

Sunulan olguda da semptomların düzelmiş olması erken dönem başarının göstergesi olmakla birlikte, 46 ve 47 numaralı dişlerin uzun dönem fonksiyonu, periapikal iyileşme ve kemik rejenerasyonu açısından düzenli kontrollerin sürdürülmesi gerekmektedir.

Bu olgunun temel klinik katkısı, çocuk hastalarda daimi posterior mandibular dişlerin mümkün olduğunca korunmasına odaklanan kombine endodontik ve cerrahi yaklaşımın uygulanabilirliğini göstermesidir.

Ayrıca olgu, pediatrik hastalarda posterior mandibular ağrı ve apeks ilişkili radyolüsensi varlığında, yalnızca akut enfeksiyon veya granülom değil radiküler kist olasılığının da düşünülmesi; gerekli durumlarda üç boyutlu görüntüleme ile tanının derinleştirilmesi ve tedavinin diş koruyucu ilkeler çerçevesinde planlanması gerektiğini ortaya koymaktadır.

Sonuç

Radiküler kist, çocukluk çağında daimi posterior mandibulada nadir görülen ancak uygun biçimde değerlendirilmediğinde diş kaybı, kemik defekti ve uzun dönem fonksiyonel sorunlara yol açabilecek inflamatuar odontojenik bir lezyondur [1,4,7,19,20].

Sunulan olguda,enfeksiyon kaynağı olan devital 46 ve 47 numaralı daimi molarların endodontik tedavi ile rehabilite edilmesi ve bunu izleyen enükleasyon ile lezyonun ortadan kaldırılması, hem kesin tanı hem de diş koruyucu tedavi hedefleri açısından etkili bir yaklaşım sağlamıştır.

Bu nedenle pediatrik hastalarda apeks ilişkili radyolüsent lezyonların yönetiminde klinik muayene, vitalite testleri, uygun radyolojik inceleme, gerekli olduğunda konik ışınlı bilgisayarlı tomografi ve histopatolojik doğrulama birlikte değerlendirilmelidir [1,8,19].

Olgu, çocuk hastalarda daimi dentisyonun korunmasının yalnızca restoratif bir hedef değil, aynı zamanda fonksiyonel, gelişimsel ve cerrahi morbiditeyi azaltan temel bir tedavi önceliği olduğunu göstermektedir [9,16-19].

Sonuç olarak, pediatrik posterior mandibular radiküler kistlerde olgu bazlı planlanan kombine endodontik ve cerrahi yaklaşım, uygun seçilmiş hastalarda başarılı klinik iyileşme ve daimi dişlerin sürdürülmesi açısından güçlü bir seçenek olarak değerlendirilmelidir.

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ANTERİOR MAKSİLLADA HORİZONTAL KRET YETERSİZLİĞİNİN KSENOGREFT VE KOLLAJEN MEMBRAN EŞLİĞİNDE EŞ ZAMANLI İMPLANT YERLEŞTİRİMİYLE TEDAVİSİ: OLGU SUNUMU VE LİTERATÜR DERLEMESİ

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Özet

Anterior maksillada implant destekli rehabilitasyon, yüksek estetik beklenti, ince bukkal kemik, çekim sonrası belirgin hacim kaybı ve yumuşak doku konturunun kolay bozulabilmesi nedeniyle implantolojinin en hassas klinik alanlarından biridirBu bölgede tedavinin hedefi yalnızca implantın kemik içerisine yerleştirilmesi değil, aynı zamanda protez odaklı ideal implant konumlandırmasını destekleyecek sert ve yumuşak doku konturlarının ve hacminin yeniden oluşturulmasıdır. Yönlendirilmiş kemik rejenerasyonu, bariyer membranlar ve kemik greftleri ile kombine edildiğinde lokalize horizontal kret yetersizliklerinin yönetiminde en iyi tanımlanmış cerrahi yaklaşımlar arasında yer almaktadır. Özellikle sığır kaynaklı ksenogreftler; osteokonduktif iskelet oluşturmaları, hacim stabilitesi sağlamaları ve ikinci bir donör saha gereksinimini ortadan kaldırmaları nedeniyle, otojen kemik kullanımının reddedildiği ya da sınırlı olduğu vakalarda rasyonel bir alternatif olarak öne çıkmaktadır.

Sunulan olgu, sistemik olarak sağlıklı ve sigara kullanmayan 49 yaşındaki kadın hastada on yıllık dişsizlik sonrasında anterior maksillada gelişen belirgin horizontal kret atrofisini içermektedir. Konik ışınlı bilgisayarlı tomografi incelemesinde standart çaplı implant yerleştirilmesine izin vermeyecek düzeyde kret darlığı saptanmış, başlangıçta düşünülen otojen kemik temelli yaklaşım ise hastanın iliak krista greftlemesini kabul etmemesi ve mandibular ramusun uygun donör saha olarak değerlendirilmemesi nedeniyle uygulanamamıştır. Bunun üzerine, rezidüel kret içine üç implantın yerleştirildiği; bukkal ekspoze implant yüzeylerinin sığır kaynaklı ksenogreft ile augmentasyona tabi tutulduğu; alanın ise rezorbe olabilen kollajen membran ve fiksasyon pinleri ile stabilize edildiği eş zamanlı bir cerrahi protokol benimsenmiştir.

Güncel literatür; uygun primer stabilite, yeterli boşluk koruma, membran immobilizasyonu ve gergin olmayan primer yara kapanışı sağlandığında, eş zamanlı yönlendirilmiş kemik rejenerasyonunun yüksek implant sağkalımı ve kabul edilebilir doku stabilitesi ile ilişkili olabileceğini göstermektedir. Bununla birlikte estetik bölgedeki gerçek başarı yalnızca erken cerrahi kapanışla değil, fasiyal konturun korunması, marjinal kemik düzeyi, peri-implant yumuşak doku seviyesi ve uzun dönem hasta memnuniyeti ile değerlendirilmelidir. Sonuç olarak, otojen kemik kullanımının reddedildiği seçilmiş anterior maksilla olgularında ksenogreft ve kollajen membran eşliğinde eş zamanlı implant yerleştirilmesi uygulanabilir bir tedavi alternatifi olarak değerlendirilebilir; ancak bu yaklaşımın klinik değeri uzun dönem radyografik ve estetik sonlanımlarla doğrulanmalıdır.

Anahtar kelimeler: Dental implant, Horizontal kret augmentasyonu, Ksenogreft, Kollajen membran, Yönlendirilmiş kemik rejenerasyonu

1.Giriş

Diş çekimini izleyen alveoler yeniden şekillenme, özellikle estetik bölgede implant planlamasını doğrudan etkileyen temel biyolojik süreçlerden biridir [1,2]. Çekim sonrası gelişen hacim kaybı yalnızca kret genişliğini azaltmakla kalmaz; aynı zamanda fasiyal konturun düzleşmesine, yumuşak doku desteğinin zayıflamasına ve gelecekte planlanan implantın protetik eksene uygun biçimde yerleştirilmesini güçleştiren üç boyutlu morfolojik değişikliklere yol açar [1,2]. Schropp ve arkadaşları, çekimden sonraki ilk yıl içinde belirgin kontur değişiklikleri oluştuğunu; Araújo ve Lindhe ise özellikle bukkal duvarın erken dönemde daha fazla rezorbe olduğunu göstermişlerdir[1,2]. Bu biyolojik gerçeklik, anterior maksillada implant rehabilitasyonunun neden yalnızca cerrahi değil, aynı zamanda estetik açıdan da yüksek riskli bir girişim olduğunu açıklamaktadır [1-3].

Anterior maksilla, ince fasiyal kemik duvarı, yüksek gülümseme hattı ve peri-implant yumuşak dokuların görünürlüğü nedeniyle küçük hacim kayıplarının dahi klinik olarak belirgin hale geldiği bir bölgedir [3-6]. Bu nedenle burada tedavinin hedefi yalnızca osseointegrasyon değildir; fasiyal konturun, papil desteğinin ve mukozal seviyenin korunması da en az implant sağkalımı kadar önem taşır [3,5,6]. Chen ve Buser'in sistematik derlemesi ile Buser ve çalışma arkadaşlarının estetik bölgedeki erken implant yerleştirme serileri, implantın doğru üç boyutlu pozisyonunun, fasiyal kontur augmentasyonunun ve yumuşak doku yönetiminin estetik başarının ana belirleyicileri olduğunu ortaya koymuştur [3-6].

Yönlendirilmiş kemik rejenerasyonu (YKR), oral implantolojide lokalize kemik yetersizliklerinin tedavisinde en güçlü biyolojik gerekçeye ve en geniş klinik kullanıma sahip yaklaşımlardan biridir [7]. Temel prensip, yumuşak dokunun defekt alanına invazyonunu bariyer membran ile sınırlandırmak, greft ve kan pıhtısı için korunmuş bir boşluk oluşturmak ve yeni kemik oluşumu için stabil bir iyileşme ortamı sağlamaktır [7]. Buser, Urban, Monje, Kunrath ve Dahlin, güncel derlemelerinde horizontal defektlerde rezorbe olabilen kollajen membranların klinik pratikte en yaygın kullanılan bariyerler olduğunu ve tekniğin başarısının materyal seçiminden çok biyolojik prensiplere uyumla ilişkili olduğunu vurgulamıştır [7].

Kemik greftleri biyolojik davranışları açısından osteogenez, osteoindüksiyon ve osteokondüksiyon ekseninde değerlendirilir [7,8]. Otojen kemik halen biyolojik altın standart kabul edilse de, ikinci cerrahi saha gereksinimi, postoperatif morbidite, sınırlı donör hacmi ve operasyon süresinin uzaması gibi nedenlerle her hastada ilk seçenek olamamaktadır [7,8]. Miron'un güncel derlemesi, implantolojide kemik greftlemesinin artık yalnızca "hangi materyalin daha güçlü olduğu" sorusundan ibaret olmadığını; defektin morfolojisi, hacim korunması gereksinimi, iyileşme süresi ve hasta beklentilerinin birlikte değerlendirilmesi gerektiğini belirtmektedir [8]. Bu bağlamda ksenogreftler, osteokonduktif iskelet sağlamaları ve yavaş rezorpsiyonları sayesinde kontur koruma amacı güdülen estetik bölge augmentasyonlarında klinik değer taşımaktadır [8-10].

Sığır kaynaklı ksenogreftler; özellikle horizontal kret augmentasyonu, alveoler kret koruma ve implant çevresindeki dehisens ve fenestrasyon defektlerinde yaygın biçimde kullanılmaktadır [9,10,12]. Carvalho ve arkadaşlarının sistematik derlemesi, horizontal augmentasyonda ksenojenik greftlerin uygulanabilir bir seçenek olduğunu; çoğu çalışmada kollajen membranla kombine edildiğini ve anlamlı horizontal hacim kazanımı sağladığını bildirmiştir [9]. Benzer biçimde Avila-Ortiz ve arkadaşları, alveoler kret koruma prosedürlerinin çekim sonrası fizyolojik kemik kaybını azaltabildiğini, özellikle membran ve ksenogreft kombinasyonlarının mid-bukkal ve mid-lingual yükseklik korunumu açısından avantaj sağlayabildiğini göstermiştir [10].

Estetik bölgede implant zamanlaması ile augmentasyon stratejisi birbirinden bağımsız düşünülemez [3,4]. Buser ve arkadaşları tarafından tanımlanan erken implant yerleştirme konsepti, fasiyal kemik desteği sınırlı veya risk profili yüksek sahalarda yumuşak doku iyileşmesine izin veren aynı zamanda sert ve yumuşak doku konturunu aynı seansta yeniden düzenlemeyi hedefleyen rasyonel bir yaklaşım sunmaktadır [4-6]. Ayrıca uygun koşullarda implant yerleştirilmesi ile kemik augmentasyonunun aynı seansta yapılması, tedavi süresini kısaltabilmekte ve hasta morbiditesini azaltabilmektedir [5,11,12]. Ancak bu yaklaşım, yeterli primer stabilite, greft stabilizasyonu ve gergin olmayan primer yara kapanışı sağlanmadan öngörülebilir başarıya ulaşamaz [7,11].

Kollajen membranların estetik bölgedeki önemi yalnızca bariyer işleviyle sınırlı değildir [7,11]. Bu membranlar, ikinci cerrahi gerektirmemeleri, kullanım kolaylığı sağlamaları ve küçük-orta boy yatay defektlerde kabul edilebilir komplikasyon profiline sahip olmaları nedeniyle pratik avantaj sunar [7,11]. Arunjaroensuk ve arkadaşları, estetik bölgede implant yerleştirmesiyle eş zamanlı yönlendirilmiş kemik rejenerasyonu uygulanan vakalarda kollajen membranların yeterli sert doku stabilitesi sağladığını bildirmişlerdir[11].Buna karşılık, membranın uygun endikasyon doğrultusunda seçilmesi, greft ile birlikte mekanik olarak stabilize edilmesi ve yumuşak doku örtüsünün bütünlüğü korunarak erken membran ekspozisyonu olmaksızın iyileşmenin sağlanması temel koşullardır[7,11].

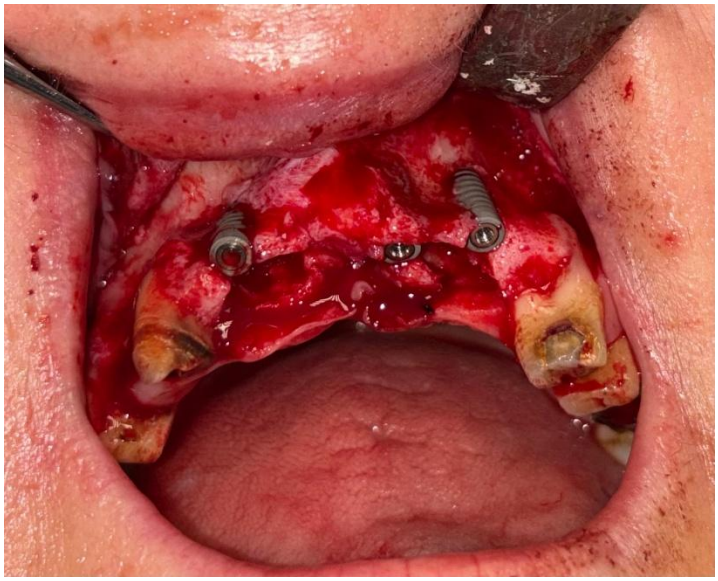
Sunulan olgu, klinik karar vermenin tam da bu çok değişkenli alanında konumlanmaktadır. Hasta, anterior maksillada uzun süreli dişsizlik sonrası gelişen belirgin horizontal kret atrofisi nedeniyle implant destekli rehabilitasyona ihtiyaç duymaktadır; ancak başlangıçta düşünülen otojen donör saha temelli yaklaşım hasta tarafından kabul edilmemiştir. Bu nedenle olgu, biyolojik ideal ile klinik uygulanabilirlik arasında denge kurma gerekliliğini temsil etmektedir. Bu makalenin amacı, söz konusu olguyu ksenogreft ve kollajen membran eşliğinde eş zamanlı implant yerleştirilmesi perspektifinden tartışmak, kararın dayandığı cerrahi mantığı ve güncel literatürle uyumunu akademik bir çerçevede ortaya koymaktır [7-9].

2.Olgu sunumu

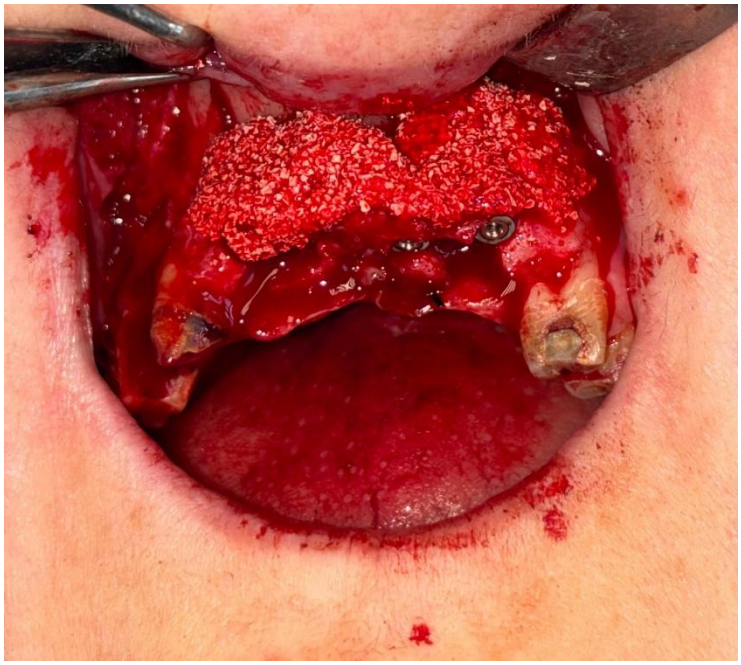
49 yaşındaki kadın hasta sistemik olarak sağlıklı olup, sigara kullanım öyküsü yoktu.On yıldır anterior maksillada dişsizlik öyküsü ile kliniğimize başvurdu. Klinik değerlendirme ve konik ışınlı bilgisayarlı tomografi incelemesi sonucunda, mevcut alveoler kret genişliğinin standart çaplı implantların uygun protetik konumda yerleştirilmesine izin vermediği belirlenmiştir.

Başlangıç tedavi planında horizontal kemik augmentasyonu öngörülmüş olmakla birlikte, hasta iliak krista kaynaklı otojen kemik greftmesini kabul etmemiş; mandibular ramus da yeterli ve uygun donör saha olarak değerlendirilmemiştir.

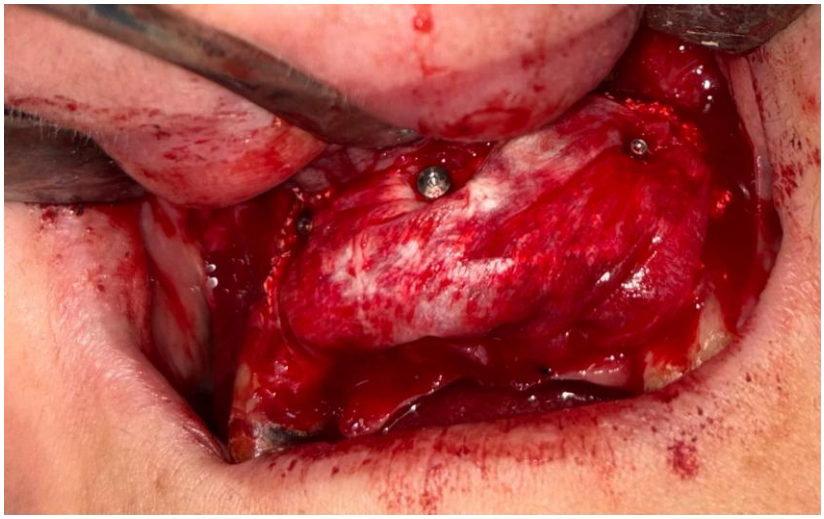
Bu koşullar altında tedavi stratejisi, rezidüel kret içine eş zamanlı implant yerleştirilmesi ve aynı seansta yönlendirilmiş kemik rejenerasyonu uygulanması şeklinde yeniden düzenlenmiştir. Cerrahi işlem lokal anestezi altında gerçekleştirilmiş; sulkuler flep tasarlanmış ve primer kapanışın gergin olmayan biçimde elde edilebilmesi amacıyla geniş flep serbestleştirmesi yapılmıştır.Rezidüel kret içine üç implant yerleştirilmiş ancak dar kret anatomisi nedeniyle implantların bukkal yüzeylerinde ekspoze alanlar oluşmuştur(Şekil 1),. Bu alanlar 3 cc sığır kaynaklı ksenogreft ile kapatılmıştır(Şekil 2); bölge 30 × 40 mm rezorbe olabilen kollajen membran ile örtülmüş ve membran üç fiksasyon piniyle stabilize edilmiştir(Şekil 3). İşlem, dikkatli yumuşak doku adaptasyonu ve primer yara kapanışı ile sonlandırılmıştır(Şekil 4). Hastanın takipleri kliniğimizde devam etmektedir.



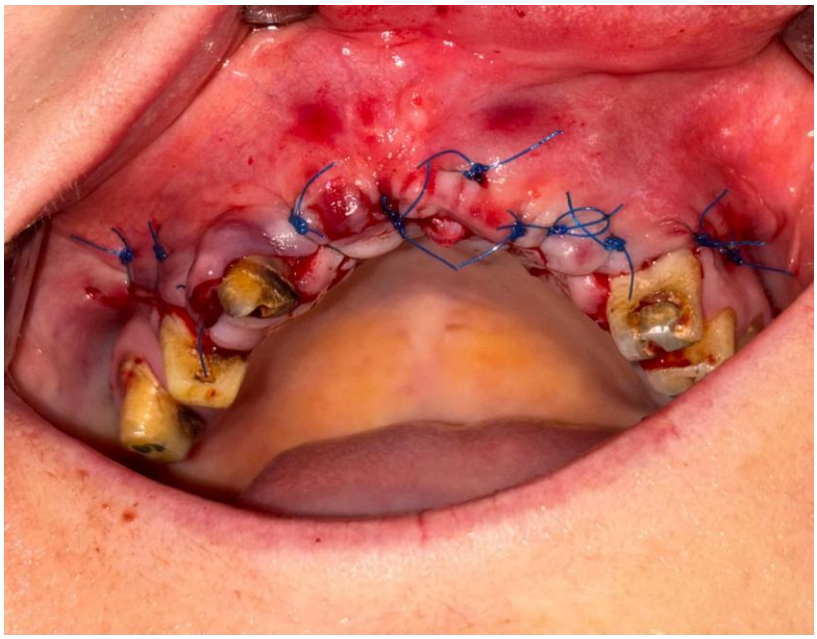
Şekil 1 İmplantların bukkal yüzeylerinde oluşan ekspoze alanlar



Şekil 2 Ekspoze alanlar sığır kaynaklı ksenogreft ile kapatılması



Şekil 3 Bölgenin rezorbe olabilen kollajen membran ile örtülmesi ve membranın üç fiksasyon piniyle stabilize edilmesi



Şekil 4 Flebin primer olarak kapatılması

3.Tartışma

Sunulan olgunun klinik açıdan en dikkat çekici yönü, estetik riski yüksek anterior maksillada uzun süreli dişsizlik sonrası gelişen horizontal kret yetersizliğinin eş zamanlı implant yerleştirilmesi ile birlikte yönetilmiş olmasıdır. Hastanın otojen kemik augmentasyonunu kabul etmemesi ve alternatif donör saha kullanımının anatomik olarak uygun bulunmaması, tedavi planının daha az invaziv ancak biyolojik prensiplerle uyumlu bir yaklaşımla yeniden düzenlenmesini gerekli kılmıştır [7,8].

Anterior maksillada horizontal hacim kaybının önemi yalnızca implantın yerleştirilebilirliği ile sınırlı değildir [3,5,6]. Bukkal kemik desteğinin yetersiz olduğu durumlarda implantın bukkal yönde konumlanması, peri-implant mukozal çekilme, kontur kaybı ve estetik uyumsuzluk gibi sorunlara yol açabilir [3,5,6]. Bu nedenle amaç, implantı mevcut kemiğe yerleştirmekten çok, protez odaklı ideal implant pozisyonuna izin verecek sert doku çevresini yeniden oluşturmaktır [3,5,6].

Sunulan olguda implantlar rezidüel kret içine yerleştirilmiş olmasına rağmen bukkal yüzeylerde ekspoze alanların kalmış olması sebebiyle, horizontal defektin yalnızca implant yerleştirilmesi ile çözülemeyeceği görülmüştür. Bu nedenle eş zamanlı yönlendirilmiş kemik rejenerasyonu uygulanması, olgunun biyolojik gereklilikleriyle uyumlu görülmüştür. Sığır kaynaklı ksenogreftin tercih edilmesi, otojen donör saha gereksinimini ortadan kaldırması ve hacim stabilitesine katkı sağlaması açısından rasyonel bir seçimdir. Kollajen membranın fiksasyon pinleri ile stabilize edilmesi ise literatür bilgileri ışığında[7,11] greft kompleksinin immobilizasyonuna ve rejeneratif alanın korunmasına hizmet etmektedir.

Bu olguda başarının yalnızca kullanılan biyomateryale değil, aynı zamanda doğru implant pozisyonuna, boşluk korumaya, greft ve membran stabilizasyonuna ve primer yara kapanışının sağlanmasına bağlı olduğu düşünülmektedir. Geniş flep serbestleştirilmesi yapılarak primer kapanış elde edilmiş olması, yönlendirilmiş kemik rejenerasyonunun temel cerrahi prensipleriyle uyumludur[7,11].

Bununla birlikte bu olguya ilişkin postoperatif hacimsel analiz ve implant stabilite ölçümleri henüz yapılmadığından marjinal kemik düzeyi ve uzun dönem estetik sonuçlar elde edilemediğinden dolayı , cerrahi başarının nicel olarak değerlendirilmesi mümkün olmamıştır. Bu nedenle söz konusu yaklaşım, kesin başarı bildiren bir sonuçtan çok, hasta tercihi ve anatomik sınırlılıklar doğrultusunda geliştirilmiş biyolojik olarak savunulabilir bir tedavi stratejisi olarak değerlendirilmiştir.

Sonuç olarak, anterior maksillada horizontal hacim kaybı bulunan ve otojen donör saha kullanımı mümkün olmayan seçilmiş hastalarda, ksenogreft ve kollajen membran ile eş zamanlı implant yerleştirilmesi uygulanabilir bir tedavi alternatifi olarak değerlendirilebilir. Ancak bu yaklaşımın gerçek klinik değeri, uzun dönem klinik ve radyografik takip ile ortaya konmalıdır [6,14,15].

4.Sonuç

Sunulan olgu ve bu olgu etrafında yapılan literatür değerlendirmesi, anterior maksilladaki horizontal kret yetersizliklerinde ksenogreft ve rezorbe olabilen kollajen membranın birlikte kullanımıyla eş zamanlı implant yerleştirmenin klinik olarak savunulabilir bir seçenek olduğunu göstermektedir [7-9,11,12]. Bu yaklaşım özellikle otojen kemik greftlemesinin hasta tarafından reddedildiği, alternatif donör saha hacminin yetersiz olduğu veya cerrahi morbiditenin azaltılmasının öncelendiği koşullarda anlam kazanmaktadır [8,13]. Bununla birlikte başarı, tek başına seçilen biyomateryalin özelliğine indirgenemez [7,8]. Estetik bölgedeki olumlu sonuç; implantın protetik gereksinimlerle uyumlu üç boyutlu konumlandırılmasına, greft hacminin doğru yönetilmesine, membranın stabilize edilmesine, yumuşak doku geriliminin azaltılmasına ve primer kapanışın korunmasına bağlıdır [3,4,6,7,11]. Bu nedenle benzer olgularda cerrahi planlama materyal merkezli değil, biyolojik prensip merkezli yürütülmelidir [7,8].

Literatür bilgileri ışığında, anterior maksillada seçilmiş horizontal defektlerde ksenogreft ve kollajen membran temelli eş zamanlı implant cerrahisi, deneyimli klinisyenler tarafından dikkatle uygulanabilecek bir tedavi protokolü olarak değerlendirilebilir [7,9,11-13]. Ancak bu yaklaşımın gerçek klinik değeri, yalnızca erken cerrahi başarı ile değil, uzun dönem fonksiyonel, radyografik ve estetik sonuçlarla doğrulanmalıdır [6,14,15].

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IMPACT OF OIL ON PHYTOREMEDIATION OF PCB CO-CONTAMINATION IN TRANSFORMER OIL USING *CHROMOLAENA ODORATA*

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ABSTRACT

Greenhouse assessment of the effect of oil on *Chromolaena odorata* ability to remove PCB from soil treated with transformer oil co-contaminated with Aroclor 1260 was done.

Method: Plants were transplanted into one kilogram of soil contained in 1L pots differently containing 100, 200, and 500 ml of transformer oil (T/O), co-contaminated with 100 ppm of Aroclor. Treatments were done in two microcosms; direct contamination and soil cultured method. Measured plant growth parameters showed that *C. odorata* growth was affected by the different concentrations of oil. Inhibition of plant growth by oil increased with concentrations.

Results: At the end of six weeks, plant growth was affected in T/O amended soil. Plants size was increased by 1.4, 0.46 and -1.0 % in direct treatment and 17.01, 6.09 and 1.08 % in soil culture at the 100, 200 and 500 ppm respectively. Untreated control showed a 43.07 % increase. Slight PCB recovery was observed in root tissues of *C. odorata* but soil PCB was reduced by 66.6, 53.2, 41.5 % and 77.3, 74.7, 58.8 % at both treatments in their respective concentrations of oil. However, unplanted control was reduced by 21.4 and 16.7 % in the two treatments at 100 ppm of oil.

Conclusion: This study has shown that with improved agronomic practices, there is a possibility of phytoremediation of soil PCB from PCB contained transformer oil contaminated soil using *Chromolaena odorata,* hence it should be optimized in the field.

Keywords: Phytoremediation, Transformer oil contamination, *Chromolaena odorata*, PCB, Soil remediation, South Africa.

Introduction

Advances in science and technology have enabled man to exploit natural resources largely, generating unprecedented disturbances in global elemental cycles (Susarla et al. 2002). The relatively recent introduction of man-made toxic chemicals, and the massive relocation of natural materials to different environmental compartments; soil, ground water, and atmosphere, has resulted in severe pressure on the self-cleansing capacity of recipient ecosystems. Various accumulated pollutants are of concern relative to both human and ecosystem exposure and potential impact. There have been efforts by many authorities in different countries to control the release of contaminants (Schnoor et al. 1995), and to accelerate the breakdown of existing contaminants by appropriate remediation techniques. Such techniques and technologies are marred by various disadvantages and usually require relatively high capital expenditure and man power as well as long term operating cost. Hence, recent interests are geared towards developing more cost effective approach to treat large volumes of contaminated natural resources such as soil, ground water and wetlands (Anyasi and Atagana 2011).

Bioremediation is the use of plants and the associated rhizospheric microorganisms to remove, transform, or contain toxic chemicals located in soils, sediments, ground water, surface water, and even the atmosphere (Gibson and Sayler 1992). This technique is currently used to treat many classes of contaminants including petroleum hydrocarbons, chlorinated solvents, pesticides, explosives, heavy

metals and radionuclides, and landfill leachates (Susarla et al. 2002). Biological method has been used for hundreds of years to treat human waste, reduce erosion, and protect water quality (Robinson et al. 2003), until about 25 years ago which saw some significant rise in the use of plants known as phytoremediation in the removal of contaminants from the environment (Barman et al. 2000; Sarma 2011). In the present study, *C. odorata* (Siam weed), was grown in Aroclor 1260 amended transformer oil-contaminated soil in order to study the effect of oil on the ability of plants in the remediation of soil-PCB from a transformer oil impacted soil. This is of importance as literatures have only reported on plants remediation of PCB without considering the impact of co-contamination of the oil, considering the fact that PCB has not been used in isolation (Chang et al. 2010).

Polychlorinated biphenyls (PCBs) are a family of anthropogenic organic compounds that is persistent in the environment causing its bioaccumulative phenomenon that enables the contaminant to be found in every part of the environment. PCB is commercially produced by direct chlorination of biphenyls (Ficko et al. 2011). A good commercial form of PCB is Aroclor 1254 and 1260, although other brand names exist (Cogliano 1998; Larsson et al. 2000). Various negative health effects in humans as well as the animals are linked to PCB compounds, this call for an urgent action on how the compound can be removed from the environment (Zeeb et al. 2006). The physico-chemical properties of PCB depend on the congener composition, but generally they are resistant to acids and bases, resistant to oxidation and hydrolysis, thermally stable, excellent electrical insulators, sparingly soluble in water and have low flammability (Andersson 2000; Anyasi and Atagana 2011). These characteristics conforms the usefulness of PCBs in diverse industrial applications, such as liquid components of transformers, capacitors, heat-exchangers, and vacuum pumps. PCB mixtures have also been used in open systems, such as plasticizers, drinking solvents, water-proofing agents, sealing liquids, fire retardants and pesticides (De Voogt and Brinkman, 1989; Geisy and Kinnan 1998; Safe 1994; Van Den Berg et al., 1998).

Transformer oil also known as insulating oil is a highly refined mineral oil that is stable at high temperatures and usually possesses excellent electrical insulating properties. Transformer oil is mostly used in oil-filled transformers, in high voltage capacitors, fluorescent lamp ballast, as well as in some high voltage switches and circuit breakers. The functions of transformer oil to these equipments ranges from insulation, suppression of corona and arcing, and also as a cooling liquid (Gray 2010). Properties of transformer oil in transformers require periodic testing to make sure that the basic electrical properties of the oil are intact as it is in operation. This informs the filtration and regeneration activities on transformers (Gray 2010). Therefore, once transformer oil is contaminated above its recommended value with PCB, it becomes hazardous and should be discharged. During the process of discharge, the environment becomes the recipient. PCB release to the atmosphere has been through the following means: from uncontrolled landfills and hazardous waste sites; incineration of PCB containing wastes; leakage from older electrical equipments in use and improper disposal of spills (USEPA 1997; Bremle and Larsson 1998).

Various traditional remediation measures for example chemical (treatment with solvents); mechanical (soil excavation), thermal (incineration), and biological (use of microorganisms), have been used for the elimination of PCBs and other organics from the environment (Waid 1986). These remediation techniques have been successful in the remediation of organic contaminants, but are marred by various disadvantages (Rodriguez and Lafuente 2002). These include the fact that the processes are expensive, some of the processes are slow hence targets only the low chlorinated biphenyls, others live the finger print of other more toxic compounds at the end as a result are not environmentally friendly and lacks general public acceptability (Idris and Ahmed 2010; Atagana 2011a). It is therefore imperative to develop a more cost effective technique for the treatment of complex PCB as contained in transformer oil.

Plants are known to take up large amount of water with nutrient from soil in soluble form in order to increase in biomass. This phenomenon has been investigated to be of benefits in the removal of pollutants from the environment and is referred to as phytoremediation (Schnoor 1997). Phytoremediation is the use of vegetation for in situ treatment of contaminants from soil and water body. It is a promising technique that can be used to manage pollution (Singh et al. 2009).

Phytoremediation is cost effective and eco-friendly strategy that can compliment or replace conventional approaches especially in the remediation of soil contaminated by PCBs (Sung et al. 2001). The principle mechanism of phytoremediation is either by stimulation of soil microbial activity and degradation of contaminants or through plant uptake of contaminants or by even their degradation products (Mackova et al. 2009). As plant-based remediation technology, phytoremediation has its general limitations- tolerance and uptake ability of plants for organics differs widely, pollutant concentrations and the presence of other toxins must also be within the limits of plants tolerance (Cunningham and Ow 1996). **S**everal factors are known to affect the effectiveness of any phytoremediation projects; they include Soil properties, Physiochemical properties of organic pollutants, Soil amendments as well as the type of Plant (Anyasi et al. 2019).

Chlomolaena odorata (L) R.M. King & H. Robinson (Siam weed) is an invasive bushy shrub of South American origin. The plant is a member of the tribe Eupatoreae in the sunflower family Asteraceae and is been regarded as one of the most notorious invasive alien plant in the plant community (Tanhan et al. 2011). *C. odorata* have been found to possess amongst its strong morphological status, to possess most qualities of a phytoremediation plant. These features are responsible for the plant's success as invasive specie in its new environments. These factors therefore present *C. odorata* as a potential plant for phytoremediation of a complex organic system as seen in the co-contamination of oil with Aroclor (Ficko et al. 2010; Atagana 2011a; Anyasi and Atagana 2018).

The interest in transformer oil arose as a result of the fact that T/O is one of the most widely used organic chemicals and the unscrupulous discharge of the oil calls for concern. However, T/O is linked with PCB contamination and has contributed in the continued proliferation of PCB in the environment. At present, little information is known regarding the treatment of transformer oil contaminated soil using phytoremediation processes (Toro et al. 2008; Sobieceka et al. 2009; Chang et al. 2010). Thus this study aimed to investigate the effect of oil on the ability of *Chromolaena odorata* to phytoremediate soil-PCB from transformer oil co-contaminated Aroclor 1260 treated soil under greenhouse conditions.

Material and methods.

Soil

Soil samples were collected from a depth of up to 30 cm, from the main campus of University of South Africa, Pretoria. The soil samples were homogenized with hand to remove pebbles, stones and gravels and, air dried, before it was put in cellophane bags and stored at 4^{o}C before use. Sub-samples of the soil (250 g) each were taken and used for soil characterization at the laboratory. Composite samples from the stored soil were separated as the cultured soil sample. The soil used has a clay features with the following characteristics: clay (72.0%), silt (18.5%), sand (9.5%), pH (6.7), total organic carbon (7.0ppm), total N (0.03% wt), total P (9.0ppm), K (15.5ppm), Ca (83.0ppm), Mg (1.2ppm), Fe (58.6ppm) moisture content (4.8%), thermal conductivity (0.2Wm^{-2}k^{-1}), and soil density (1.25g/cm).

Plants

Chromolaena odorata plants were collected from the Department of Botany University of KwaZulu-Natal Pietermaritzburg and propagated by stem cuttings in the greenhouse at the University of South Africa. Soil samples were mixed with animal manure that was obtained from the Department of Veterinary Science, University of Pretoria, Onderstepoort, at the ratio of 9:1. The carbon, nitrogen and phosphates values (CNP) of the animal manure were analyzed at a private laboratory, the values were C=52.7 ppm; N=81.0 % wt and P=50 ppm). The plant cuttings were planted into the prepared soil bed employing the method described by Anyasi and Atagana (2014). Plants rooting hormone "Indole Butyric Acid" IBA, supplied by Plantland Malanseuns in Roslyn-South Africa was applied, this was to aid rooting of the cuttings. The plants in the soil bed were allowed to grow for three months and were then used for subsequent propagation and experimentation. The bed was watered manually using watering can to maintain 70 % moisture at field capacity.

PCB and transformer oil

Commercial PCB in form of Aroclor 1260 in surrogate standard concentration of 1000 ppm in hexane was supplied by Sigma Aldreich-Germany, and used Transformer oil (T/O) was provided by City power Johannesburg-South Africa and new oil (Nynas-LYRA X) supplied by Nynas oil- Sweden. Working standard solution was prepared from the surrogate standard using hexane fraction to make out composites of 100 ppm concentration. This means that transformer oil samples were amended to contain 100 ppm of PCB using Aroclor in hexane.

Treatments

1. Transformer oil direct treatment samples (T/O_D) and

2. Transformer oil culture Suzuki samples (T/O_S).

Control samples

1. Soil samples planted without contamination to test the toxicity of the contaminants on plants (C1);

2. Soil samples contaminated without plants to test for other possible measures of dissipation of the contaminants (C2);

Experimental design

42 set of PVC pot were used for the experiment each filled with 1 kg of soil. The pots were divided into two (21 each for the two transformer oil treatments), each section were further divided into six (3) replicates each for the treatments and controls). Thus, three (3) *C. odorata* plants were tested in two (2) pollutants among six (6) treatments replicated into three (3). A total of one hundred and twenty six plants were used in the study.

Experimental procedures

Five weeks old *C. odorata* plants were used in this study; the plants were transplanted into contaminated soil according to the treatment and were allowed for six weeks. In T/O direct treatments, plants were directly transplanted into the T/O_D treated soil samples. In Suzuki (sprout culture adopted from Suzuki *et al*. (1977) method however, plants were transplanted in a cultured soil which is contained in cellophane bags with holes at the bottom for protrusion of the roots. The bags containing the cultured soil and plants with protruded roots were placed on T/O treated soil contained in the PVC cups. This adopted and amended Suzuki method was designed to avoid the toxic effects of T/O on plants which posed a problem during the preliminary stage of the study. The initial length and number of mature leaves per plants (MLPP) was noted. The experiment was allowed for six weeks at prevailing environmental conditions, watered to maintain moisture at 75 % field capacity with manual watering can. Effort was made at ensuring that watering was done in such a way as to only wet the soil at any point in time avoiding much run off, weeds were removed manually at intervals. Measurements were also made at weekly intervals for the plant length, MLPP, leaf colour at different treatments and the root length which was only measured on the day of harvest. There was no application of inorganic manures to the soil mixes, but organic animal compost was used during the preparation of the soil at the ratio 1:9 manure to soil.

Sampling

After six weeks of growth of the plant in the contaminated and control set up, the soil and plants were sampled. The plants were removed carefully from the pots after loosening the soil around the pot using a kitchen knife; the roots were separated from the soil by shaking off the soil leaving the only adhering particles of the soil regarded as the rhizosphere soil. During this process, the entire plants were washed using running tape water, rinsed with distilled water and allowed to air dry, it was weighed afterwards to get the wet biomass and root lengths were measured. The plants were then separated into leaf, stem and roots, and the entire samples weighed using Mettler Toledo balance model PB_{1502} with maximum capacity of 1510 g. The soil samples were carefully collected also, homogenized and divided into sets together with the plants samples in preparation for subsequent extraction and analysis. All cuttings of the plants were done with a kitchen knife rinsed with acetone between uses to minimize cross

contamination. Harvested and prepared plant samples were kept in Whirlpak™ bags; Nasco-South Africa, in the refrigerator until time for analysis. Before the analysis, composite samples of the plant tissues were oven dried for the determination of the change in biomass. This was deduced from the initial (wet weight) at harvest and final weight (dry weight) after the entire plant was oven-dried until constant weight was attained. However any plant matter that was not collected for analysis was left in the green house in airtight containers for later use and appropriate disposal.

Determination of final PCB in soil and PCB recovery in plant tissues after six weeks of treatment with transformer oil co-contaminated with Aroclor 1260

All glass wares were washed with liquid detergent, rinsed with water and then soaked in Dichloromethane (DCM) over night. They were then rinsed with water, followed with distilled water and finally with acetone to remove any adhering organic substances (Perrin and Armerego 1981). Soil and plant samples were thoroughly homogenized for analysis and sub-sampled for the determination of wet and dry weight ratio. The samples for biomass determination were dried at 50^{o}C until constant mass using Lancon industrial oven with heating integration of 40-100^{o}C and were measured to obtain the dry mass. The dried plant samples were then ground using commercial blender, sieved at 2 mm and were stored prior to extraction while the soil samples were ground using a commercial mortar and was sieved at 2 mm. Five grams of 2 mm sieved dry soil as well as 5 g of 2 mm sieved plant samples were extracted using soxhlet apparatus for 4 hrs at 4-6 cycles per hour with 50 ml mixture of hexane-acetone (1:1, v/v), after which the extracted solution was concentrated to 2 ml in rotary evaporator (Buchi Rota vapor™ Japan model R-200 with heating bath B-490 and heating intensity of 20-180^{o}C). USEPA Method 3630B: Silica Gel Cleanup was used, this method have been shown to specifically address Aroclors [37].The extract from soxhlet extraction was dissolved in 10 ml hexane and passed from a glass chromatographic column (i.d 20 mm and 400 mm height) parked with layers of silica gel and anhydrous sodium sulphate and then eluted with 50 ml of hexane. The eluent was finally concentrated with rotary evaporator for the second time to about 1 ml and was analyzed using GC-MS.

Analysis and quantification of total PCB recovery in extracts from soil and plant samples

The method adopted here was the USEPA modified 8089/8081 method for the determination of total PCB. The analysis was conducted using Agilient 7890 GC equipped with 5975 Mass Spectometry and auto injector, an SupelcoWAX SPB™-1 (30 m x 0.25 mm x 0.25 µm) column was used with N_2 as the carrier gas. Prior to analysis of samples, recovery test was carried out using the standard Aroclor samples to ascertain the linearity of the response. One micro liter of the sample extract was injected into the GC. Injector and detector chamber temperatures were 260^{o}C and 300^{o}C, respectively. The oven temperature was initially set at 180^{o}C for 0.5 min, ramped at 30^{o}C per min to 260^{o}C, it was held for 18 min then 15^{o}C per min to 270^{o}C and held for 25 min. PCB congeners were identified by retention time matching to the surrogate standards which was prepared using the commercial stock samples of PCB inform of Aroclor 1260 prepared in concentrations of 1, 5, 10, 20, and 50 µg/ml in hexane. The value of the chromatogram was quantified using peak area integration. The initial content of PCB in transformer oil spiked was measured to be 6.8, 7.1, 6.1, 6.9, 6.3, and 6.7 in T/O_D and also 8.9, 7.4, 6.5, 7.3, 7.8, and 6.4 ppm in T/O_S

Statistical analysis of values

Results were analyzed by analysis of variance using three replicates at 95% level of significant difference to determine the mean differences of treatments in the experiment.

Results

Soil and plants growth parameters

The conditions of the soil in which the plants was grown is as presented above, although the soil was slightly acidic, other parameters indicated that *C. odorata* roots including the soil organisms will not have any resistance to thrive. After six weeks of growth in soil treated with Transformer oil co-contaminated with Aroclor 1260, growth inhibition was observed in plants especially the direct treated

samples; such inhibition was even lethal to plants in higher concentration of 500 ppm of oil. There was improved growth of *C. odorata* in the soil cultured Suzuki method. Plant growth measured from the difference between the initial and final length of *C. odorata* is presented in Figure 1, while percentage growth rate deduced is as presented in Table 2. Mean percentage growth rate was higher in T/O_S at 100 ppm (17.01) than the T/O_D (1.40). Untreated control C1 have percentage growth rate of 43.3 which is significantly different from that of the treated samples (p= 0.07). Relative mean Percentage growth rate at 200 ppm were lower than in 100 ppm treatment but were higher than the 500 ppm respectively. Mean percentage growth rate of value less than zero (-1.03), was obtained in T/O_D at 500 ppm treatment. Meanwhile, the growth of *C. odorata* was found to be negatively correlated with increase in concentration of soil transformer oil. In all treatments, percentage growth rate between treated and untreated control was significantly different at p= 0.005.

The number of mature leaf per plant (MLPP) of *C. odorata* at any interval of time was observed to be influenced by the presence of oil in its surrounding. MLPP followed the same trend as seen in growth rate as well as increase in root length. MLPP in T/O_D at 100 ppm increased from initial 27 leaves to final 29 leaves, leaving a mean percentage increase to 7.41. Mean percentage increases in MLPP in T/O_D at 200 and 500 ppm were zero respectively as the plant leaves were completely dried at the end of the experiment. In T/O_S, MLPP values were higher; hence at 100 ppm it was 50.0 but dropped to zero at 200 ppm and remained in zero at 500 ppm (Table 2). Relative mean Percentage change in MLPP at untreated control (C1) was higher than the treated samples; and such values were significantly different (p= 0.013) from that of the treated experiments.

Root lengths of *C. odorata* at different concentrations of transformer oil co-contaminated with 10 % Aroclor 1260, maintained the same trend as observed in growth rate and MLPP. Percentage change in root length was high in T/O_S at 100 ppm (50.60), which is not significant with that of untreated control (68.98). Root length at this treatment was however reduced considerably at 200 and 500 ppm (20.34 and -0.24) respectively. In T/O_D treatment, percentage change in root length was lower at 100 ppm than in T/O_S and such effect was increased at higher concentrations. Results of root length of *C. odorata* after six weeks of growth in an Aroclor treated soil is presented in Figure 3 and Table 4.

The leaves of *C. odorata* at different concentration of transformer oil co-contaminated with 100 ppm of Aroclor were marked by significant colour changes few days after contamination. The colour changes were evident with the light green colouration and black spots, an evidence of the inhibitive effect of transformer oil to the growth of plants. Untreated control maintained its green leaf colour throughout the six weeks of the experiment.

Effect of different concentrations of transformer oil co-contaminated with 100 ppm of Aroclor 1260 treatment on the ability of *C. odorata* to retain water in its tissues.

As was deduced from the initial (wet weight) at harvest and final weight (dry weight), at 100 ppm, percentage water retention ability was higher in T/O_S than in T/O_D (49.25 and 27.07) respectively, these values were lower than what was obtained in untreated control (75.12 %). As the concentration of the oil is increased, such phenomenon was found to increase, this can be found in 200 and 500 ppm treatments where the corresponding values were 59.84 vs. 34.48 % and 62.81 vs. 40.67 % for T/O_S and T/O_D respectively (Table 5a-5c). In all, water retention ability of treated samples were significantly different from untreated control at p=0.05.

Total PCB recovery from soil and plant tissues.

Mean percentage change in soil total PCB concentration at T/O_D were 61.6, 53.2, 41.5, 55.9, 16.3, 18.8 for 100, 200 and 500 ppm of transformer oil as well as in control experiments respectively, having reduced to 2.61, 3.32, 3.51, 5.42, 5.27, 5.44 ppm from initial concentration of 6.8, 7.1, 6.1, 6.9, 6.3, 6.7 ppm of PCB among the treatments and treated controls respectively. No PCB detection was observed both at the beginning and at the end of the six weeks experiment in untreated controls. In T/O_S however, mean percentage change in total soil PCB at the end of the experiment were 77.3, 74.7, 58.8, 16.7, 25.5, 21.1 for the 100, 200 and 500 ppm of transformer oil as well as treated controls. The initial concentrations of PCB in the soil were 8.9, 7.4, 6.5, 7.3, 7.8, and 6.4 ppm and the final soil

concentrations were 2.02, 1.87, 2.68, 6.08, 5.81and 5.05 ppm for 100, 200 and 500 ppm of transformer oil and treated controls 1, 2 and 3 respectively.

At the end of the phytoremediation experiment on the effect of oil on remediation of PCB co-contaminated in transformer oil using *chromolaena odorata* for six weeks, there was no detection of PCB in the tissues of the plants in T/O_D treatment, although mean final soil PCB concentration in that treatments were lower than the initial treatment with Aroclor 1260 of 100 ppm (Table 6). However, in T/O_S treatments PCBs were found in the root tissues of plants especially at the 100 and 200 ppm of oil treatments (0.10 and 0.11 ppm) given a total root PCB of 0.62 and 0.52 µg for respective 100 and 200 ppm of oil concentrations respectively. Mean root bioaccumulation factors of 0.001 were recorded in those treatments respectively.

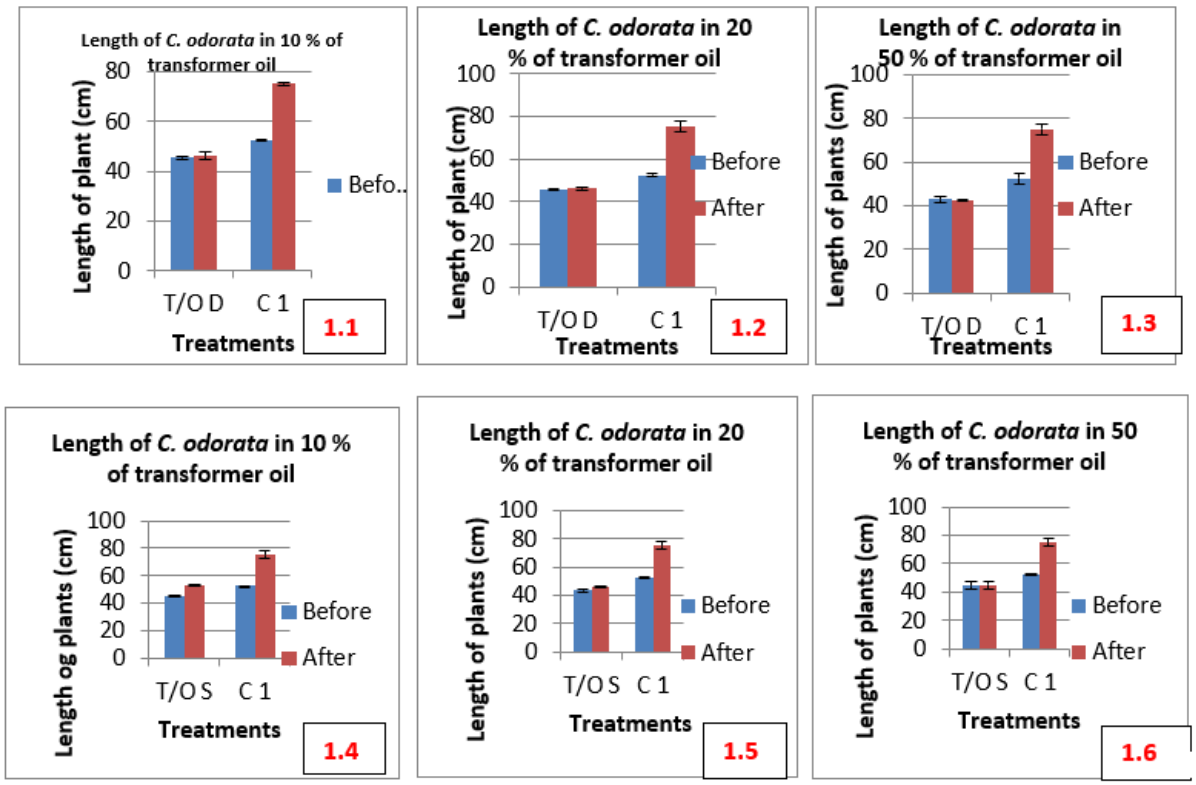

Figure 1: Length of plant at different concentrations of T/O co-contaminated with Aroclor 1260 in soil (Error bars indicate standard error of the mean), before=initial length, after=final length

Table 2: Percentage growth rate of *C. odorata* at different concentrations of T/O co-contaminated with Aroclor 1260 in soil.

Treatments	**% growth rates of *C. odorata***		
	100 ppmT/O	**200 ppm T/O**	**500 ppm T/O**
T/O_D	**1.40[a]**	**0.46[a]**	**-1.03[a]**
C1	**43.30[b]**	**41.30[b]**	**42.36[b]**
C2	**NP**	**NP**	**NP**

Treatments	% growth rates of *C. odorata*		
	100 ppmT/O	200 ppm T/O	500 ppm T/O
T/O $_S$	17.01[a]	6.09[a]	1.08[a]
C1	43.30[b]	41.30[b]	42.36[b]
C2	NP	NP	NP

Values with the same alphabets in superscript in the same column were not significant at 5% level according to Bonferoni test. T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1, C2=control 2, NP=not palnted

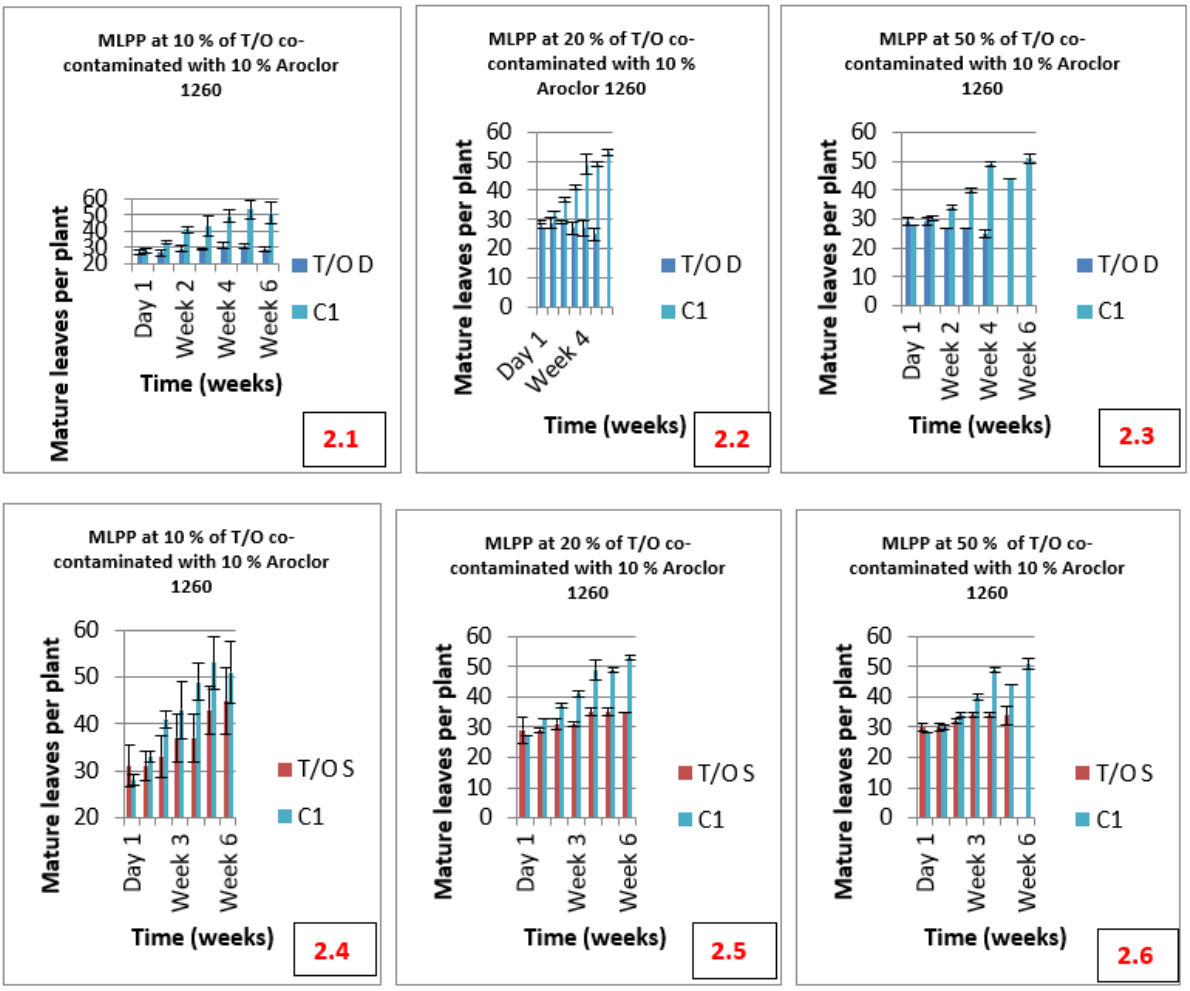

Figure 2: MLPP at different concentrations of T/O co-contaminated with Aroclor 1260 (Error bars indicate standard error of the mean), T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1,

Table 3: Percentage change in mature leaves per plant in different concentrations of Aroclor and T/O treated soil 2.

Treatments	% increase in mature leaves per plant		
	100 ppm T/O soil (cm)	200 ppm T/O soil (cm)	500 ppm T/O soil (cm)
T/O D	7.41[a]	0.00[a]	0.00[a]
C1	82.14[c]	96.30[c]	82.14[b]
C2	NP	NP	NP

Treatments	% increase in mature leaves per plant		
	100 ppm T/O soil (cm)	200 ppm T/O soil (cm)	500 ppm T/O soil (cm)
T/O S	50.00[b]	20.69[b]	0.00[a]
C1	82.14[c]	96.30[c]	82.14[b]
C2	NP	NP	NP

Values with the same alphabets in superscript in the same column were not significant at 5% level according to Bonferoni test. T/O D=direct transformer oil, T/O S=Suzuki transformer oil, C1=control 1, C2=control 2, NP=not palnted

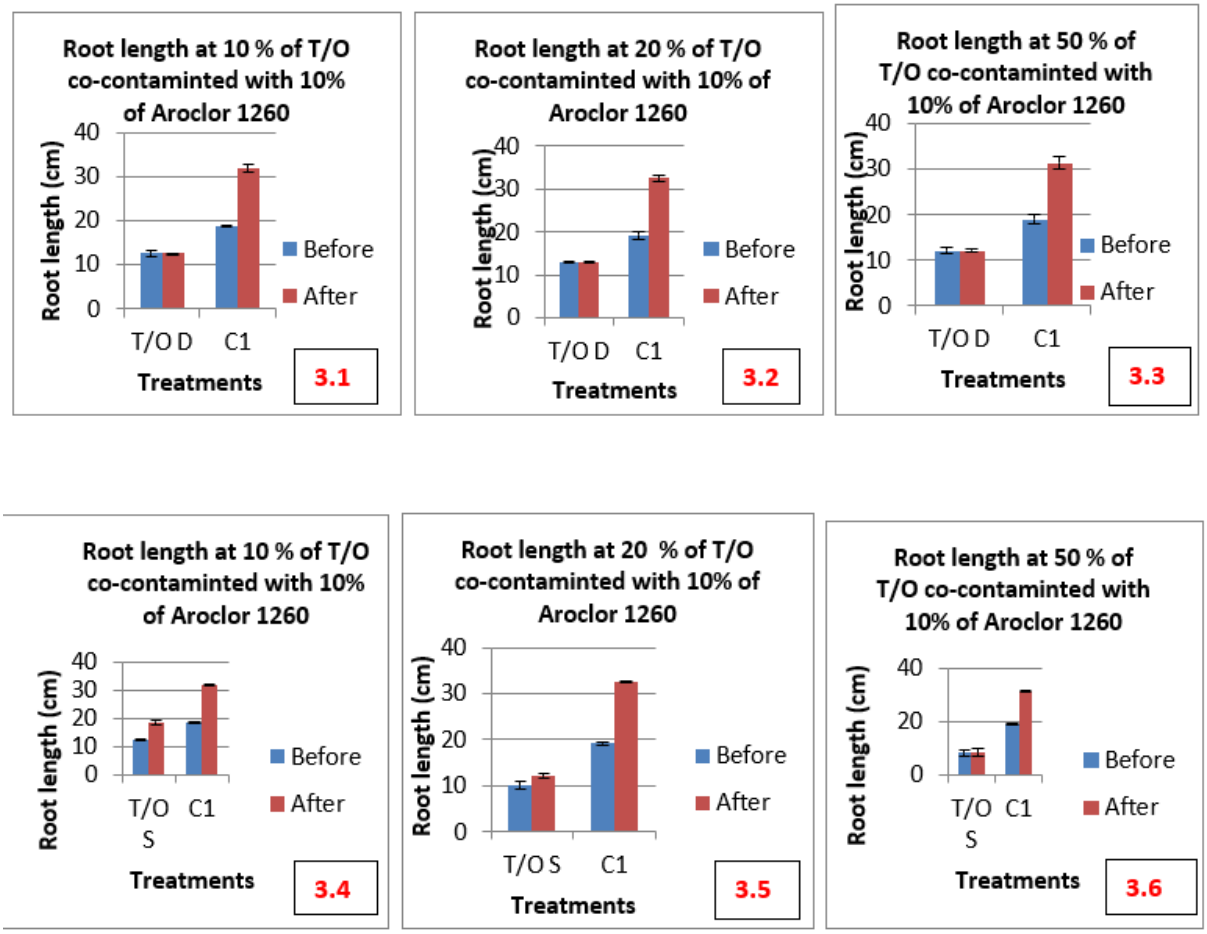

Figure 3: Root length at different concentration of Transformer oil co-contaminated with of Aroclor 1260 (Error bars indicate standard error of the mean), before=initial length, after=final length

Table 4: Percentage change in root length at different concentrations of Transformer oil co-contaminated with Aroclor 1260.

Treatments	Percentage change in root length		
	100 ppm T/O soil (cm)	200 ppm T/O soil (cm)	500 ppm T/O soil (cm)
T/O $_D$	0.30[a]	0.08[a]	-0.33[a]
C1	69.98[b]	69.13[b]	65.18[b]
C2	NP	NP	NP

Treatments	Percentage change in root length		
	100 ppm T/O soil (cm)	200 ppm T/O soil (cm)	500 ppm T/O soil (cm)
T/O $_S$	50.60[a]	20.34[a]	-0.24[a]
C1	69.98[b]	69.13[b]	65.18[b]
C2	NP	NP	NP

Values with the same alphabets in superscript in the same column were not significant at 5% level according to Bonferoni test. T/O_D=direct transformer oil, T/O_S=Suzuki transformer oil, C1=control 1, C2=control 2, NP=not palnted

Table 5a: Percentage change in biomass of *C. odorata* at 100 ppm of transformer oil co-contaminated with Aroclor 1260 treatments.

Treatments/Set-up (ppm)	Wet weight (g)	Dry weight (g)	Difference (g)	% change
T/O_D	5.69[a]	4.15[a]	1.54[a]	27.07[a]
C1	13.06[b]	1.76[a]	11.30[b]	86.52[b]
C2	NP	NP	NP	NP

Treatments/Set-up (ppm)	Wet weight (g)	Dry weight (g)	Difference (g)	% change
T/O_S	6.64[a]	3.37[a]	3.27[a]	49.25[a]
C1	13.06[b]	1.76[a]	11.30[b]	86.52[b]
C2	NP	NP	NP	NP

Values with the same alphabets in superscript in the same column were not significant at 5% level according to Bonferoni test. T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1, C2=control 2, NP=not palnted

Table 5b: Percentage change in biomass of *C. odorata* at 200 ppm of transformer oil co-contaminated with Aroclor 1260 treatments.

Treatments	Wet weight (g)	Dry weight (g)	Difference (g)	% change
T/O_D	7.25[a]	4.75[a]	2.50[a]	34.48[a]
C1	92.07[b]	6.99[a]	85.08[b]	92.41[b]
C2	NP	NP	NP	NP

Treatments	Wet weight (g)	Dry weight (g)	Difference (g)	% change
T/O_S	13.57[a]	5.45[a]	8.12[a]	59.84[a]
C1	92.07[b]	6.99[a]	85.08[b]	92.41[b]
C2	NP	NP	NP	NP

Values with the same alphabets in superscript in the same column were not significant at 5% level according to Bonferoni test. T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1, C2=control 2, NP=not palnted

Table 5c: Percentage change in biomass of *C. odorata* at 500ppm of transformer oil co-contaminated with Aroclor 1260 treatments.

Treatments	Wet weight (g)	Dry weight (g)	Difference (g)	% change
T/O$_D$	8.95^a	5.31^a	3.64^a	40.67^a
C1	13.06^{ab}	1.33^a	11.73^b	89.82^b
C2	NP	NP	NP	NP

Treatments	Wet weight (g)	Dry weight (g)	Difference (g)	% change
T/O$_S$	18.66^a	6.94^a	11.72^a	62.81^a
C1	13.06^a	1.33^a	11.73^a	89.82^b
C2	NP	NP	NP	NP

Values with the same alphabets in superscript in the same column were not significant at 5% level according to Bonferoni test. T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1, C2=control 2, NP=not palnted

Table 6: PCB recovery results: final soil PCB concentration, total PCB concentration, percentage PCB absorbed, percentage change in PCB, and PCB concentration factor

Treatments	Initial soil PCB conc. (ppm)	Final soil PCB conc. (ppm)	Total PCB in plants tissue (ppm)	% PCB absorbed	% change in PCB
T/O$_D$ 100	6.8	2.61	--	--	61.6
C1	BD	BD	BD	BD	0
C2	6.9	5.42	NP	NP	21.4
T/O$_D$ 200	7.1	3.32	--	--	53.2
C1	BD	BD	BD	BD	0
C2	6.3	5.27	NP	NP	16.3
T/O$_D$ 500	6.1	3.57	--	--	41.5
C1	BD	BD	BD	BD	0
C2	6.7	5.44	NP	NP	18.8
T/O$_S$ 100	8.9	2.02	--	--	77.3
C1	BD	BD	BD	BD	0
C2	7.3	6.08	NP	NP	16.7
T/O$_S$ 200	7.4	1.87	--	--	74.7
C1	BD	BD	BD	BD	0
C2	7.8	5.81	NP	NP	25.5
T/O$_S$ 500	6.5	2.68	--	--	58.8
C1	BD	BD	BD	BD	0
C2	6.4	5.05	NP	NP	21.1

Conc.=concentration, BD=below detection, NP=not planted, RF=remediation factor, T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1, C2=control 2

Table 7: PCB concentrations in different plants tissues among different concentrations of Aroclor and T/O soil treatments (values are reported as the mean of three replicates and their subsequent standard deviation).

			Root			Stem			Leaf			Total			
Treatments	**Init. Soil PCB (ppm)**	**Residual Soil PCB (ppm)**	**Dry weight biom. (g)**	**Absd. Root PCB (ppm)**	**Total root PCB (ppm)**	**Dry weight biom. (g)**	**Absd. Stem PCB (ppm)**	**Total stem PCB (ppm)**	**Dry weight biom. (g)**	**Absd. Leaf PCB (ppm)**	**Total leaf PCB (ppm)**	**Total plant biom. (g)**	**Total plant PCB (ppm)**	**TLF**	**RF/BAF**
T/O$_D$ 100	**6.8 ±0.24**	**2.61 ±0.02**	**1.04 ±0.12**	**BC**	**N/A**	**2.92 ±0.10**	**BC**	**N/A**	**2.30 ±0.13**	**BC**	**N/A**	**6.26 ±0.26**	**N/A**	**N/A**	**N/A**
C1	**BD**	**0**	**1.83 ±0.36**	**BC**	**N/A**	**3.72 ±0.25**	**BC**	**N/A**	**3.64 ±0.06**	**BC**	**N/A**	**9.19 ±0.70**	**N/A**	**N/A**	**N/A**
C2	**6.9 ±0.24**	**5.42 ±0.23**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**
T/O$_D$ 200	**7.1 ±0.49**	**3.31 ±0.08**	**0.34 ±0.07**	**BC**	**N/A**	**2.65 ±0.08**	**BC**	**N/A**	**2.02 ±0.19**	**BC**	**N/A**	**5.01 ±0.21**	**N/A**	**N/A**	**N/A**
C1	**BD**	**0**	**1.83 ±0.36**	**BC**	**N/A**	**3.72 ±0.25**	**BC**	**N/A**	**3.64 ±0.06**	**BC**	**N/A**	**9.19 ±0.70**	**N/A**	**N/A**	**N/A**
C2	**6.3 ±0.00**	**5.27 ±0.69**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**
T/O$_D$ 500	**6.1 ±0.16**	**3.57 ±0.02**	**0.20 ±0.05**	**BC**	**N/A**	**1.42 ±0.34**	**BC**	**N/A**	**1.12 ±0.25**	**BC**	**N/A**	**2.74 ±0.15**	**N/A**	**N/A**	**N/A**
C1	**BD**	**0**	**1.83 ±0.36**	**BC**	**N/A**	**3.72 ±0.25**	**BC**	**N/A**	**3.64 ±0.06**	**BC**	**N/A**	**9.19 ±0.70**	**N/A**	**N/A**	**N/A**
C2	**6.7 ±0.16**	**5.44 ±0.42**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**
T/0$_S$ 100	**8.9 ±0.33**	**2.02 ±0.00**	**6.24 ±1.24**	**0.10 ±0.07**	**0.62**	**3.07 ±0.08**	**BC**	**N/A**	**1.64 ±0.05**	**BC**	**N/A**	**10.95 ±0.21**	**N/A**	**N/A**	**0.001**
C1	**BD**	**BC**	**6.40 ±0.56**	**BC**	**N/A**	**3.83 ±0.31**	**BC**	**N/A**	**1.83 ±0.08**	**BC**	**N/A**	**12.06 ±0.07**	**N/A**	**N/A**	**N/A**
C2	**7.3 ±0.06**	**6.08 ±0.02**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**

T/0S 200	**7.4 ±0.49**	**1.87 ±0.06**	**4.77 ±0.20**	**0.11 ±0.07**	**0.52**	**2.36 ±0.35**	**BC**	**N/A**	**1.27 ±0.20**	**BC**	**N/A**	**8.40 ±0.14**	**N/A**	**N/A**	**0.001**
C1	**BD**	**BC**	**6.40 ±0.56**	**BC**	**N/A**	**3.83 ±0.31**	**BC**	**N/A**	**1.83 ±0.08**	**BC**	**N/A**	**12.06 ±0.07**	**N/A**	**N/A**	**N/A**
C2	**7.8 ±0.16**	**5.81 ±0.06**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**
T/0S 500	**6.5 ±0.08**	**2.68 ±0.08**	**0.98 ±0.10**	**ND**	**N/A**	**1.41 ±0.02**	**ND**	**N/A**	**0.81 ±0.06**	**ND**	**N/A**	**3.20 ±0.00**	**N/A**	**N/A**	**N/A**
C1	**BD**	**BC**	**6.40 ±0.56**	**BC**	**N/A**	**3.83 ±0.31**	**BC**	**N/A**	**1.83 ±0.08**	**BC**	**N/A**	**12.06 ±0.07**	**N/A**	**N/A**	**N/A**
C2	**6.4 ±0.24**	**5.05 ±0.65**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**	**NP**

Conc.=concentration, BD=below detection, NP=not planted, RF=remediation factor, T/O $_D$=direct transformer oil, T/O $_S$=Suzuki transformer oil, C1=control 1, C2=control, N/A=not applicable, TLF=translocation factor, RF/BAF=bioaccumulation factor

Discussion

Growth of *C. odorata* in transformer oil contaminated soil

Phytoremediation of PCB co-contaminated in transformer oil in form of 100 ppm of Aroclor by *C. odorata* in this study behaved differently at different concentrations of transformer oil in the soil. This could be attributed to the toxicity of transformer/hydrocarbon containing oil to plants. Increase in concentration of oil in soil has been reported to increase the phytoxicity to plants until such concentration that it became lethal to the plants (Erickson 1997; Atagana 2008). In this study, the growth of *C. odorata* was tremendously affected by the presence of transformer oil in the soil especially when the oil is in direct contact with the plant (T/O_D). 500 ppm of transformer oil per kilogram of soil was lethal to *C. odorata* at this treatment. This was shown by the withering of the plant the first week they were transplanted into the contaminated soil, as evidenced by the low percentage growth obtained in T/O_D experiment. Such effect has been described as physiological shock experienced by plants when it changes environment (Vamerali et al. 2010). However, growth performance of *C. odorata* were favorably in the T/O_S experiments, the reason perhaps being that the plant did not have direct contact with the contaminated soil except through the roots. Hence the plants in this treatment had relatively high percentage growth with values not significant with that of T/O_D but significantly different from the values of the untreated control. Meanwhile, various weeds have shown strong adaptability to poor soil condition, therefore it is not out of place that *C. odorata* was able to thrive on T/O treated soil (Lingenfelta and Hartwig 2007; Singh et al. 2008; Anyasi and Atagana 2018). *Chromolaena odorata* being a very resilient plant with such good properties for example the ability to survive in an oil contaminated soil and other harsh environment was harnessed in this present study (Atagana 2011a/b). Furthermore, plants in the higher concentration of transformer oil (500 ppm) of T/O_D had percentage growth rate which is less than zero meaning that the plants could not survive the duration of the experiment. This evidently implies that only the high T/O treatments have lethal inhibitive effects to the growth of *C. odorata*. Lethality of *C. odorata* in this experiment may have been caused by the depletion of the nutrient in the soil as a result of the contaminant (Zeeb et al. 2006; Anyasi et al. 2019).

Mature leaves per plant were increased especially in the lower oil treatments, an indication of growth among the plants growing in that contaminated soil. However, higher oil concentration of 200 and 500 ppm contributed in the reduction of plant growth rate to 1.08 and 6.09 % respectively within the Suzuki ammended experiment with a slight increase in MLPP in 200 ppm of oil, but withering of the plants was observed at 500 ppm of both Suzuki method as well as in direct treatment with transformer oil as a result, it could not develop more leaves. Untreated control maintained a high growth percetage increase in MLPP with values significantly different from those of T/O_D and T/O_S treatments. This result therefore is in aggreement with the report that exposure of plants to a concentration higher than what it can tolerate may cause chlorosis of the leave, plant dehydration, stunted growth and perhaps death (Merkl et al. 2004; Anyasi and Atagana 2004). Baek et al. (2004), reported on the inhibition of red bean and corn by poly aromatic hydrocarbon (PAHs) content in crude oil contamination of between 10-1000 ppm in soil. Showing that phytoxicity of oil increases with the increase in the number of aromatic rings (Dominguez-Rosado et al. 2004; Atagana 2011b). Meanwhile the multiplication of leaves by plants in the T/O_S treatment is a good correlation to the fact that *C. odorata* can tolerate high concentration of oil in soil compared to the results of other scholars that have used other plants species (Palmroth et al. 2006; Diab 2008; Muratova 2009).

In this study, mean leaf colour change was greener in untreated control, and progressively turned pale green with dark spots as the concentration of transformer oil was increased from 100-500 ppm. Leave of *C. odorata* varies in colour when it is growing in an environment that possesses growth supportive enabling nutrients. Leave colour could range from light to middle green colour (Luwum 2002). The greener the colour of the leaf, the more supportive the nutrient are to the growth of the plants in a soil (Anoliefo and Edogbai 2001).

This study presented an average shoot to root ratio range of 4:1 to 13:1. This ratio is within the range observed by one of the first studies on phytoremediation using a field tobacco plants (Suzuki et al. 1977; Perrin and Armarego 1981). The study reported that plants with low concentration of organics could still extract a valuable quantity of PCBs with a large shoot biomass. Contrastingly this study could not obey the model reported by Gler (1940), but proffers a higher root biomass increase which explains the reason why PCB absorption by the plant was concentrated in the root tissue. This should not be a surprise considering the tremendous improvement in science and technology between 1940 to present. The values of the percentage change in root length of the plants as used in this greenhouse experiment maintained the same trend that was reported in the growth rate and MLPP. Wiltse *et al*, (1998), reported an increased root biomass which was as a result of root length increase. These lead to increased surface area of the root, causing a subsequent increase in rhizosphere volume. This however means that root biomass is also important indicator in organic contaminant remediation process (Brandt 2003). Reduced root length resulting to low biomass increase of the root could lead to reduced rhizosphere volume and thus will have impact on the root surface of the plant towards the contaminants. Smith *et al*. (Smith et al. 2007) agrees that high root biomass enhances contaminant degradation. Increased shoot biomass was however suggested by Ficko *et al*, (2010), for optimization of phyoremediation of organic contaminants which synonymously increased the amount of the contaminant removed by the shoot tissues. Such increased shoot biomass concomitantly lead to an increase in root biomass enabling the adsorption of the contaminants in the root. The progressive reduction in the measured parameters of *C. odorata* grown in a soil treated with different concentrations of transformer oil co-contaminated with Aroclor 1260 should be attributed to changes in soil condition as a result of hydrophobicity of the oil which interferes with nutrient and water uptake as well as gaseous exchange (Smith et al. 1989).

Effect of different concentrations of transformer oil co-contaminated with Aroclor 1260 on the ability of *C. odorata* to retain water.

Percentage change in biomass at T/O_D and T/O_S was significantly different from each other and an increase in their value was observed as the concentration was increased from 100 to 200 to 500 ppm. This explains the fact that the presence of transformer oil in soil containing *C. odorata* affects transpiration ability of the plants thence affecting its physiological responses (Vamerali et al. 2010). Such increased trend was also significantly different from that of untreated control which recorded all time high of above 89 %. This is synonymous with the reports of Minai-Tehrani (2008) on a study of

the effect of heavy crude–oil contamination on germination and growth of Rough meadow-grass. Presence of water in plants signifies presence of nutrient and these aids plants growth and replenishment (De Rouw 1991). High change in biomass from wet to dry is an indication of high water content in plants, hence an indication of plant grown in a growth supportive environment. Therefore, increased change in biomass is a good indicator for plants phytoremediation ability. *C. odorata* possesses good remediation ability as it has been linked with the ability to travail in oil contaminated environments (Palmroth et al. 2009). Meanwhile, the presence of organic pollutant in soil is known to cause a lot of adversities to plants, a good example being that when a plant is growing in an organic contaminated soil, transpiration pull is reduced by the closure of stomatal walls reducing evaporation of water from the plants (Minai-Tehrani 2008; Anyasi et al. 2019).

Phytoremediation ability of *C. odorata* to PCB on transformer oil contaminated soil.

In transformer oil amended soil treatments, the concentrations of PCB in different oil treatments were not phytotoxic to *C. odorata* as the plant has been shown to survive 500 ppm of PCB concentration in authors previous study hence was able to complete the growth duration of the experiment in those treatments. That is to say if the plant could manage the inhibition of the transformer oil then there is possibility of phytoremediation of the PCB content as observed in different concentration of transformer oil in the experiment (Anyasi and Atagani 2014). There was no measurement of concentration of the oil at the end of the experiment but the influence of the oil was observed on the percentage reduction of PCB in the experiment. Percentage reduction of PCB in the experiment was high at the lower transformer oil treatment but continued to decrease as the content of oil was increased. However, percentage reduction of PCB in unplanted control experiment showed a reduced value as compared to that of oil treated and planted experiments. This shows that actual phytoremediation of PCB from the co-contamination of Aroclor in transformer oil was aided by the presence of *C. odorata*. Although *C. odorata* was able to cause reduction of PCB in this experiment, the plant was affected by phytotoxicity of the oil in the 500 ppm concentration of oil in the two treatments. This was shown by the downwards trend of the percentage reduction of PCB concentration in the residual soil as the content of the oil per kilogram of soil was increased and the low concentration of PCB traces in the root tissues of the plants in the Suzuki treatment at both the 100 and the 200 ppm per kilogram treatment of the oil. PCB contamination between 0-260 µg/g have been reported not to be phytotoxic to various plants tested for its phytoremediation ability, but higher concentration of PCB was seen to cause stress to the plants [12; 31; 63](Webber and Mrozek, 1979; Zeeb et al. 2006; Tanhan et al. 2011). The severity of transformer oil to growth of *C. odorata* throughout the duration of this experiment at higher concentration of the oil may not have been caused by co-treatment with Aroclor as the plant was found to survive at much higher PCB-concentrated soil (Authors unpublished work). This implies that it could have been caused by oil inhibition and perhaps other factors not measured.

However, total PCB concentrations found in the root tissues of *C. odorata*, ranges from 0.10 to 0.11ppm, the values could not give any remediation factor for the plants as a result of the fact that such presence of PCB was not found in the above ground tissues of the plant. Therefore C. *odorata* only absorbed PCB at 100 and 200 ppm transformer oil per kilogram of soil in the Suzuki experiment. Such effect was not possible at 500 ppm concentrations as well as in the direct treatment of the soil with T/O. This is in agreement with the study of Pinsker (Pinsker 2011), which reported that initial soil PCB has a great effect on the amount of PCB absorbed by plants, its translocation as well as the concentrations of the residual PCB in the soil at the end of a phytoremediation study. There was higher mean percentage reduction of PCB concentration in the entire experiment compared to the mean percentage PCB reductions of other plants species in phytoremediation studies reported in literature per unit time (Mackova et al. 2009; Ficko et al. 2010; Teng et al. 2010). However PCB reduction was also observed at the unplanted control, the reason behind such observation could be attributed to natural attenuation and perhaps other parameters not measured (Aslund et al. 2007).

Different plant species have been reported on their ability to grow in high PCB or oil content in the soil as to be able to phytoremediate the soil containing the contaminants (Salt et al. 1998; Low at al. 2009). In those reports such plants were found to be able to tolerate the contaminants in soil even at high concentration and were able to grow and remediate such soil (White et al. 2006; Muratova et al. 2009).

In this study, *C. odorata* was able to grow through the duration of the experiment and contributed in the reduction of soil PCB concentration to about 73% compared to unplanted control that was only reduced to about 25%. This action by the plant to such soil contamination was most obvious when the plants were prevented from direct contact with the oil because it was only at such treatment that the plant grew well except at the high concentration of the oil per kilogram of the soil. The fact that no PCB congeners were recovered at the shoot but only trace quantities at the root tissues of *C. odorata* even when there was appreciable reduction in the concentration of the contaminant is an indication of probable rhizodegradation although the resultant degradation product was not analyzed. This report is in agreement with Epuri and Sorensen (1997) that reported a complete mineralization of hexachlorobiphenyl in Aroclor 1260-contaminated soil that was planted with Tall fescue. Such effects have also been elucidated by other studies (Singer et al. 2003; Checkol et al. 2004). However, future studies should involve the analysis of the resultant compound from the degradation of Aroclor 1260 in the presence of transformer oil by the root of *C. odorata* to enable a conclusive result to be drawn (Aken et al. 2010; Anyasi et al. 2019).

Conclusions and recommendation

The results of this study showed that the presence of transformer oil in soil at both low and high concentration inhibits *C. odorata* growth parameters, hence reduces the ability of the plant to phytoremediate soil PCB. The presence of *C. odorata* in this experiment contributed in the remediation of the soil at low co-contamination of the oil, but the effects of the plants were negatively impacted at high co-contamination of the oil at direct contact with the plant. At such high concentration, plant growth was hampered by the oil hence reducing phytoremediation ability. *C. odorata* contributed in the reduction of soil PCB concentration at the end of the experiment. The use of soil culture Suzuki method demonstrated that by using appropriate methodology, phytoremediation of soil contaminated by transformer oil co-contaminated with Aroclor could be enhanced. Although natural attenuation was found to also act on such unaided environment, but such effect was not appreciable. Therefore soil culture phytoremediation of soil PCB contained in transformer oil using *Chromolaenana odorata* should be tried in the field. As *C. odorata* has so demonstrated the ability to withstand the inhibition of PCB co-contaminated in transformer oil as it could for other pollutants, it then present the plant as a good candidate for the remediation of PCB contained transformer oil-contaminated soil using appropriate method.

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AGING AND GERIATRIC HEALTH

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ABSTRACT:

Aging is a generic and inevitable process that all organisms experience. It is the result of the progressive accumulation of various molecular and cellular damages over time. However, human aging has changed over the years, improving the average life expectancy and the physical appearance of people.

Nonetheless, it leads to a gradual decline in physical and mental abilities, increasing the risk of diseases that can ultimately lead to death. Old age is also characterized by the presence of complex health conditions known as geriatric syndromes.

In this context, Geriatrics is established as the branch of medicine dedicated to the study, prevention, diagnosis, treatment, and rehabilitation of diseases specific to older adults. It is based on the CGA model (Comprehensive Geriatric Assessment), a method that allows detecting and clarifying physical and/or mental problems, as well as observing the individual's abilities. Its goal is to ensure the greatest independence and quality of life for the elderly person.

The responsible geriatric physician must have the knowledge, skills, and competencies necessary to implement comprehensive care strategies, as well as to strengthen support networks that allow for the patient's reintegration into their daily, family, and social life, applying and adapting resources to meet the person's needs.

Keywords: Aging, Health, Geriatric, Older adults, Reintegration.

INTRODUCTION

El envejecimiento es un proceso natural y universal que, en las últimas décadas, ha adquirido una relevancia creciente debido al acelerado aumento de la población adulta mayor en todo el mundo. Es un fenómeno demográfico que plantea retos significativos para los sistemas de salud, las familias y la sociedad.

A medida que las personas envejecen, se incrementa el riesgo de enfermedades crónicas y de los llamados síndromes geriátricos, las cuales son reconocidas como condiciones multifactoriales que afectan la autonomía, la funcionalidad y la calidad de vida.

La salud geriátrica surge como una disciplina especializada que busca comprender y atender las necesidades particulares de los adultos mayores, integrando aspectos médicos, psicológicos y sociales.

Su objetivo no se limita a prolongar la vida, sino a garantizar que esta etapa se viva con dignidad, bienestar y participación en la comunidad. En este contexto, resulta indispensable reflexionar sobre el impacto del envejecimiento en la salud, identificar los principales desafíos y diseñar estrategias que permitan responder de manera integral y humanizada a las demandas de una sociedad que envejece.

RESEARCH AND FINDINGS

I. EL ENVEJECIMIENTO

El envejecimiento suele ser referido y entendido como el cambio gradual biológico de un ser vivo el cual presenta diferencias cognitivas, físicas y sociales, este es un proceso continuo que se comienza desde el nacimiento y prosigue a lo largo de toda la vida.
Este proceso mientras más prosigue aumenta el daño molecular interno y externo del ser humano, resultando en el aumento de la vulnerabilidad a enfermedades, así como aumentan el riesgo de afectación a tejidos y órganos.

Ávila (2018), menciona que el envejecimiento, comúnmente suele ser marcado por connotaciones negativas, y que, por el contrario, esta debería verse de manera positiva, mencionando tres definiciones distintas para el envejecimiento, la primera es la "cronológica" la cual su principal factor es la edad para la comprensión de ese proceso; la segunda es la "funcional" la cual es la que permite ver cuando comienzan y aparecen las limitaciones y discapacidades; dando por último la que lo entiende como parte del proceso de ciclo vital de las personas y las características singulares.

Cuando se habla de envejecimiento, se deben entender dos cosas, la primera es que no hay que confundir la vejez con el envejecimiento, si bien, las dos se relacionan con el "crecimiento", no son lo mismo. El envejecimiento como ya se ha dicho es una serie de procesos biológicos que comienzan desde el nacimiento y terminan con la muerte, y que, en el proceso pueden presentar problemas de salud; en cambio la vejez es una etapa comprendida de la vida. En otras palabras, el envejecimiento es un proceso, y la vejez es una etapa especifica.
Ahora, en segundo lugar, el envejecimiento no se presenta igual para todas las personas y esta misma no es una enfermedad; Pérez y Sierra (2009) declaran que rara vez una persona muere de "vejez", la gran mayoría del tiempo mueren por una causa derivada del envejecimiento, como lo son por ejemplo un paro cardiaco.

Estos mismos, aseguran, que el envejecimiento se debería estudiarse a profundidad, siendo algo ya imprescindible, ya que se observa conforme pasa el tiempo el aumento acelerado de la longevidad y por lo cual se puede observar de igual manera el aumento acelerado del envejecimiento implicando una necesidad de comprender tanto los aspectos fisiológicos como de comportamiento de los individuos de edad avanzada, así como también los efectos a nivel social y económico.

I) CAMBIOS FISIOLOGICOS

Salech (2012) describe que algunos cambios asociados al envejecimiento suelen ser:

A. Cardiovascular

- Rigidez vascular y cardíaca
- Mayor disfunción endotelial
- Volumen expulsivo conservado
- Mayor riesgo de arritmias

B. Renal

- Menor capacidad para concentrar orina
- Menores niveles renina y aldosterona
- Menor hidroxilación vitamina D

C. Nervioso Central

- Menor focalización actividad neuronal
- Menor velocidad procesamiento
- Disminución memoria de trabajo
- Menor destreza motora

D. Muscular

- Disminución fuerza
- Caídas
- Fragilidad

E. Metabolismo / Glucosa

- Mayor Producción adipoquinas y factores inflamatorios
- Mayor resistencia insulínica y diabetes (pág. 19-29)

II. SÍNDROMES GERIÁTRICOS

Los síndromes geriátricos, son aquella forma de presentacion de las enfermedades, durante el proceso de envejecimiento en un adulto mayor, que suelen ser causadas por el ambiente o de manera natural en el organismo.

En otras palabras, son un complejo de signos y síntomas que llegan a generar patologias que aumentan el riesgo a la muerte del paciente; así como son a su vez la más frecuente fuente de incapacidad

En años anteriores, los "síndromes geriátricos" eran referidos como características que eran más comunes en gente mayor (ancianos) que han ingresado en la zona de geriatría, más, sin embargo, debido al paso del tiempo y el estudio e interés en el envejecimiento este término pudo ser cambiado al que ahora conocemos.

A pesar de que los 5 principales síndromes son la *inmovilidad, inestabilidad, deterioro cognitivo, incontinencia urinaria y la fragilidad;* estos comparten algunas características, tal cual lo mencionan Millán, Morant, Alba et al. (2023) en su investigación, las cuales son:

- Elevada frecuencia.
- Carácter sindrómico (constituye una forma de presentación de diferentes patologías)
- Originan un importante deterioro en la calidad de vida
- Puede ser prevenible en algunos casos
- Su abordaje diagnóstico y terapéutico requiere valoración integral

I) SINDROMES PRINCIPALES

Como se había dicho, existen 5 grandes y principales síndromes geriátricos, que son aquellos que se presentan más comúnmente en las personas ya en la etapa de vejez y en su proceso de envejecimiento.
Millan et al. (2013) establece algunos de ellos:

- *La inmovilidad.* En palabras de la RAE la inmovilidad es "la incapacidad de moverse o cambiar de posición, que se aplica tanto a objetos físicos como a estados emocionales o mentales"; dentro del contexto de los síndromes geriátricos, es definido como la "disminución de la capacidad de desempeñar las actividades de la vida diaria debido al deterioro muscular y de las funciones motoras", este es un síntoma que suele aparecer o comenzar a ser constante a partir de los 75 años.
- *La inestabilidad (caídas).* La RAE califica la caída como "la declinación o declive de algo", es decir, es la precipitación repentina al suelo producida de forma involuntaria (puede haber perdida de conciencia).

- *Incontinencia urinaria.* Es la perdida involuntaria de orina, esta puede ser leve (algunas gotas al mes), la moderada (algunas gotas diarias) y la severa (perdida de mayores cantidades de orina).
- *Deterioro cognitivo.* Es definido como la alteración, perdida o reducción de manera total o permanente de varias o todas las funciones mentales, las cuales incluyen memoria, lenguaje, pensamiento, razonamiento y orientación, afectando la capacidad de llevar su vida cotidiana.
- *Fragilidad*. Es la disminución de la reserva fisiológica, es un estado que presenta mayor pérdida de resistencia y un mayor riesgo de incapacidad, dejando a la persona en un estado vulnerable.

III. VALORACIÓN GERIÁTRICA INTEGRAL (VGI)

La Valoración Geriátrica Integral (VGI) se ha consolidado como la herramienta primordial y la "piedra angular" de la práctica geriátrica moderna, superando el modelo médico tradicional para responder a la complejidad del envejecimiento.

La VGI se define como un proceso diagnóstico multidimensional, dinámico y estructurado, usualmente interdisciplinario, que busca cuantificar los problemas y las capacidades médicas, funcionales, psíquicas y sociales del anciano. Su objetivo final es trazar un plan de tratamiento y seguimiento a largo plazo que optimice los recursos y logre el mayor grado de independencia y calidad de vida del paciente. Este proceso sigue un patrón bio-psico-social-funcional donde todas las esferas interactúan entre sí, de modo que cualquier cambio en una repercute sobre las demás.

Para Vargas Esquivel y Luz María (2001), la importancia de la VGI cobra un auge especial debido a la transición demográfica y epidemiológica, caracterizada por un incremento de las enfermedades crónico-degenerativas e incapacitantes. Sostiene que el modelo más adecuado para medir la salud en el anciano es aquel que se centra en la capacidad funcional (la aptitud para atenderse a sí mismo y desarrollarse en su entorno familiar y social).

La VGI es fundamental porque permite la observación sistemática del proceso terapéutico con el fin de impedir o retardar la aparición de incapacidades. Además, destaca que el c*ambio en el estado funcional* debe ser considerado el indicador más sensible para identificar una nueva enfermedad en el adulto mayor.

Soria Perdomo (2018) resalta que permite salir de la concepción tradicional de la medicina para atender coordinadamente a la población en situación de fragilidad.

Su diferencia clave con la valoración tradicional radica en el énfasis que pone en las "cinco I" de las afecciones geriátricas: *deterioro intelectual, inmovilidad, inestabilidad, incontinencia e iatrogenia*. Por su parte, Sánchez García (2020) señala que este proceso mejora la detección de problemas no identificados previamente, descubriendo enfermedades no sospechadas en más del 50% de los pacientes mayores de 65 años. Asimismo, constituye la herramienta más útil para determinar el estado de salud y estimar la supervivencia, independientemente de la suma de patologías que presente el individuo.

La evidencia científica sólida demuestra que la VGI realizada por equipos interdisciplinares, mejora significativamente los resultados de salud en comparación con el abordaje médico convencional. Se ha comprobado que reduce la mortalidad, mejora la independencia funcional y aumenta las probabilidades de que el anciano siga viviendo en su domicilio tras una hospitalización aguda, reduciendo el riesgo de vivir en una residencia.

De igual manera, Sanjoaquín Romero et al. (s/f) subraya que la VGI permite situar al paciente en el nivel médico y social más adecuado a sus necesidades, reduciendo ingresos hospitalarios innecesarios e institucionalizaciones prematuras.

A su vez se describe que, la VGI es una respuesta necesaria a la presentación atípica e inespecífica de las enfermedades en el anciano (como infecciones sin fiebre o infartos indoloros), que suelen escaparse a la anamnesis tradicional. Su importancia reside en alcanzar un diagnóstico cuádruple (clínico, funcional, mental y social) que configure la imagen real del anciano como si fuera un puzle. Además,

este proceso es vital para prevenir la iatrogenia, dado que el riesgo de efectos adversos por medicamentos es de 3 a 5 veces mayor en ancianos que en adultos; la VGI permite una revisión farmacológica exhaustiva para evitar el "encarnizamiento diagnóstico y terapéutico".

Los autores coinciden en que la VGI no solo es una técnica, sino un lenguaje común que dota a los profesionales de herramientas objetivas (escalas y cuestionarios) para una atención humanizada. Dada la realidad sociodemográfica actual, es imperativo que la enseñanza de la VGI sea parte obligatoria y específica en los planes de estudio de Medicina y Enfermería para responder al reto de ofrecer una atención excelente al paciente más frágil.

IV. POLITICAS PUBLICAS

Según Razo-González (2014), hasta antes de la década de los setenta, el país carecía de una política pública definida; la atención a los ancianos se relegaba al ámbito privado y religioso bajo preceptos de caridad y beneficencia. No fue sino hasta 1979 que se dio un paso hacia la institucionalidad con la creación del Instituto Nacional de la Senectud (INSEN), hoy INAPAM.

Esta autora destaca que el enfoque inicial se basaba en la "pobreza e integración social", donde el adulto mayor era visto como un "objeto" de asistencia. Sin embargo, bajo la influencia de recomendaciones internacionales, se ha transitado hacia un enfoque de derechos, que promueve la habilitación de las personas mayores como sujetos activos y busca la protección de sus derechos sociales y humanos. A pesar de este avance discursivo, Razo-González advierte que el INAPAM ha enfrentado dificultades para ejercer su papel rector debido a la falta de recursos técnicos y financieros suficientes.

El diseño de las políticas sociales en México no ha sido un proceso aislado. Los organismos como la ONU, la OMS y la CEPAL han determinado las representaciones sociales de la vejez y las agendas gubernamentales. Especialmente tras las Asambleas Mundiales sobre el Envejecimiento en Viena (1982) y Madrid (2002), se impulsaron planes de acción que obligaron a los gobiernos a visualizar el envejecimiento como un fenómeno demográfico ineludible.

Un aporte crítico de estas autoras es la demanda creciente de un Sistema Nacional de Cuidados. Argumentan que, ante la precarización del empleo y el aumento de la longevidad, la sobrecarga de cuidados ha recaído históricamente en las familias y, de manera desproporcionada, en las mujeres. Por ello, proponen que el Estado asuma una corresponsabilidad efectiva, transformando el cuidado en un derecho garantizado que integre al sector privado y a la comunidad.

Desde una perspectiva médica y poblacional, los autores Gutiérrez Robledo et al. (s/f) señalan que México atraviesa un proceso de envejecimiento acelerado: para 2050, se estima que el 22.5% de la población tendrá 60 años o más. El gran reto para el sistema de salud es la carga de enfermedades crónicas (cardiovasculares, diabetes, tumores), responsables del 79.1% de las defunciones.

La esperanza de vida y la esperanza de vida saludable; en México, los individuos pierden en promedio casi nueve años de vida saludable debido a enfermedades crónicas que aparecen a edades cada vez más tempranas. Ante esto, proponen cuatro líneas estratégicas urgentes:

- Prevención a lo largo del curso de vida: Abordar factores de riesgo desde la juventud para retrasar la discapacidad.
- Atención médica centrada en la persona: Organizar los servicios de salud según las necesidades y preferencias del adulto mayor, no solo de su patología.
- Creación de entornos adaptados: Fomentar espacios amigables y reducir la discriminación.
- Integración médico-social: Vincular los servicios de salud con sistemas de cuidados a largo plazo.

Complementando el enfoque de salud, Muñoz Hernández (2011) propone un modelo de integración social que privilegia la ayuda a domicilio como alternativa a la institucionalización en asilos u hospitales. Este enfoque busca mantener a los adultos mayores en su entorno habitual para prevenir riesgos de desinserción social.

Sugiere la implementación de "cuasi mercados" de servicios sociales, donde el Estado financia y regula, pero diversos sectores (público, privado y OSC) suministran los cuidados domiciliarios. Asimismo, destaca modelos comunitarios como el de la Comunidad Participativa Tepito (Comparte), que utiliza el lema "el barrio como alternativa al asilo", fomentando redes vecinales de apoyo y autogestión de los adultos mayores para preservar su autonomía.

Finalmente, Alejandro Klein (2024) ofrece una visión crítica sobre la insuficiencia de las políticas actuales, describiendo a la mexicana como una "sociedad que desampara". Klein argumenta que existe un déficit crónico en las políticas sociales, sumergidas en una alta desigualdad, donde el 72% de los adultos mayores padece vulnerabilidad social.

El autor denuncia la persistencia de un estereotipo de desvalimiento, que califica al adulto mayor como "anciano decrépito" e improductivo. Se propone transitar hacia un "paradigma de plenitud de vida", donde se reconozca al adulto mayor como un sujeto con potencialidades, capacidad de autonomía y empoderamiento.

Las políticas públicas en México enfrentan el reto de pasar de un discurso de derechos a una implementación operativa que garantice la salud geriátrica, la seguridad económica y el derecho al cuidado, rompiendo con los estereotipos de vulnerabilidad para fomentar una verdadera ciudadanía en la vejez.

V. RETOS DEL SISTEMA DE SALUD

México atraviesa un cambio demográfico sin precedentes: la población de adultos mayores está creciendo a un ritmo mucho más acelerado que en los países desarrollados. Mientras que a Francia le tomó 115 años duplicar su índice de envejecimiento del 7% al 14%, se estima que México alcanzará este cambio en tan solo 28 años. Como señala Carmen García Peña (2022), este fenómeno plantea el reto de optimizar oportunidades para la salud y la seguridad con el fin de asegurar la calidad de vida, bajo el paradigma del envejecimiento activo.

El sistema de salud actual, sin embargo, responde solo parcialmente a estas necesidades. El modelo vigente sigue siendo predominantemente reactivo y curativo, diseñado para atender enfermedades agudas y no la cronicidad compleja del anciano.

La carga de la enfermedad se ha desplazado hacia las enfermedades no transmisibles (ECNT), que representan el 84% de las muertes en el país. En la población mayor de 60 años, la prevalencia de hipertensión alcanza el 72.8% y la de diabetes el 17.4%. Teniendo en cuanta a la nutricion, como un papel importante en estas atribuciones.

Un problema central es la multimorbilidad: el 7% de los adultos mayores padece cinco o más enfermedades simultáneamente, lo que eleva exponencialmente los costos y la complejidad del tratamiento. García Peña (2012) subrayan que los hogares con adultos mayores consumen un 50% más de recursos en salud que el promedio, y que la carga acumulada de enfermedad crónica es la principal razón del incremento en los costos asistenciales.

De acuerdo con Gutiérrez Robledo, Kershenobich Stalnikowitz y Caro López et al. (2015) la dependencia funcional constituye el desafío más apremiante para el sistema. Aunque la esperanza de vida ha aumentado a 76 años, la esperanza de vida saludable es de apenas 65.8 años, lo que implica vivir casi una década con enfermedad y discapacidad.

Se ba reportado que cerca del 26% de los adultos de entre 60 años (y más) tienen limitaciones para realizar actividades básicas de la vida diaria.

Considerando esto, la falata de un sistema o red de apoyo para los cuidados y servicios de forma regulada, deja a las familias con la principal carga económica y mental (predominada mente en las mujeres); acrecentando la vulnerabilidad para las dos partes y las demás personas en el nucleo familiar.

Existe una carencia crítica de personal especializado. Según Avila Fematt A. , Montaña Álvarez M. , Salinas Rodríguez A. (2013) México cuenta con una media nacional de apenas 0.38 geriatras por cada 10,000 habitantes mayores de 60 años. Para alcanzar estándares internacionales mínimos, el país

necesitaría formar cerca de 2,000 geriatras en pocos años, una meta difícil de alcanzar dado que actualmente solo egresan unos 20 por año. Esta insuficiencia se agrava por la concentración de especialistas en las grandes urbes, dejando desprotegidas a las zonas rurales.

La seguridad económica es otro reto sistémico. Berenice Ramírez y Ham Chande (2012) señalan que la informalidad laboral deja a más de la mitad de la población sin acceso a pensiones contributivas. Esto obliga a muchos ancianos a seguir trabajando en condiciones precarias o a depender totalmente de transferencias familiares y remesas. Aarón Salinas Rodríguez y su grupo de investigación han documentado que el 40% de los hogares con un adulto mayor con discapacidad incurre en gastos catastróficos de salud, gastando casi cuatro veces más en consultas externas que hogares sin discapacidad.

Para enfrentar estos retos, los autores proponen un cambio de paradigma hacia un Modelo de Atención Integral centrado en la persona. Las líneas estratégicas sugeridas por el Instituto Nacional de Geriatría incluyen:

- *Geriatrizar los servicios:* Capacitar al personal de primer contacto en competencias geriátricas y crear "Unidades de Enlace Geriátrico" multidisciplinarias.
- *Enfoque preventivo*: Implementar el modelo de núcleos gerontológicos de ayuda mutua, propuesto por Víctor Manuel Mendoza Núñez, para fomentar el autocuidado y la autogestión.
- *Marco legal y derechos*: Avanzar hacia la exigibilidad de los derechos establecidos en la Ley de los Derechos de las Personas Adultas Mayores, combatiendo el "viejismo" y la discriminación por edad.
- *Investigación transnacional*: Vincular la investigación científica con la política pública para garantizar que las intervenciones se basen en evidencia real de la población mexicana.

El sistema de salud debe dejar de ver el envejecimiento como una "carga" y comenzar a planificarlo como un proceso dinámico que requiere una respuesta intersectorial, financiamiento sólido y un enfoque preventivo a lo largo de todo el curso de vida.

CONCLUSION

El envejecimiento, es aquel proceso complejo que implica cambios biológicos, psicológicos y sociales. Son cambios que, a pesar de ser naturales, dan lugar a los síndromes geriátricos, que no suelen ser enfermedades aisladas, si no, un grupo de condiciones que afectan la calidad de vida de una persona.

No debería entenderse como una pérdida progresiva o en una definición enteramente negativa, si no, como una etapa natural del crecimiento humano, una etapa que requiere una valoración integral y estrategias de prevención.

Los síndromes geriátricos son señales de alerta que demandan un abordaje interdisciplinario, centrado en la persona y en su entorno. Reconocerlos y atenderlos oportunamente permite no solo prolongar la vida, sino asegurar que sea una vida con dignidad, funcionalidad y bienestar.

Se destacan como principales síndromes, la inmovilidad, la inestabilidad, la incontinencia urinaria, el deterioro cognitivo y la fragilidad; todas ellas afectan fuertemente la autonomía de una persona. Estos síntomas son principales ya que son los más comunes de ver, más sin embargo no todos experimentan lo mismo, e incluso, pueden presentarse de otras formas.

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GEOLOGY AND GEOCHEMICAL EVALUATION OF GOLD POTENTIAL IN KORO, PART OF PATIGI SHEET 204SE, NIGERIA

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Abstract

This study evaluates the gold mineralization potential of the Koro area (Patigi Sheet 204SE), Kwara State, Nigeria, using an integrated approach involving airborne geophysical interpretation, geological mapping, petrographic analysis, and geochemical investigation. The study area lies within the northern extension of the Egbe-Isanlu Schist Belt of the Nigerian Basement Complex, a region recognized for structurally controlled mesothermal gold systems but relatively underexplored in this segment. Airborne magnetic and radiometric datasets were processed using first vertical derivative, tilt derivative, analytic signal, and horizontal gradient techniques to delineate lithological boundaries, structural fabrics, and hydrothermal alteration zones. Results from the geophysical analysis reveal dominant NE-SW to NNE-SSW structural trends, intersected by NW-SE cross-cutting faults that define potential pathways for mineralizing fluids. Geological mapping at a scale of 1:12,500 identified migmatitic gneiss, granites, amphibolites, and quartz veins, with evidence of deformation including shearing, fracturing, and veining. Petrographic analysis confirms mineral assemblages dominated by quartz, feldspars, biotite, and amphibole, alongside microstructural features indicative of tectono-metamorphic evolution. A systematic soil geochemical survey conducted on a 200m X 200m grid, with samples analyzed using ICP-MS, indicates generally low background gold concentrations but highlights discrete anomalous zones. Gold and associated pathfinder elements, such as arsenic, copper, lead, and antimony, show positive correlations and spatial clustering at NW-SE structural intersections, suggesting structurally controlled mineralization. The integration of geophysical, geological, and geochemical datasets confirms the presence of a structurally controlled hydrothermal gold system within the study area. The delineated anomalies and structural targets provide a strong basis for further exploration, including detailed infill geochemical sampling, trenching, ground geophysics, and drilling to evaluate subsurface continuity and economic potential.

Keywords: Gold mineralization, Geophysics, Geochemistry, Structural geology, Koro, Egbe-Isanlu Schist Belt

I. Introduction

Gold (Au) has long held a unique position among the elements, valued not only for its aesthetic appeal and role as a financial hedge but increasingly for its critical applications in modern technology and medicine. As a siderophile element with high electrical conductivity and resistance to corrosion, it is indispensable in the electronics industry. However, its primary global driver remains its status as a "safe-haven" asset, which continues to spur intensive exploration efforts worldwide (Frimmel, 2008).

Nigeria is endowed with significant gold mineralization, primarily hosted within the Proterozoic schist belts of the western half of the country. Historically, gold mining in Nigeria dates back to 1913, with peak production occurring in the 1930s. The mineralization is generally associated with the Schist Belts (such as the Ilesha, Egbe-Isanlu, and Kushaka belts) and is often controlled by structural features like shear zones and faults within the Pan-African Basement Complex (Woakes and Bafor, 1984; Garba,

2003). Despite this potential, much of the country's gold remains underexplored, with current activities dominated by artisanal and small-scale miners.

Gold Exploration and the Egbe-Isanlu Schist Belt

Modern gold exploration relies on a multi-disciplinary approach, integrating geological mapping, aerogeophysical data interpretation, and detailed geochemical surveys to identify "blind" deposits. The Egbe-Isanlu Schist Belt, located in North-Central Nigeria, is a critical focal point for such studies. This belt is characterized by a suite of metasedimentary and metavolcanic rocks, including phyllites, schists, and amphibolites, often intruded by Granitoids (Olobaniyi, 2003).

Previous studies in the Egbe-Isanlu area have highlighted the presence of gold-bearing quartz veins and associated hydrothermal alterations. Research has shown that mineralization in this region is typically orogenic, linked to the late-stage tectonic events of the Pan-African Orogeny (Danbatta, 2008). In the Koro area of the Pategi Sheet 204SE, the geological setting suggests a continuation of these favourable mineralized structures. Evaluating the geochemical signature of the soil and rocks in this specific sector is essential to unlocking its economic potential and providing a blueprint for sustainable mineral development in Kwara State.

II. Study Area

The study area falls within Patigi Sheet 204SE, and it is bounded by latitude 8°32'45" to 8°35'15" and longitude 5°54'15" to 5°57'15", it spans an area of approximately 25.88km^2 and it is located within the environs of Patigi Local Government Area of Kwara State, Nigeria (Figure 1). The region is located in West Africa's Guinea Savannah belt, which is known for its moderate grasslands and sparse shrubbery. In the region, tall grass grows to its fullest extent from September to December. The vegetation cover is tropical and is characterized by alternating rainy and dry seasons. During the dry season, there are intermittent showers. The North-East trade winds (harmattan)" keep the humidity low from December through January. The average yearly rainfall ranges from 700 to 1300 millimeters. The area is underlain by the Basement Complex of Nigeria, which consists of the Migmatite-Gneiss Complex; the Upper Proterozoic supracrustal rocks known as the Schist belts, and the Syn to late tectonic granitic rocks, which intruded the Migmatite-Gneiss Complex and the Schist belts that are pan-African in age (Obaje, 2009).

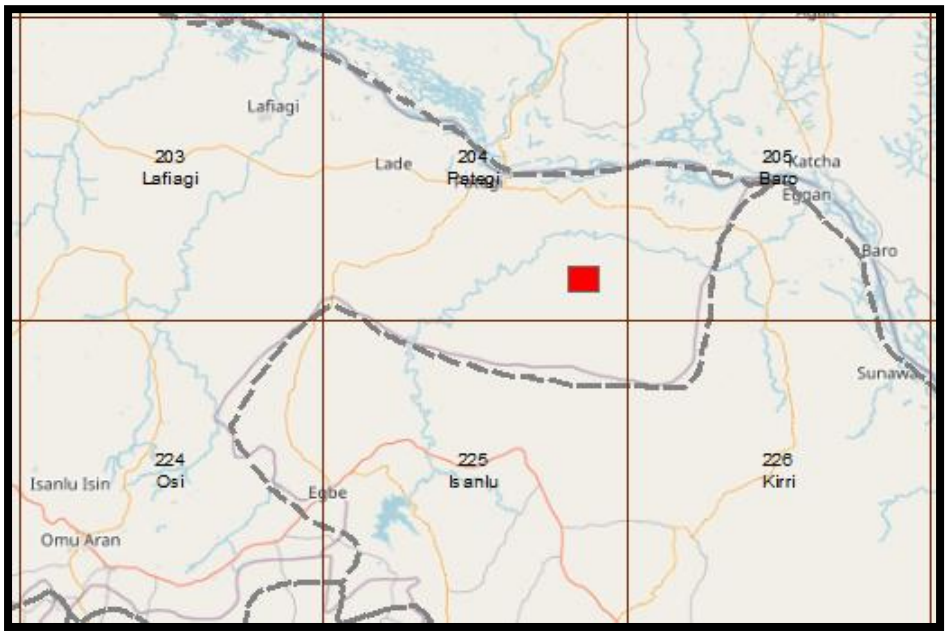


Figure 1: Topographical Index Map showing the spatial location of the study area within Sheet 204SE (Patigi)

III. Materials and Methods

The evaluation of the gold potential in the Koro area followed a systematic, multi-disciplinary exploration workflow. This integrated approach ensured that surface geochemical signatures were interpreted within a robust litho-structural framework.

- **Pre-Field Litho-structural Analysis**

The study commenced with the acquisition of high-resolution **aero-geophysical data** from the **Nigerian Geological Survey Agency (NGSA)**. Using Oasis Montaj and ArcGIS software, these data were processed to generate enhanced magnetic and radiometric maps. This phase focused on identifying deep-seated structural controls, such as shear zones, faults, and hydrothermal alteration zones, which often serve as conduits for mineralizing fluids in the Nigerian Basement Complex.

- **Geological Mapping and Field Operations**

Building on the geophysical interpretations, a detailed field mapping exercise was conducted on a scale of 1:12,500 across the study area located within **Patigi Sheet 204SE**. The primary objective was to ground-truth the interpreted structures and confirm the local lithology. During this phase, 30 representative rock samples were systematically collected from outcrops for subsequent laboratory study. Special attention was paid to quartz vein orientations and evidence of hydrothermal activity. Structures like joints, faults, foliations, and field relations of one lithology with other lithologies were observed.

- **Petrographic Studies**

To understand the mineralogical composition and paragenetic sequences of the host rocks, 10 thin sections were selected and prepared. Petrographic analysis was performed using a polarizing microscope to identify key rock-forming minerals, textures, and microstructures that assist in naming rocks and in assessing microstructures indicative of gold mineralization.

- **Geochemical Soil Sampling**

Residual soil samples were collected across a predetermined 200 X 200 regional soils grid prepared over the high prospect areas where cross-sectional features occur. Sampling was focused on the B-horizon to minimize the influence of organic matter and surface contamination. Approximately 500g of soil was collected at each station and securely bagged. The sampling density was designed to provide adequate coverage for identifying geochemical anomalies across the Koro study site.

- **Laboratory Analysis**

The prepared soil samples were submitted for high-precision laboratory analysis. **Inductively Coupled Plasma Mass Spectrometry (ICP-MS)** was utilized to determine the concentrations of gold (Au) and a suite of associated pathfinder elements. The use of ICP-MS ensured low detection limits and high sensitivity, which are critical for detecting subtle geochemical signatures in a primary exploration target. Analysis was carried out at ALS Laboratory South Africa.

- **Data Integration and Statistical Analysis**

The final stage involved the integration of the geophysical, geological, and geochemical datasets. Statistical analysis was performed on the assay results to determine the background and threshold values for gold and its pathfinder elements. Multivariate techniques, including the calculation of **Pearson**

correlation coefficients (r), were applied to evaluate the relationship between gold and other elements, the relationship between one pathfinder element and the other, helping to distinguish between lithogenic signatures and true mineralization anomalies.

IV. Findings and Discussions

- **Geology and Structures**

Litho-structural Interpretation

The integrated analysis of aeromagnetic and radiometric data revealed a complex structural framework dominated by NE-SW and NNE-SSW regional trending lineaments and localized NW-SE cross faults. These regional structures are consistent with the regional deformation patterns of the Pan-African Orogeny. Magnetic highs and lows coincide with Amphibolites and felsic rocks, respectively, also indicative of zones of suspected alterations. The structural complexity is indicative of multiple episodes of deformation **(Figure 2)**. Radiometric ternary maps highlighted distinct potassium (K) and thorium (Th) anomalies, often coinciding with hydrothermally altered zones within the amphibolite units. A combination of processing, interpretation, and integration of aero-magnetic and aero-radiometric data was used to produce a preliminary litho-structural map, which serves as a pre-field source of information to guide the ground-truthing exercise.

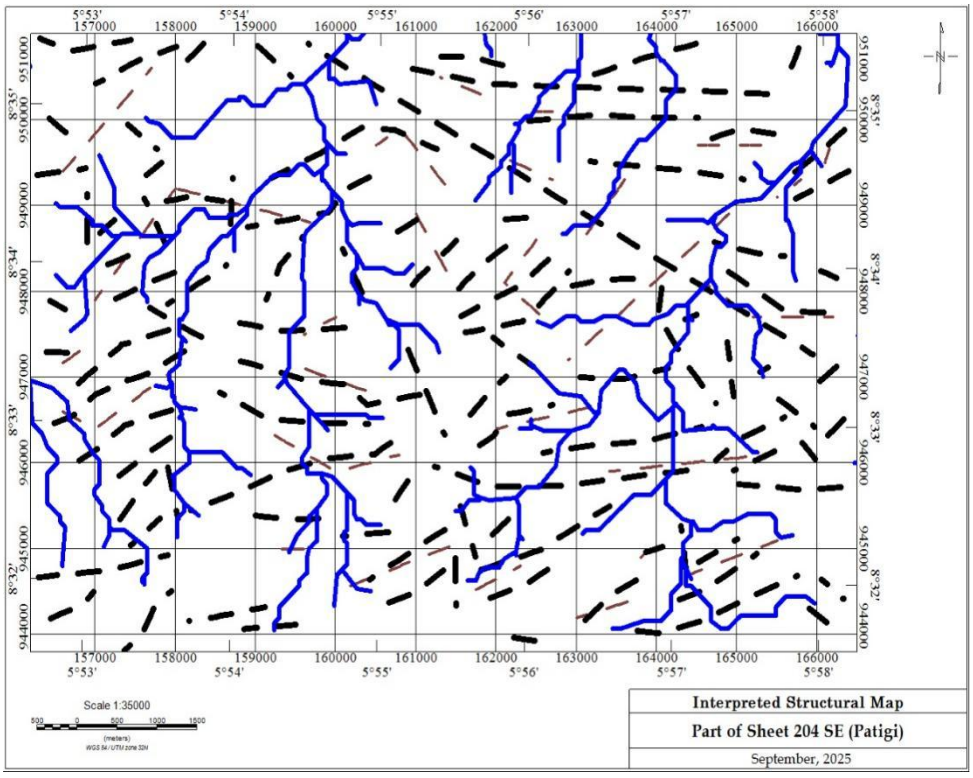


Figure 2: Aero-magnetic Structural Interpretation Map

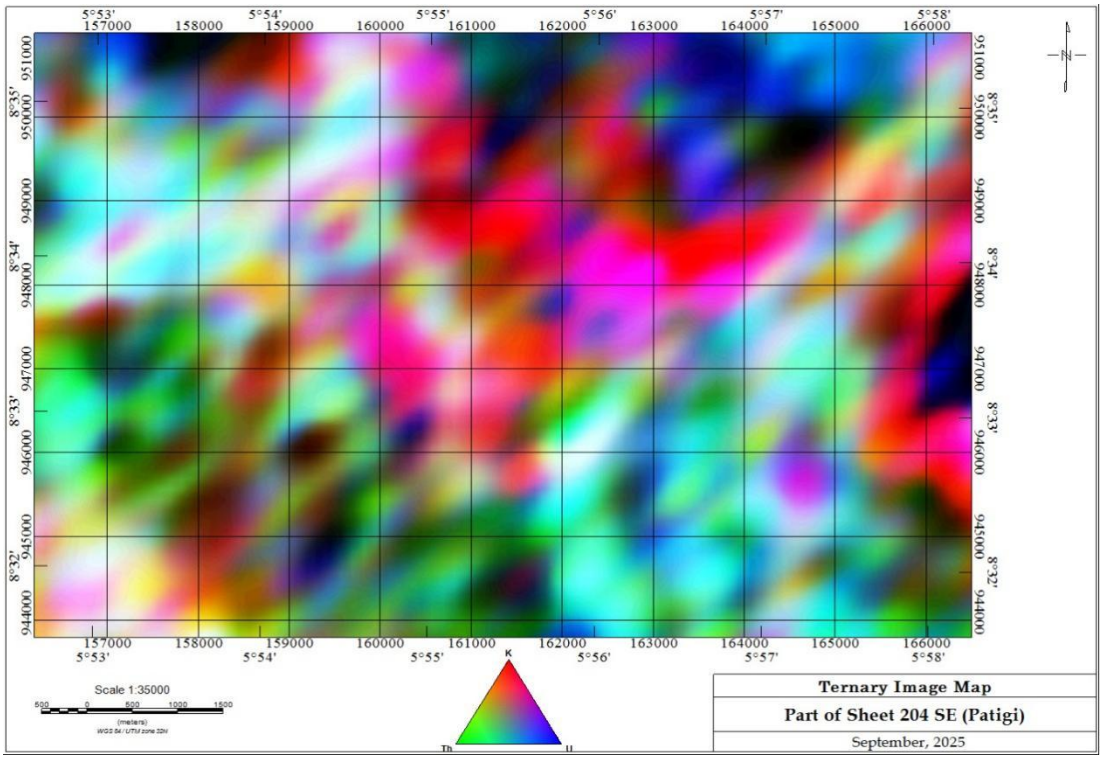


Figure 3: Ternary Image map

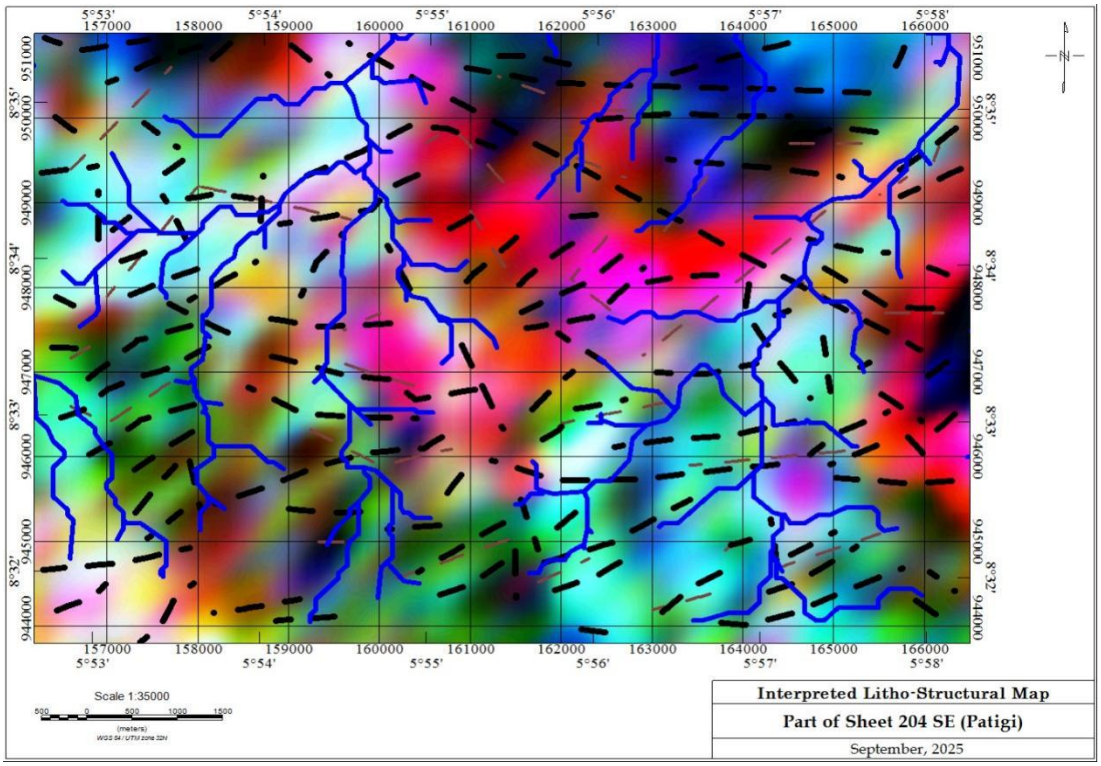


Figure 4: Structural Interpretation Map in relation to Ternary Image Map: A combination of Aeromagnetic and Aero-radiometric Data Interpretations

- **Ground Truthing and Field Observations**

The study area, located 22.5km southeast of Pategi, is situated within the **Nigerian Basement Complex**, comprising a suite of Migmatite-gneisses, Schist Belt units (Amphibolite schist), and Older Granite intrusions. Field mapping and reconnaissance identified five primary lithological units from a total of 30 outcrops that were studied on the field:

- **Granitic Suites:** Both fine-medium and medium-coarse grained granites were observed. These units frequently outcrop as bouldery or dome-shaped bodies and appear to have intruded the surrounding schists and gneisses, predominantly following a NE-SW orientation.
- Amphibolite and Amphibole Gneiss: These mafic-rich units are characterized by their dark grey to greenish-grey coloration, aphanitic textures. Structural measurements of foliation indicate a NW-SE strike, reflecting the intense tectonic history of the region.
- Migmatitic Gneiss: Exposed along river channels, these rocks display classic neosome (pegmatitic) and paleosome (gneissic) components with a general NNE-SSW trend. Some outcrops show a distinct migmatite flow structure (Figure x), while others show a weak foliation of platy minerals.
- Metasedimentary Units: Quartzite and quartz-schists form subtle topographic highs. Though weathered, these units exhibit a preferred NW-SE orientation, dipping toward the SW.
- Altered Quartz (The Exploration Pointer): The central regions of the tenement contain quartz rubbles and highly fractures and disjointed quartz outcrops showing sulphide oxidation and hematization. These alterations are direct evidence of hydrothermal fluid activity, marking them as high-priority targets for gold mineralization.

The migmatitic gneises, granites, and granitic gneisses occupy over 80% of the study area and are spread all across the area. Field observations show that the granites intruded the migmatite/grainitic gneisses as contacts were established and relics of the older rocks (gneisses) were seen in some of the outcrops, which actually shows an incomplete assimilation of the granitic melt (Figure x).

A total of ten (10) samples out of the thirty (30) rock samples collected during the field mapping exercise were sent as representative samples for the study area for preliminary petrographic analysis through the production of thin section slides for observation under a plane and cross polarized light of a petrographic microscope

Figure 5: Field Mapping exercise and Hand Specimen Samples of Rock: A: Migmatite-gneiss, B: Gneiss, C: Coarse Grained Granite, D: Granite, E: Altered Quartz, F: Migmatite, G: Amphibolite

- **Petrographic Characteristics**

Ten (10) representative rock samples were taken from the number of outcrops located within the study area for thin section production and analysis. Thin-section analysis of representative samples, including

granites, gneisses, amphibolites, and quartz veins, revealed a diverse mineralogical assemblage characteristic of the Nigerian Basement Complex.

- **Granites and Gneisses:** These units are primarily composed of quartz, plagioclase, microcline, and micas (biotite and muscovite). Quartz grains in both units are predominantly anhedral and non-equidimensional, displaying internal fractures and distinct undulatory extinction, which indicates post-crystallization tectonic stress. Plagioclase is identified by its characteristic albite twinning, while microcline exhibits diagnostic cross-hatch (tartan) twinning. Biotite and muscovite appear as subhedral, elongated crystals with a preferred orientation, with biotite showing strong pleochroism from light to dark brown.

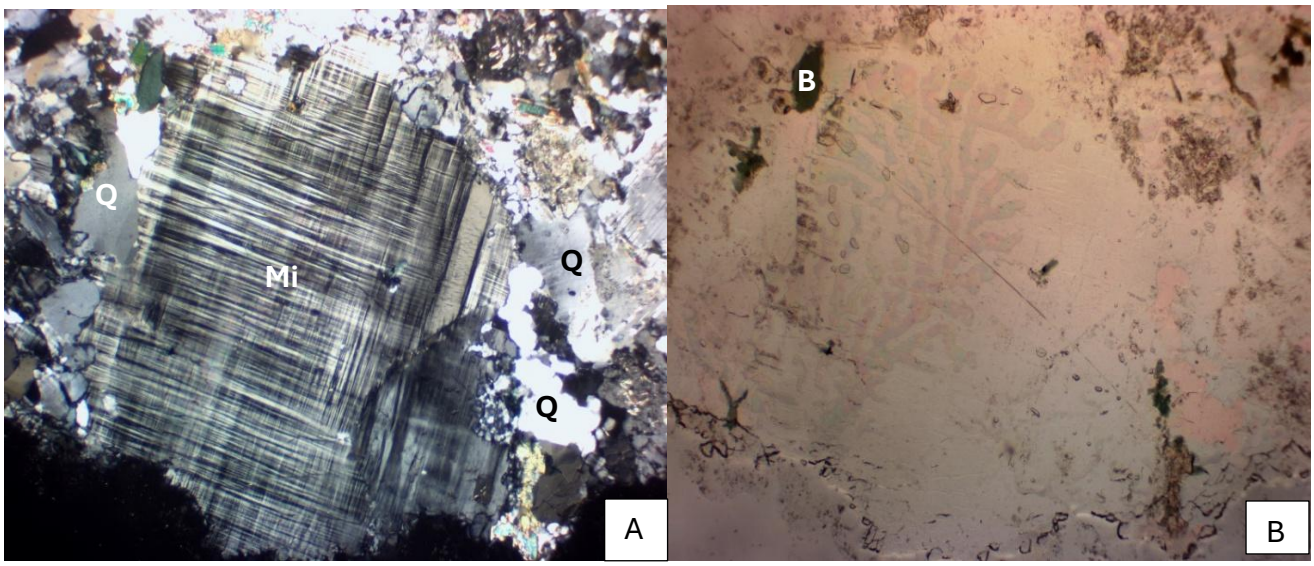


Figure 6. Photomicrograph of granites composed of Microcline (Mi), Biotite (B) and quartz (Q) under (A) crossed- polarized light, (B) plain-polarized light (Mag. 20x).

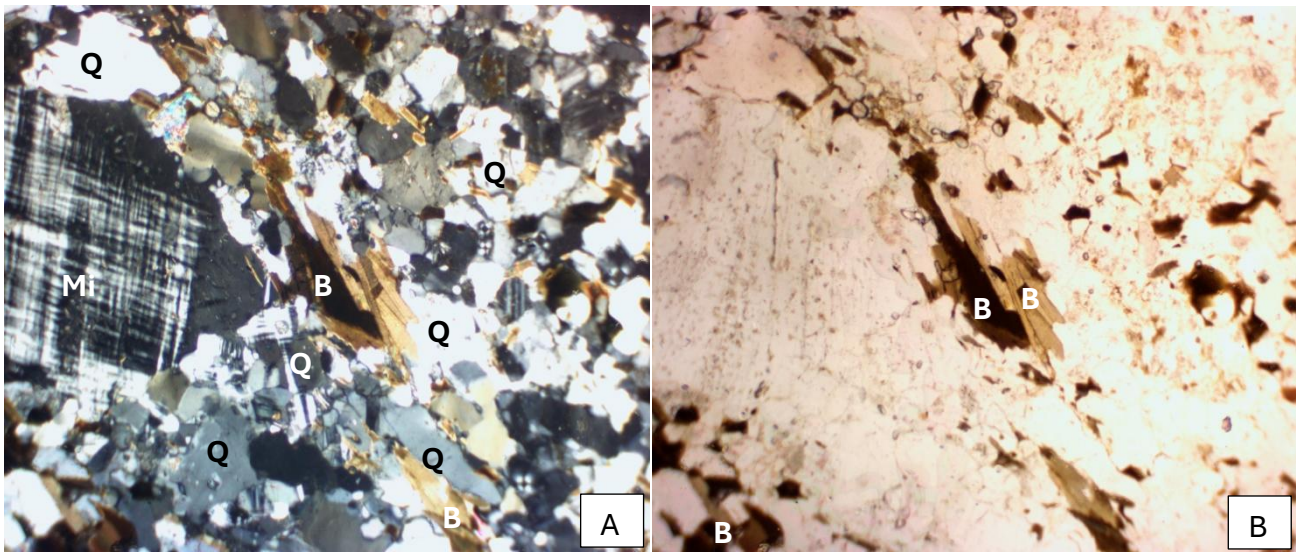


Figure 7. Photomicrograph of gneisses composed of microcline (Mi), biotite (B) and quartz (Q) under (A) crossed-polarized light, (B) plain-polarized light (Mag. 20x).

- **Amphibolites:** The amphibolite suite consists of amphibole (hornblende), plagioclase, quartz, and orthoclase. Hornblende is distinguished by its strong pleochroism (pale yellow to dark green) and characteristic cleavage. Notably, the presence of opaque minerals which remain extinct under both plane and cross-polarized light suggests the presence of metallic ores or sulfides, potentially pointing to the site's economic mineral potential.

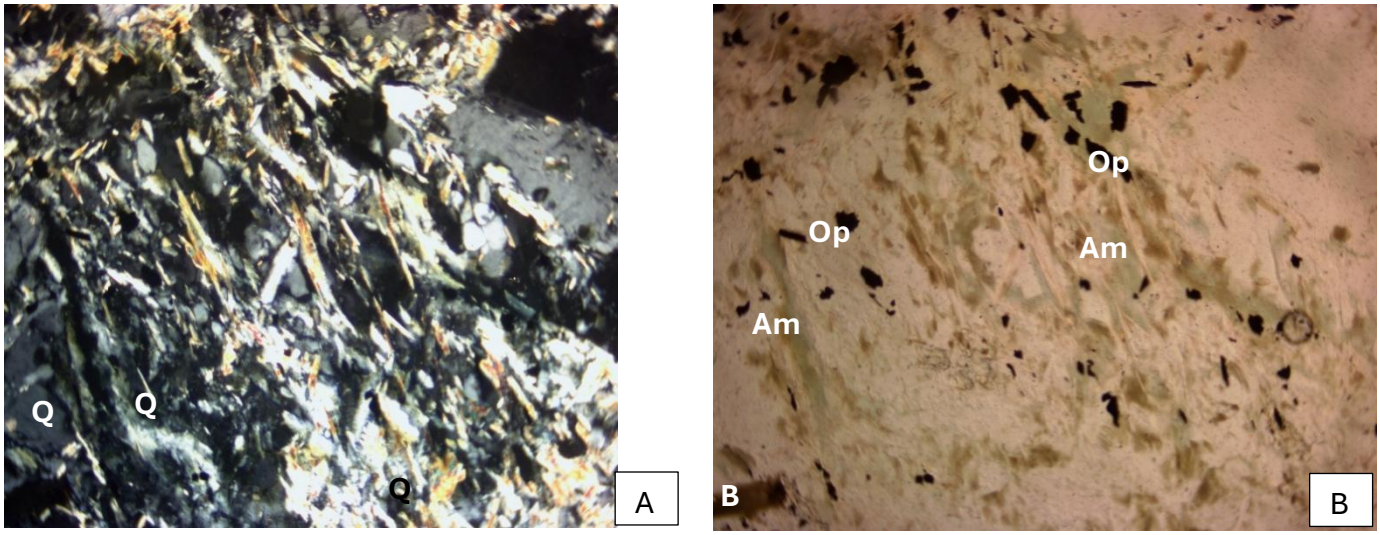


Figure 8. Photomicrograph of amphibolite composed of amphibole (Am), Plagioclase (PL), Orthoclase (OT), Opaque (Op), and quartz (Q) under (A) crossed-polarized light, (B) plain-polarized light (Mag. 20x).

- **Quartz Veins:** Dominated by large, anhedral quartz crystals, these samples exhibit interlocking boundaries and conchoidal fractures. The prevalence of undulose ("wavy") extinction across these veins suggests they have been subjected to significant hydrothermal and structural deformation, consistent with the localized shear zones identified in the aeromagnetic data.

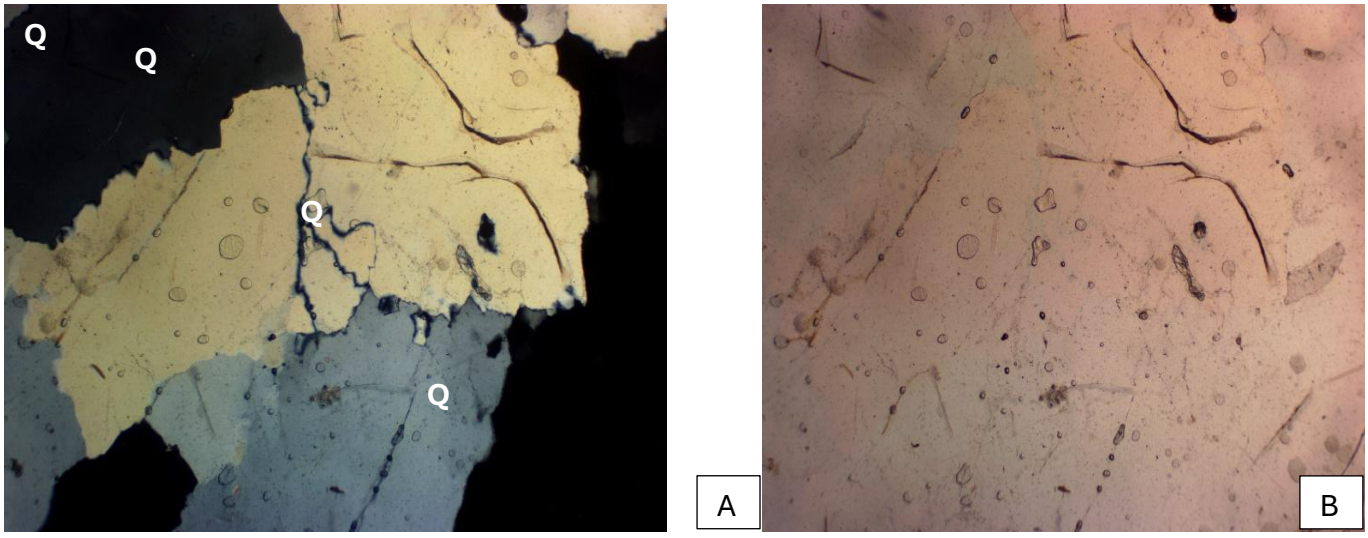


Figure 9. Photomicrograph of quartz vein composed of quartz (Q) and biotite (B) under (A) crossed-polarized light, (B) plane-polarized light (Mag. 20x).

- **Geochemical Dispersion and Statistical Analysis**

The geochemical evaluation of 95 residual soil samples (N-95) provides a clear picture of the distribution of elements across the Koro study area. Statistical analysis (Table 1) was bench marked against Average Crustal Abundance to determine the relative enrichment of gold and its pathfinders.

Figure 10: Residual Soil Sampling at Shallow depth of 20-50cm, dependent on soil profile

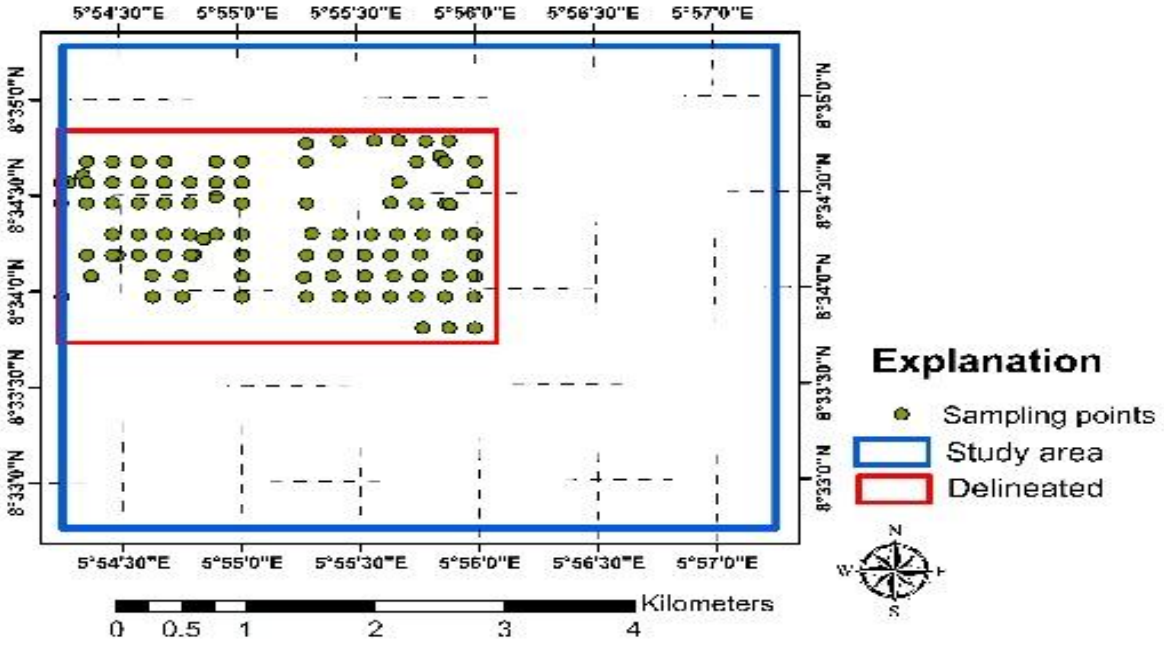


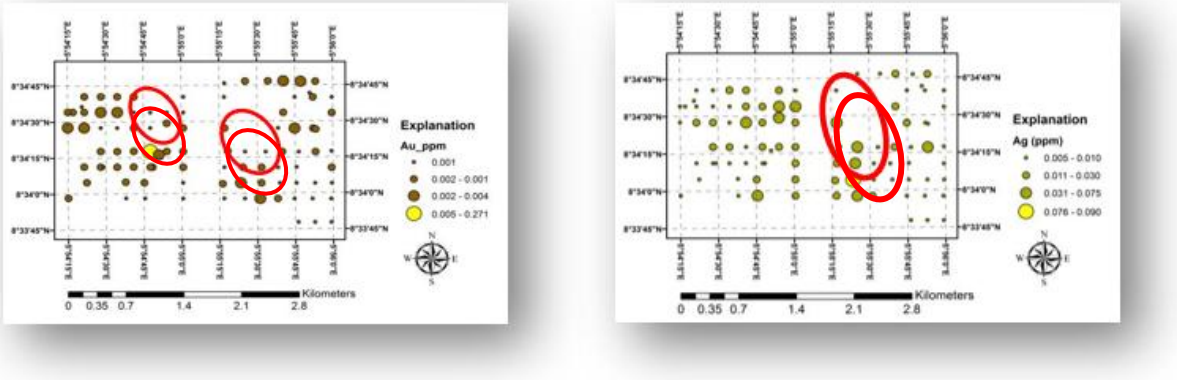
Figure 11: Gridded Soil Sample Plan for regional (200m X 200m) across high prospect zone

Table 1: Background Average Crustal Abundance Statistics for Gold and its Pathfinder Elements

Elements	Au	Ag	As	Cu	Pb	Sb	Zn
N	95	95	95	95	95	95	95
Background	0.001	0.01	0.7	17.9	11.9	0.1	29
Average Crustal Abundance	0.004	0.075	1.8	60	14	0.2	70
Mean	0.003737	0.018947	1.026316	24.61053	17.67474	0.118263	34.6
Std.Deviation	0.027716	0.015691	0.897184	21.76811	19.16993	0.047157	26.74601
Min	0.0005	0.005	0.1	1.6	4	0.025	1
Max	0.271	0.09	6.4	124	146	0.33	146

- **Gold (Au) and Silver (Ag) Distribution**

Gold concentrations in the study area range from 0.0005 ppm to 0.271 ppm, with a mean value of 0.0037 ppm. While the local background (0.001 ppm) is lower than the global crustal average (0.004 ppm), a significant anomalous peak of 0.271 ppm was identified in the central-western sector. This anomaly follows a distinct NW-SE trend, suggesting a primary structural control. Silver (Ag) mirrors this trend in the south eastern portion, with concentrations ranging from 0.005 to 0.09 ppm.



Figures 12: Concentration Point Map of Gold and Silver in the Residual Soil of the Study Area

- **Pathfinder Element Behavior (As, Pb, Cu, Sb)**

The distribution of pathfinder elements further substantiates the gold potential:

- **Arsenic (As):** Ranges from 0.1 to 6.4 ppm. Despite a low mean (1.026 ppm), isolated values in the eastern axis exceed crustal abundance, maintaining the characteristic NW-SE orientation.
- **Lead (Pb) and Copper (Cu):** Lead reached a maximum of 146 ppm, and Copper peaked at 124 ppm. Both elements exhibit spatial patterns and directional trends identical to Arsenic and Gold, suggesting a common hydrothermal source.

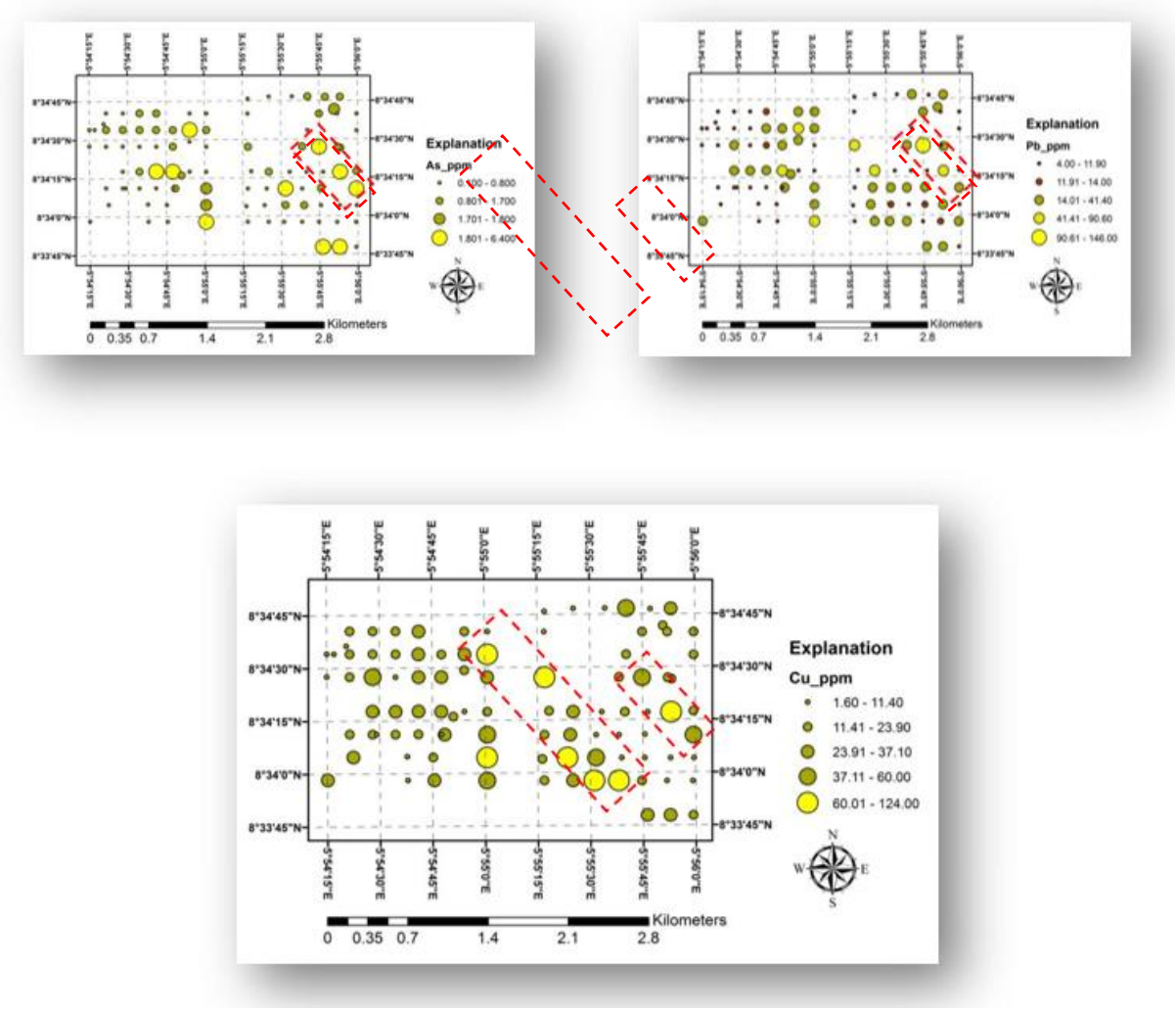


Figure 13: Concentration point map of Arsenic (As), Copper (Cu), Lead (Pb) in residual soil of the study area

- **<u>Correlation Coefficient and Inter-Elemental Relationships</u>**

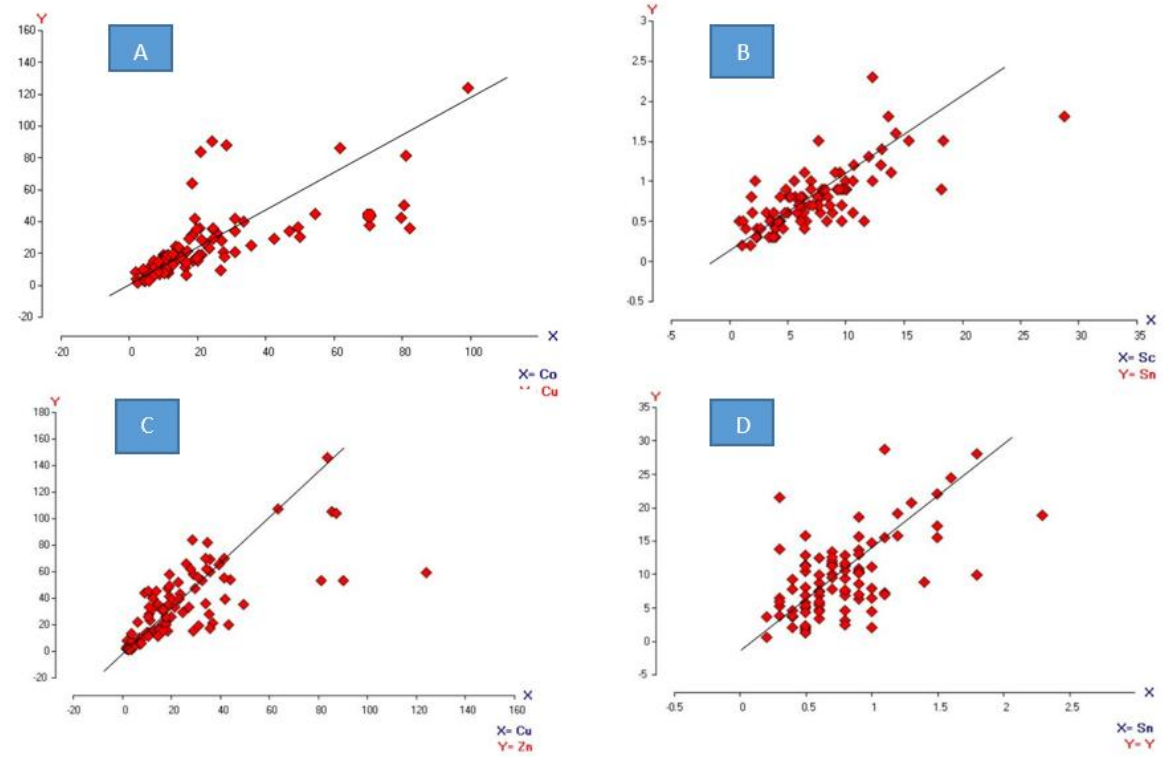
The computation of the Pearson correlation coefficient for all pairs of elements is one of the initial steps in conducting multivariate analysis. Certain elements tend more or less to be associated with another element or group of elements (Goldschmidt, 1954), so that different types of bedrock or mineralization are determined by specific elemental associations. It is also performed to uncover inter-element relationships or associations inherent in the geochemical data that could be interpreted as characteristic of the geological or geochemical processes operating in the study area. Pearson's correlation coefficient method is used in order to delineate the inter-elemental relationships. The coefficient measures the strength of the linear relationship between any two variables. Correlation coefficients were also determined to identify the relationship between different geochemical factors that often influence the concentrations and associations of elements using SPSS 16.0 (Statistical Program for the Social Sciences). This computer software package is used to calculate the correlation coefficient and determine the inter-elemental relationship.

Certain groups of elements respond more or less similarly to a given set of environmental conditions. Consequently, mutual correlations between different elements serve to identify variations in the geochemical landscape more clearly (Levinson, 1974). The correlation matrix for the data obtained in this study (Table 5) was generated using the Statistical Package for the Social Sciences (SPSS), and it shows both negative and positive correlations.

Some of the elements exhibit fairly strong to strong positive correlations with each other and weak negative to positive correlations with certain other elements. Moreover, the strong positive correlation between some of the elements, notably, Ag/Cu, Ag/Zn, As/Ce, As/Pb, As/Sb, Co/Cr, Co/Cu, La/Sc, La/Y, Sc/Y, Sc/Sn just to mention a few, may be indicative of a common source of mineralization or concentration

Table 2: Pearson correlation matrix of soil geochemical data from the study area showing significance at 0.5 and *above*.

	Au	Ag	As	Ce	Co	Cr	Cu	La	Li	Nb	Pb	Sb	Sc	Sn	Y
Au	1														
Ag	0.0091	1													
As	0.1028	0.084	1												
Ce	0.1811	0.21	0.7594	1											
Co	0.3059	0.3657	0.6819	0.6439	1										
Cr	0.021	0.136	0.4787	0.2925	0.5962	1									
Cu	0.0568	0.6443	0.3728	0.4025	0.6941	0.4573	1								
La	0.0168	0.317	0.1462	0.2263	0.2878	0.1935	0.4784	1							
Li	-0.037	0.2698	0.0157	0.008	0.2861	0.0391	0.38664	0.2175	1						
Nb	0.0279	0.2492	-0.135	-0.0644	-0.081	-0.154	0.009	-0.13	0.1237	1					
Pb	0.2245	0.383	0.7049	0.8773	0.6966	0.2982	0.442	0.0982	0.2054	0.00811	1				
Sb	0.2017	-0.1096	0.7914	0.5314	0.4521	0.3063	0.15751	0.0446	-0.1075	-0.1857	0.5013	1			
Sc	-0.006	0.4918	0.2383	0.2927	0.5807	0.4456	0.75887	0.6295	0.3994	-0.081	0.2491	-0.0146	1		
Sn	-0.069	0.3781	0.0554	0.0729	0.2993	0.2377	0.40992	0.4125	0.4387	-0.0077	0.0904	-0.1111	0.7291	1	
Y	-0.046	0.3858	0.0897	0.0937	0.2906	0.1665	0.49607	0.7436	0.1984	-0.1233	-9E-04	-0.1119	0.7755	0.5877	1
Zn	-0.019	0.7528	-0.009	0.1444	0.3292	0.093	0.71143	0.4792	0.5664	0.31337	0.2499	-0.2133	0.6446	0.4707	0.5



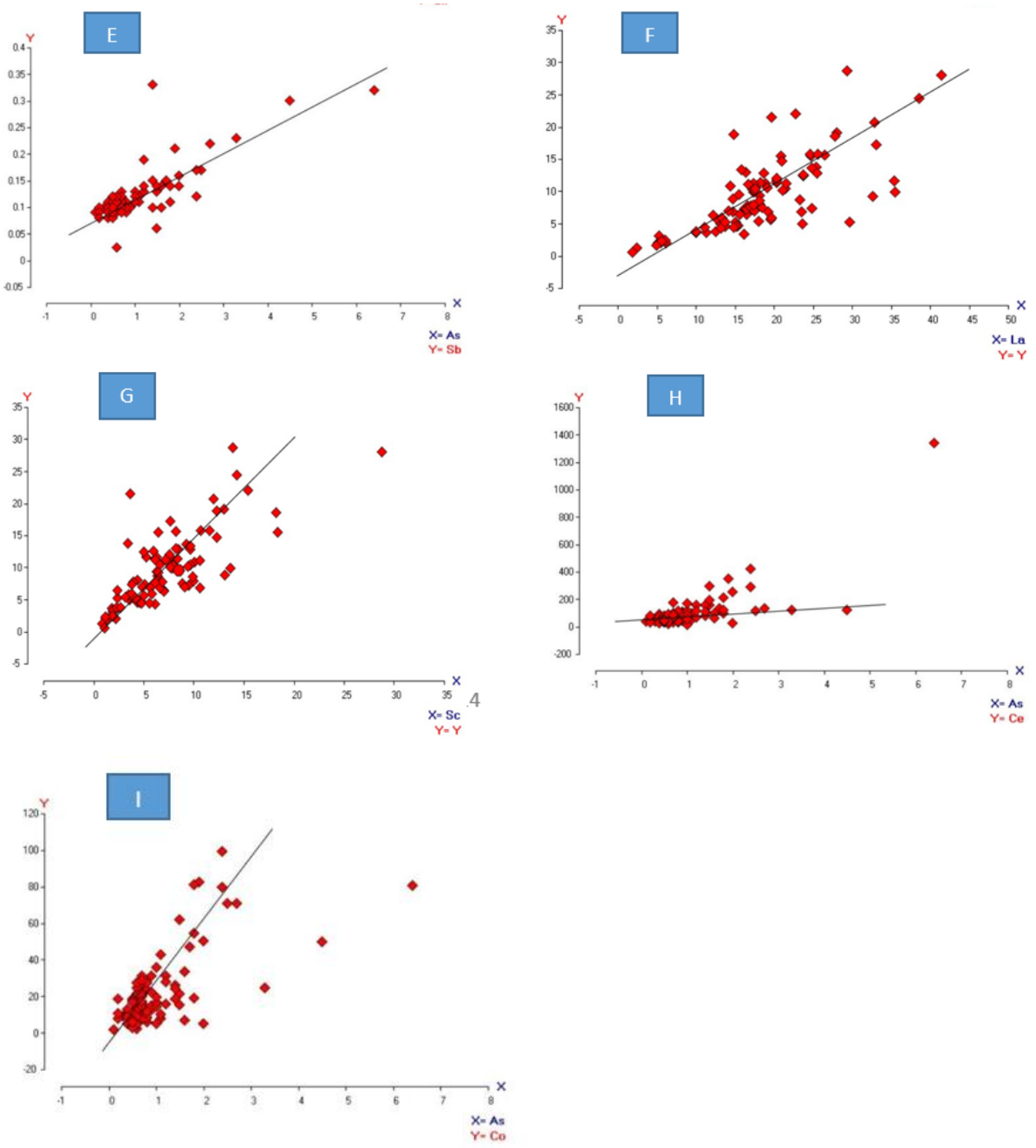


Figure 14: Binary Plots of (A) Co/Cu, (B) Sc/Sn, (C) Cu/Zn, (D) Sn/Y, (E) Au/Sb, (F) La/Y, (G) Sc/Y, (H) As/Ce, (I) As/Co

From the correlation table and binary plots above using the Pearson linear correlation of elements which measures the linear relationship/association between pairs of elements, the correlation matrix for the data shows that a strong association exist between certain elements; Trace elements (As, Sb, Ce & Sn), Base metals (Cu, Co, Zn & Cr) and Rare Earth Elements (La, Sc & Y). Within the correlated elements, the plots show positive correlation between each other as shown in the correlation plots and correlation table with a significant value of 0.5 and above, which interprets a strong association and a possible common source of mineralization.

- **The Gold-Pathfinder Association:** The geochemical maps for Au, Ag, As, Cu, and Sb show striking similarities in high-concentration zones. This co-precipitation signature is indicative of a unified mineralizing event.

- **Elemental Groupings:** Multivariate analysis identified three primary associations:
    1. **Trace Elements:** As, Sb, Ce, and Sn.
    2. **Base Metals:** Cu, Co, Zn, and Cr.
    3. **Rare Earth Elements (REE):** La, Sc, and Y.

These strong positive correlations confirm that the mineralization in Koro is likely tied to a single, litho-structurally controlled system rather than isolated occurrences.

V. Conclusion and Recommendations

The geochemical and petrographic study of the Koro area confirms a promising environment for gold mineralization. Although average concentrations appear low relative to global crustal averages, the presence of a 0.271 ppm Au anomaly, spatially coincident with pathfinder elements (Cu, Pb, As) and following a consistent NW-SE structural trend, points to significant underlying mineral potential.

To further delineate the ore body and transition from preliminary to a detailed phase, the following is recommended:

1. **Higher-Density Sampling:** Conduct systematic soil sampling at a 50m x 50m grid within the delineated anomaly zones to increase spatial resolution.
2. **Subsurface Investigation:** Execute selective pitting (5-10m depth) to evaluate soil horizons and determine the continuity of mineralization at depth.
3. **Ground Geophysics:** Integrate the current geochemical findings with Induced Polarization (IP) or Ground Magnetics to pinpoint subsurface sulfide concentrations and structural conduits.
4. **Targeted Trenching:** Focus follow-up activities on the central-western and eastern axes where the NW-SE geochemical trends are most pronounced.

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INTEGRATED ANALYSIS OF AEROMAGNETIC, AERO-RADIOMETRIC AND GEOCHEMICAL DATA TO DELINEATE LITHIUM BEARING PEGMATITES IN KUJE SHEET 207 NORTH-CENTRAL, NIGERIA

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ABSTRACT

The increasing global demand for lithium, driven by its critical role in rechargeable batteries and renewable energy technologies, has intensified exploration in under-investigated regions of the Nigerian Basement Complex. Despite favourable geological conditions, the study area remains poorly explored for lithium mineralization. This study evaluates its mineralization potential using an integrated geophysical, geological and geochemical approach. High-resolution aeromagnetic and aero-radiometric datasets acquired were processed using derivative-based and radiometric filtering techniques. Aeromagnetic data enhanced by first vertical derivative, tilt derivative, analytic signal, and Centre for Exploration Targeting (CET) analysis reveal dominant NE-SW, NNE-SSW, and E-W trending structures consistent with regional Pan-African fabrics. Analytical signal maps define distinct magnetic domains, while Euler deconvolution indicates source depths ranging from shallow (<300 m) to deep-seated (>1,000 m), suggesting multi-level structural controls on mineralization. Radiometric analysis of potassium (K), equivalent thorium (eTh), and equivalent uranium (eU), including ternary and K/Th ratio maps, delineates zones of hydrothermal alteration spatially associated with structural features. Field mapping confirms lithologies dominated by migmatite, biotite gneiss, muscovite schist, and NE-SW trending pegmatite intrusions. Whole-rock geochemical data indicate silica-rich (51.03-75.34 wt.% SiO_2), aluminous (9.81–19.17 wt.% Al_2O_3), and variable alkali compositions, reflecting felsic to highly evolved melts with granitic affinity. Geochemical discrimination plots of Na_2O+K_2O+CaO vs. SiO_2, and A/NK vs. A/CNK) confirm a peraluminous granitic source, consistent with melts derived from crustal protoliths. Fractionation and mineralization potential were further evaluated using K/Rb vs Rb, K/Rb vs Cs, and Ta/(Ta+Nb) vs Mn/(Mn+Fe) plots, which indicate moderately evolved pegmatites belonging to the rare-metal LCT (Li-Cs-Ta) family. Trace element ratios (K/Rb <100) and enrichment patterns suggest significant fractionation and potential lithium mineralization. The integration of geophysical signatures with geochemical evidence highlights structurally controlled, fractionated pegmatite systems with significant lithium mineralization potential. These findings underscore the role of crustal evolution, magmatic differentiation, and structural controls in rare-metal enrichment.

Keywords: pegmatite, lithium, fractionation, protoliths, hydrothermal alteration.

INTRODUCTION

Lithium (Li) has emerged as a strategically critical mineral due to its indispensable role in the global transition toward low-carbon energy systems. It is a fundamental component in rechargeable batteries used in electric vehicles (EVs), grid-scale energy storage, and portable electronic devices. Consequently, the rapid growth in clean energy technologies has significantly increased global demand for lithium, positioning it as a cornerstone of modern industrial and sustainable development (Linnen et al., 2012; Gourcerol et al., 2019). Among the primary geological sources of lithium, granitic pegmatites particularly Li–Cs–Ta (LCT)-type pegmatites are of major economic importance (Goodenough et al., 2025).

Pegmatites represent the final stage of magmatic crystallization, forming from volatile-rich residual melts derived from granitic magmas. During fractional crystallization, early-formed minerals such as feldspar and quartz preferentially incorporate major elements, while incompatible elements including Li, Nb, Ta, Cs, Rb, Be, Sn, and W become progressively enriched in the residual melt. This enrichment ultimately leads to the formation of rare-metal mineral assemblages such as spodumene, columbite–tantalite, beryl, and cassiterite within coarse-grained pegmatitic bodies. These bodies occur globally and constitute significant sources of critical metals essential for advanced technologies (Müller et al., 2023; Yang et al., 2022).

The exploration of Li-bearing pegmatites has increasingly relied on integrated approaches combining geological, geochemical, and geophysical techniques. Airborne geophysical methods, including aeromagnetic and aero-radiometric surveys, are widely used for regional-scale mapping of structural features and alteration zones, while ground-based methods such as electrical resistivity tomography (ERT) and induced polarization (IP) provide higher-resolution subsurface characterization. These methods are particularly effective in delineating structural controls, lithological contrasts, and hydrothermal alteration associated with pegmatite emplacement (Chen et al., 2023; Liu et al., 2026).

In Nigeria, lithium mineralization is predominantly associated with Pan-African pegmatites within the Precambrian Basement Complex. Previous studies, including regional aeromagnetic surveys conducted by the Nigeria Geological Survey Agency (2009), have identified prominent structural lineaments and magnetic anomalies across the North-central region. Subsequent investigations (e.g., Bonde et al., 2019; Lawali et al., 2020; Adamu et al., 2021; Augie et al., 2022a,b, 2024; Salako et al., 2024; Ohaegbuchu et al., 2025) employed aeromagnetic, radiometric, and geochemical datasets to evaluate mineralization potential. These studies revealed dominant structural trends, typically NW–SE to N–S, and suggested that mineralization is structurally controlled and possibly linked to hydrothermal processes. Adjacent areas such as Gwagwalada have also shown structurally controlled mineralized zones associated with basement lineaments (Egbelehulu et al., 2025), while aeromagnetic analyses have identified key faults and fracture systems influencing mineralization (Abdulsalam et al., 2024).

Despite these advances, significant gaps remain. Most previous investigations are regional in scope and rely predominantly on airborne datasets, with limited integration of ground-based geophysical methods such as ERT and IP for detailed subsurface validation. Furthermore, advanced edge-detection techniques such as the first vertical derivative combined with Centre for Exploration Targeting (FVD–CET) and analytic signal coupled with CET (AS–CET) have not been widely applied in the area to enhance structural interpretation. In addition, there is a lack of comprehensive integration of aeromagnetic, radiometric, and geochemical datasets specifically focused on the Kuje area, resulting in insufficient local-scale characterization of Li-bearing pegmatite mineralization.

This study addresses these limitations by employing an integrated exploration approach that combines aeromagnetic, aero-radiometric, and whole-rock geochemical analyses to delineate subsurface structures, hydrothermal alteration zones, and magma fractionation trends associated with Li-bearing pegmatites in the Kuje area. High-resolution airborne datasets are first utilized to identify structural features and prospective zones, followed by detailed field mapping and geochemical investigations to validate and constrain mineralization. The novelty of this study lies in the application of advanced edge-detection filters and the integration of multi-source datasets to improve the delineation of structurally controlled pegmatite mineralization, thereby enhancing exploration targeting in the region.

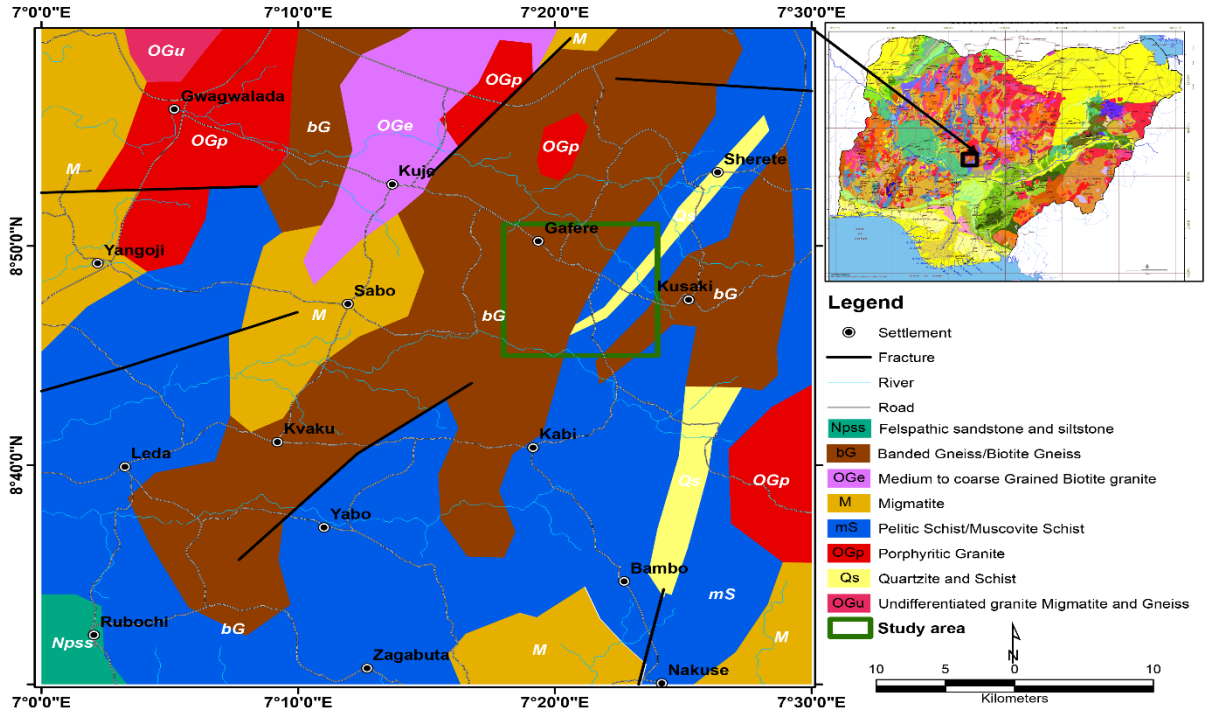


Figure 1. Integrated Geological and Structural Map of the study area

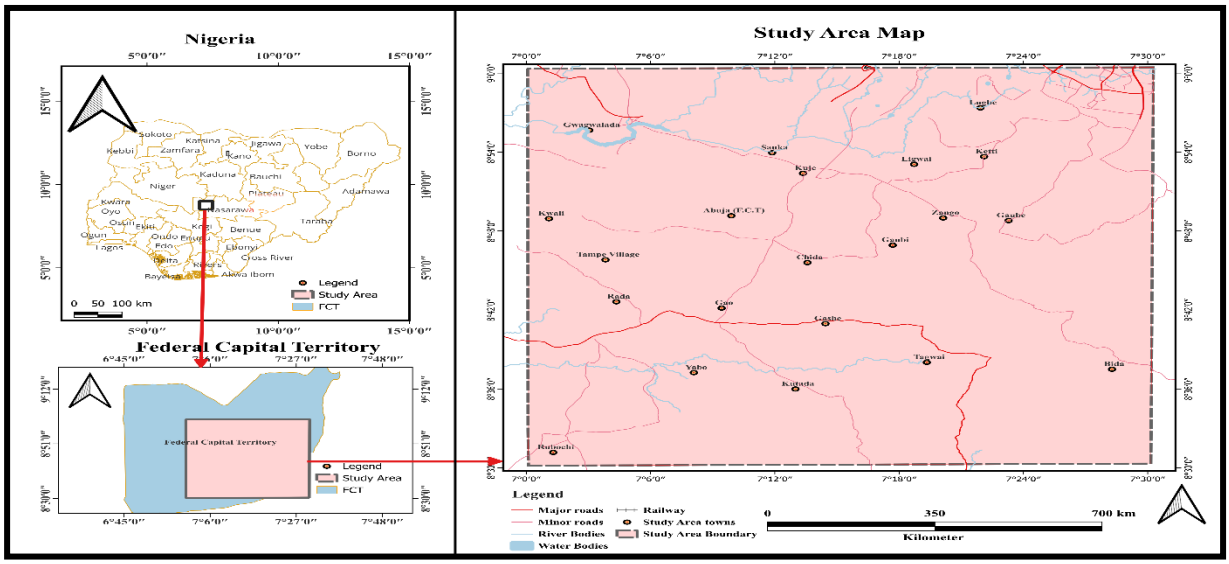


Figure 2. Location Map of Abuja Showing the Study Area

The study area lies within Kuje area of Federal capital Territory and as part of Kuje sheet 207NE. Kuje is located between Latitudes 8°30′ 00″ and 9° 0′ 00″ N and Longitudes 7° 0′ 00″ and 7° 30′ 00″ E. The area is part of the Nigerian basement complex and is accessible by the Minna-Bida Trunk A road and other several minor roads and footpaths and comprises major towns such as Sauka, Ligwai, Gaubi, Chida, Gao, Rada, Ketti and Bida. The study area spans about 3100 square kilometers and lies within the Precambrian basement complex which reflects the broader regional framework, characterized by a mix of migmatites, schists, granites, and pegmatites. As shown in Figure 1, Previous field studies and geological mapping in the area have revealed the predominant geology to be migmatite, granite gneiss,

muscovite and pellitic Schist, porphyritic granite, Quartzite and feldspathic sandstone and siltstone (Rahaman, 1988; Wazoh et al., 2016).

MATERIAL AND METHODS

Airborne Magnetic Method

The aeromagnetic data sheet 207 Kuje, which covered the study region, was used in the present study. Fugro conducted an airborne survey in 2009 for the Nigerian government's NGSA. The conditions and parameters set up for the data collection by the Fugro airborne survey are: (a) altitude of 100 m, (b) tie line spacing of 2000 m, and (c) a flight line spacing of 500 m aligned NW –S. The maps are half-degree sheeted and have a 1:100,000 scale. Of all the aforementioned parameter and data collection settings, the dataset defined is high resolution aeromagnetic (HRAM), which is typically used to map shallower subsurface causative bodies.

Using the International Geomagnetic Reference Field (IGRF 2010), regional abnormalities were removed from the aeromagnetic data through processing. We reduced the overall magnetic intensity map to the equator to locate magnetic anomalies above their source bodies and remove the anomalies' tilt. The generated RTE map was then subjected to a number of improvement and filtering processes, which improved the interpretability of the data.

The TMI corrected anomaly grid has been filtered and reduced to the magnetic equator (Figure 3) in order to highlight a magnetised body anomaly, which is typically dependent on the body's orientation in relation to the north magnetic pole, inclination, declination, and local earth's field. Geosoft (Oasis Montaj), Arc GIS, and Surfer tools were used to handle and analyse the data using improved FVD and AS techniques.

In order to identify the shallowest geological source, the first vertical derivative, which can be computed in the frequency or space domain, is frequently applied to total magnetic field data. A cause structure can be imaged more clearly thanks to the enhancement, which tends to reduce anomaly complexity and sharpen anomalies over bodies. Due to its tendency to magnify short wavelength noise, the transition may be loud. In magnetic interpretation projects, first vertical derivative data are now practically essential showcasing the zones of essential geological formations/structures. Equation (1) presents the general derivative's algorithm. The AS amplified the variation in magnetisation of the magnetic sources in the area and indicated the edges of anomalous texture. These variations in magnetisation may be influenced by different earth materials as well as different mineralised zones, particularly metallic minerals such as lithium-bearing pegmatite. CET reveals linear structures (lineament), and these structures can define faults, fractures, or shear zones that represent mineralisation veins.

The anomaly in FVD is much narrower and more nearly matches the width of the magnetic rock body that caused it; the derivatives are given in Equation (1) (Roest et al., 1992). These techniques have been improved in this research by linking with CET (FVD CET) to reveal structural features, which as well showed the location of the result.

$$L(r) = rn \quad (1)$$

where n order of differentiation.

The amplitude of the analytical signal (AS) can now be established (Pham et al., 2020) using Equation (2). In this study, the estimation was used with the analytical signal coupled with the CET (AS-CET) approach to highlight important zones of lineament. This was further linked to ArcGIS, which revealed more information about the area's location.

$$|AS(x,y,z)| = \sqrt{\left(\frac{\partial M}{\partial x}\right)^2 + \left(\frac{\partial M}{\partial y}\right)^2 + \left(\frac{\partial M}{\partial z}\right)^2} \quad (2)$$

where x, y, z are the directions of total magnetic field and AS (x, y, z) is the amplitude of the analytic signal at (x, y, z); T is the observed magnetic field at (x, y, z).

To estimate source depth of magnetic sources, researchers have used the 3-D Euler deconvolution technique (Nabighian & Hansen, 2001). The method relies on the assumption that anomalous magnetic fields of localized structures are homogeneous functions of the source coordinates and, consequently, satisfy Euler's homogeneity equation. Typically, the structural index (SI) remains fixed, and the locations and depths (x_0, y_0, z_0) of any sources are determined using the following equation (5),

$$\partial f/\partial x\,(x - x_0) + \partial f/\partial y\,(y - y_0) + \partial f/\partial z\,(z - z_o) = SI(B - f) \quad (3)$$

where f is the observed field of location (x, y and z) and f is the base level of the field [regional value at the point (x, y, z)] and SI is the structural index or degree of homogeneity.

Aero-radiometric Data

In this study, the aero-radiometric datasets from sheet 207 Kuje were utilised. These datasets were also collected under the same survey conditions as the previously mentioned aeromagnetic data, and they were similarly obtained from the NGSA, collected by Fugro airborne survey on behalf of Nigeria's Federal Government (FGN). The Geosoft "Oasis Montaj Software" was utilised to process each radio element using the gridded data that was obtained. The aero-radiometric data were processed to create maps visualizing the surface distributions of potassium, equivalent thorium, and equivalent uranium. This aero-radiometric technique has been shown to be highly valuable for identifying areas of hydrothermal alteration and mapping geological units. The Potassium (K), equivalent thorium (eTh ppm), equivalent uranium (eU), and ternary imageries were used in the enhancement processes. These operations resulted in maps that correlate with the pattern and trend of geological units Shives RBK et al., 1997. The analysis of radiometric data straddles the geochemistry-geophysics divide. Due to the differing radioactive fngerprints, the high-resolution aero-radiometric survey is capable of mapping lithologies, detecting zones of hydrothermal alterations, deciphering highly radioactive geologic deposits, revealing surficial structures, and determining the concentration of the radioelements (eU, eT, and K).

An essential component of the mineralisation interpretation of radiometric data is the integration of the three radio elemental concentration channels, K, eU, and eT, with the TC channel and other relevant data. The abundance of the radioelements is useful in locating possible host rocks favourable for mineralisation. However, the abundance ratios eU/eT, eU/K, and eT/K are frequently more diagnostic of lithology and hydrothermal alteration changes than the abundances of the individual radioelements. However, eU/K, eU/eT, and eU are very important for delineating uranium deposits, K/eT for delineating hydrothermal alterations and potassic hydrothermally altered zones. Tis study generated maps to identify lithological units by analysing K, eU, and eTh radioelements in conjunction with the ternary images, and the K/eT ratio was used to delineate the hydrothermal alteration zones in the survey area.

Geological Mapping and Whole rock Geochemistry

Geological field mapping was carried out using a geological hammer, compass–clinometer, GPS receiver, and field recording materials. The study involved systematic traverse mapping to identify lithological units, structural features, and their spatial relationships. Outcrops were examined and described based on field relationships and macroscopic characteristics such as colour, texture, and mineral composition.

Structural measurements, including strike and dip, were obtained using a compass–clinometer, while joint orientations were recorded for rosette analysis. Geographic coordinates and elevations of sampling locations were acquired using GPS. A total of twelve (12) rock samples were collected, comprising eight (8) pegmatite and four (4) host rock samples, selected to represent the study area. All samples were labelled, bagged, and transported to the laboratory. The samples were air-dried, cleaned of organic materials, and crushed to <2 mm, followed by pulverization to <75 µm. Equipment was thoroughly cleaned between samples to prevent contamination. Both partial and total digestion methods were employed. Aqua regia digestion (HCl–HNO_3) was used for partial extraction of mobile elements, while total digestion using HF–HNO_3 in a microwave system ensured complete dissolution of silicate matrices. In resistant samples, fusion with lithium metaborate was applied. All procedures followed standard safety protocols due to the use of strong acids. Elemental concentrations (major, trace, and rare earth

elements) were determined using Atomic Absorption Spectroscopy (AAS). This technique quantifies metals based on the absorption of element-specific wavelengths of light by free atoms, with absorbance proportional to concentration. Flame AAS was used for major and minor elements, while graphite furnace AAS was employed for trace-level analysis. The interpretation of the geochemical data was done using a geochemical tool kit (GCDkit). Descriptive statistics were used to discriminate between mineralized and nonmineralized rock samples. Results of whole-rock geochemical analysis was used to evaluate the chemical characteristics of the rocks and the petrogenesis of the rock units and associated LCT mineralization in the study area.

FINDINGS AND DISCUSSIONS

Aeromagnetic Data Interpretation

Aeromagnetic data interpretation was carried out using the 2009 International Geomagnetic Reference Field (IGRF)-corrected dataset (Sheet 207: Kuje), obtained from the Nigerian Geological Survey Agency (NGSA). The dataset, covering approximately 3,100 km², was processed within Oasis Montaj (version 8.4) to generate Total Magnetic Intensity (TMI) Figure 3 and Reduced-to-Equator (RTE) maps (Figure 4), which are particularly suitable for enhancing anomaly positioning in low-latitude regions. To improve structural delineation and depth estimation, several enhancement techniques were applied, including analytic signal (AS), first vertical derivative (FVD) and Euler deconvolution. These methods collectively enhance anomaly resolution, define structural boundaries, and estimate depths to causative bodies, making them effective for

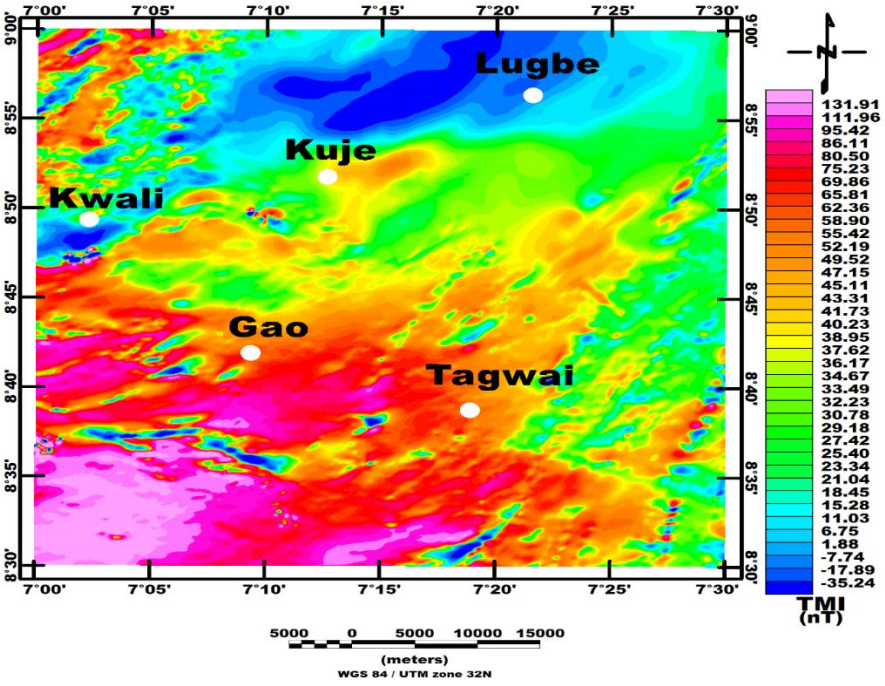


Figure 3. Total Magnetic intensity Map of the study area

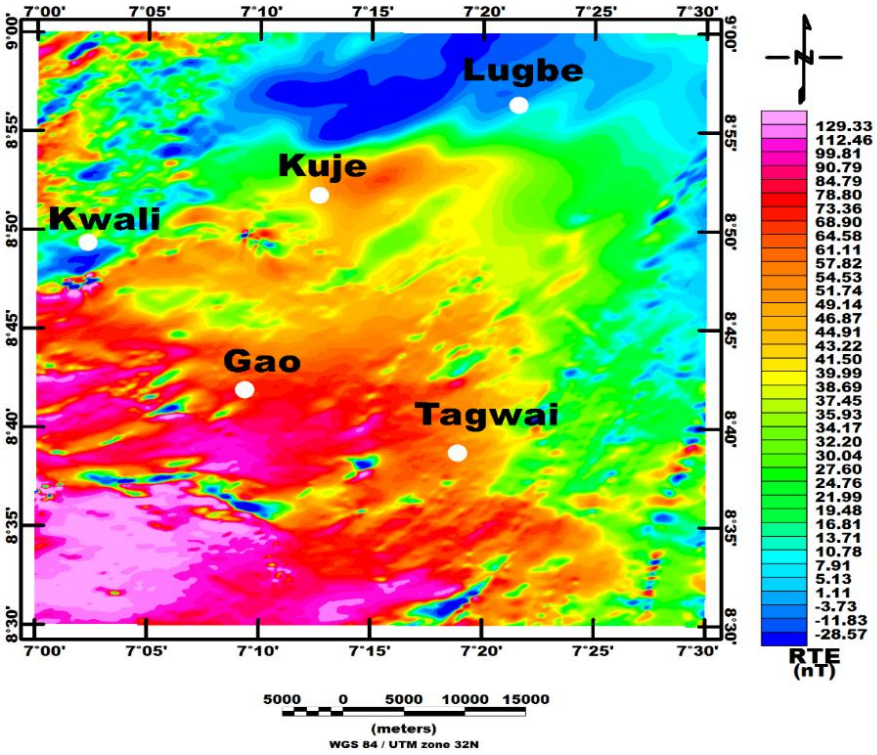


Figure 4. Reduced to Equator Map of the study area

mineral exploration in basement terrains (Aina & Aizebeokhai, 2021; Lawal, 2020).

The TMI map, following removal of a regional IGRF value of 34,000 nT, reveals magnetic intensity values ranging from −35.24 nT to 131.91 nT. Negative magnetic anomalies are predominantly concentrated in the northern part of the study area, particularly around Lugbe, Kuje, and parts of Kwali, with values between −35.24 nT and −7.74 nT. Additional low magnetic intensities are observed in scattered pockets within the eastern sector, ranging up to 18.45 nT. In contrast, strong positive magnetic anomalies, reaching a maximum of 131.91 nT, are mainly distributed across the southern half of the study area, especially around Gao, and exhibit a dominant NE–SW structural trend. These high magnetic zones correlate closely with mapped basement lithologies, including migmatite, migmatitic gneiss, banded gneiss, biotite gneiss, quartzite, and schist–phyllite assemblages, indicating the presence of magnetite-rich and structurally deformed rocks.

Application of the RTE transformation repositions magnetic anomalies directly over their causative sources by correcting for the inclination and declination of the Earth's magnetic field. The RTE-TMI map, with values ranging from −28.57 nT to 129.33 nT, exhibits strong agreement with the geological framework. The coexistence of positive and negative anomalies reflects the heterogeneous nature of the migmatite–gneiss complex, where variations in magnetic intensity are controlled by differences in mineral composition, particularly ferromagnetic content, as well as the degree of metamorphism and deformation. Highly magnetic zones are associated with magnetite-bearing lithologies, whereas low or negative anomalies are indicative of intense deformation, alteration, or reduced magnetic mineral content.

The analytic signal map (Figure 5) enhances anomaly peaks directly over their sources and effectively delineates lithological boundaries and structural features independent of magnetization direction. Based on amplitude variations, three magnetic zones are identified: low (0.003–0.008 nT/m), intermediate (0.009–0.031 nT/m), and high (0.034–0.176 nT/m). High-amplitude zones are predominantly concentrated around Kwali, southwestern Gao, and the southern part of the study area, and are associated with highly magnetic lithologies such as biotite granite, banded gneiss, quartzite, and migmatite. These zones are indicative of intrusive bodies and potential mineralization, consistent with established

relationships between high analytic signal amplitudes and magnetically susceptible rocks (El-Raouf et al., 2023). Intermediate zones correspond to younger metasedimentary units such as phyllites, while low-amplitude zones are associated with sedimentary terrains, including feldspathic sandstone and siltstone.

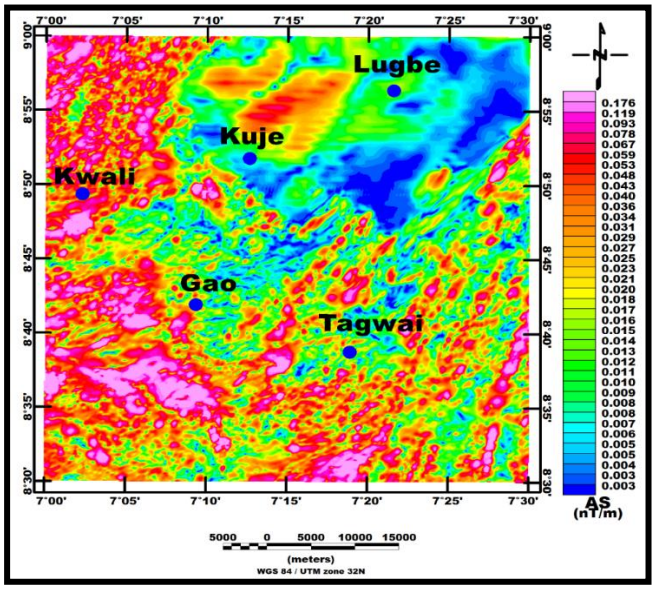


Figure 5. Analytic Signal Map

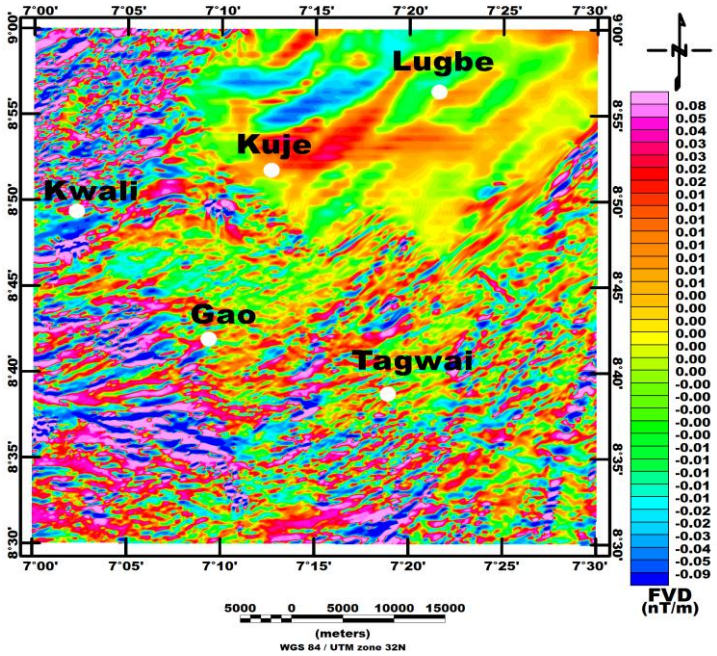


Figure 6. First Vertical Derivative Map of the study area

The first vertical derivative map enhances shallow magnetic features by amplifying high-frequency anomalies and suppressing regional trends, thereby sharpening anomaly boundaries and improving the identification of structural elements as in figure 6. The map reveals numerous linear features trending NW–SE, NE–SW, and E–W, interpreted as faults, fractures, and lithological contacts. High-amplitude, narrow anomalies are indicative of near-surface intrusions, dyke-like bodies, and magnetized veins, which are commonly structurally controlled and associated with mineralization. Abrupt changes in

anomaly patterns further indicate fault intersections, shear zones, and tectonic boundaries that may act as for hydrothermal fluid migration and sites of pegmatite emplacement (Osinowo & Abdulmumin, 2019).

Structural interpretation is further enhanced through Centre for Exploration Targeting (CET) analysis (Figure 7), which automatically extracts and delineates lineaments and zones of structural complexity from the RTE dataset. The results show a high density of lineaments in the southern half of the study area, indicating intense deformation and increased mineralization potential. Dominant lineament orientations are NE–SW and NNE–SSW, consistent with regional tectonic trends associated with the Pan-African orogeny. These structures play a critical role in controlling lithological distribution, fluid flow, and mineral deposition.

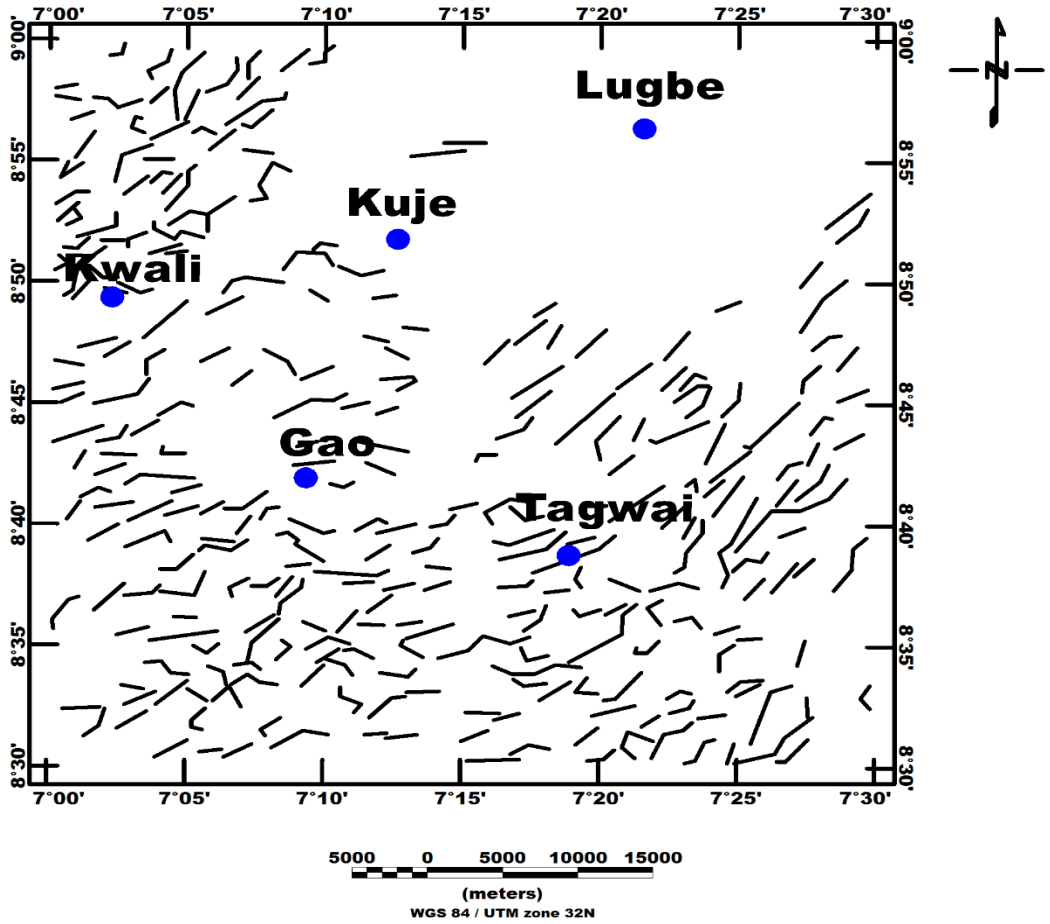


Figure 7. Structural Lineament Map

Depth estimation using Euler deconvolution indicates that magnetic sources occur at varying depths, ranging from less than 300 m to greater than 1,000 m as seen in Figure 8. However, most of the highly magnetic structures and intrusive bodies are concentrated at shallow depths of less than 100–300 m. In addition, mineralization-related features, particularly in hydrothermally altered zones within the southern part of the study area, are generally confined to depths of less than 500 m. These depth estimates are consistent with results obtained from analytic signal, FVD, radiometric ratio maps, and CET structural analysis.

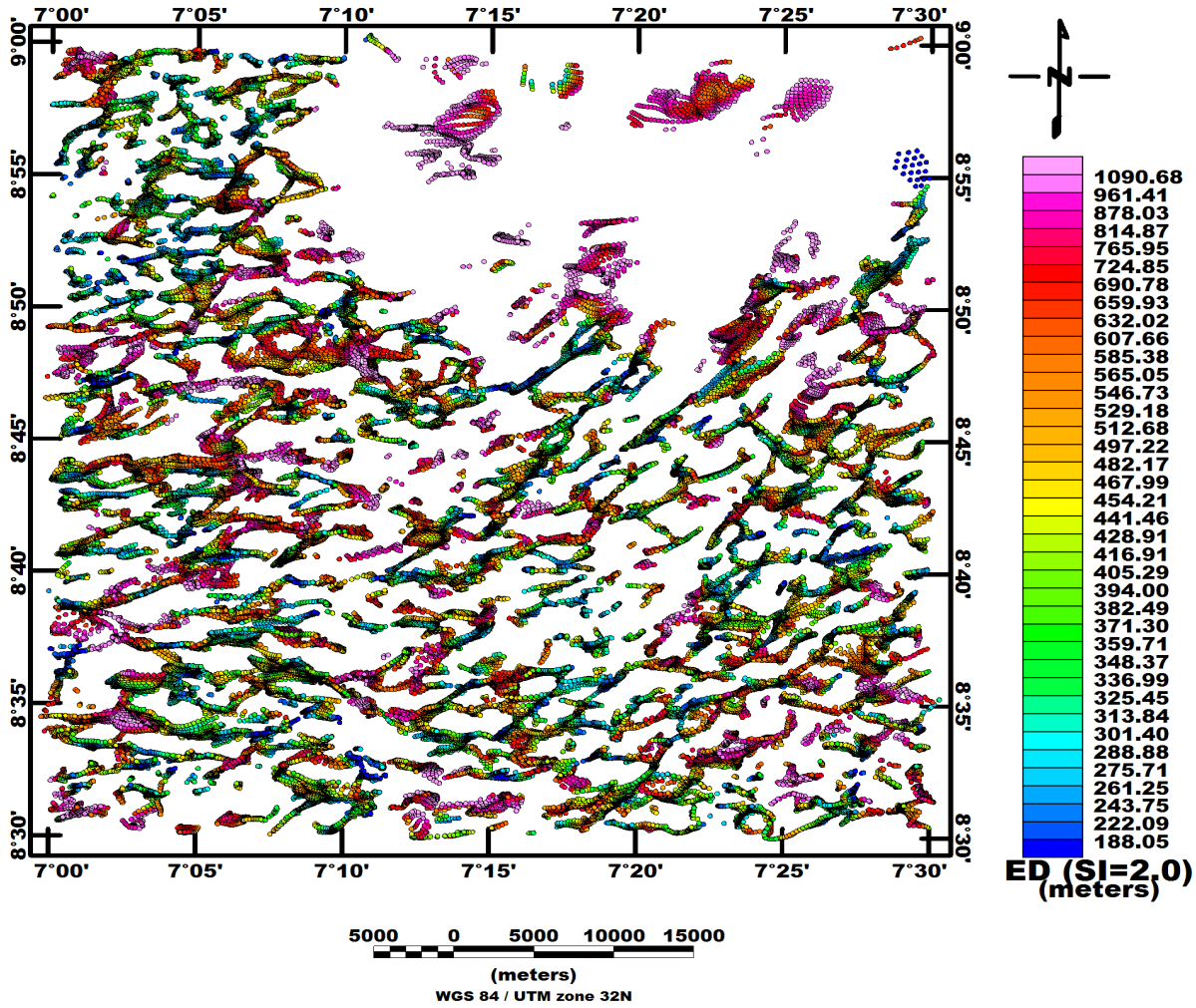


Figure 8. Euler-Deconvolution

Aero-Radiometric Data Interpretation

Airborne radiometric data provide essential information for lithological discrimination, alteration mapping, and identification of radiogenic mineralization. Beyond direct uranium detection, variations in potassium (K), thorium (Th), and uranium (U) concentrations enable effective differentiation of rock types based on their mineralogical composition. Potassium is typically hosted in minerals such as muscovite, biotite, and K-feldspars (orthoclase and microcline), whereas uranium and thorium occur mainly in accessory phases including zircon, apatite, sphene, monazite, and allanite (Hoover et al., 1992). Geochemically, uranium is relatively mobile under oxidizing and hydrothermal conditions, while thorium remains largely immobile and is transported mainly through mechanical processes. As a result, felsic and highly evolved rocks tend to show elevated uranium and thorium concentrations, particularly with increasing alkalinity.

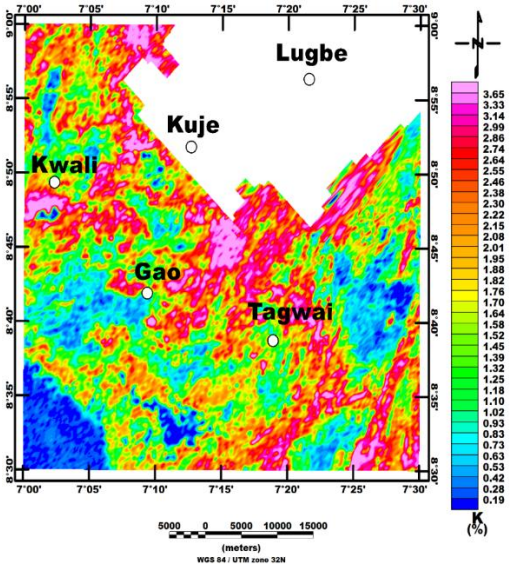


Figure 9. Potassium concentration map

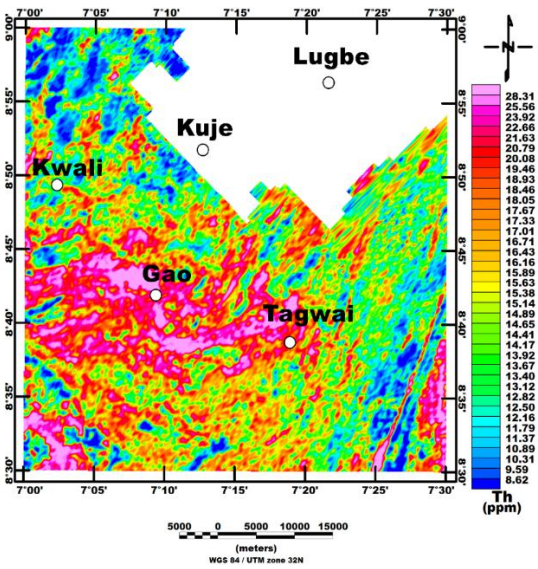


Figure 10. Thorium concentration Map

The potassium distribution map (Figure 9) indicates values ranging from 0.19% to 3.65%, reflecting both lithological variability and possible alteration effects. High potassium concentrations (>2.74%) are predominantly observed in the southeastern part of Kuje, the Tagwai region, and areas east of Gao and south of Kwali, while moderately high values (2.38–2.74%) form NE–SW trending zones consistent with regional structural fabrics. These high-potassium zones correlate with Pan-African Older Granitoids, including biotite granite and granite porphyry, as well as associated metamorphic units such as schists, phyllites, migmatites, and granite gneiss. In contrast, low potassium values (<0.53%) are concentrated mainly in the southwestern sector and correspond to sedimentary lithologies such as feldspathic sandstone and siltstone, reflecting reduced feldspar and mica content. Elevated potassium signatures are commonly associated with hydrothermal alteration, whereas weathering processes may lead to potassium depletion (Wilford et al., 1997; Dickson & Scott, 1997).

Thorium concentrations range from 8.62 to 28.31 ppm, with high values (>21.63 ppm) occurring mainly in the western to southwestern parts of Gao, east of Tagwai, and in the southwestern extremities of the study area (figure 10). These high thorium zones are associated with felsic intrusive rocks and high-grade metamorphic units, particularly granitoids and migmatite–gneiss complexes. Moderately high thorium values are observed along the southern boundary, while low concentrations (8.62–12.82 ppm) extend from the north-northwestern to southeastern regions and are attributed to metasedimentary and metavolcanic rocks, which typically contain fewer thorium-bearing accessory minerals.

Uranium concentrations range from 0.98 to 6.54 ppm and are classified into high (>4.15 ppm), moderately high (3.42–4.15 ppm), moderately low (2.29–3.07 ppm), and low (<2.29 ppm) zones (Figure 11). High uranium concentrations are mainly concentrated in the southern part of the study area, particularly around Gao and south of Kwali, where granitic and migmatitic lithologies dominate.

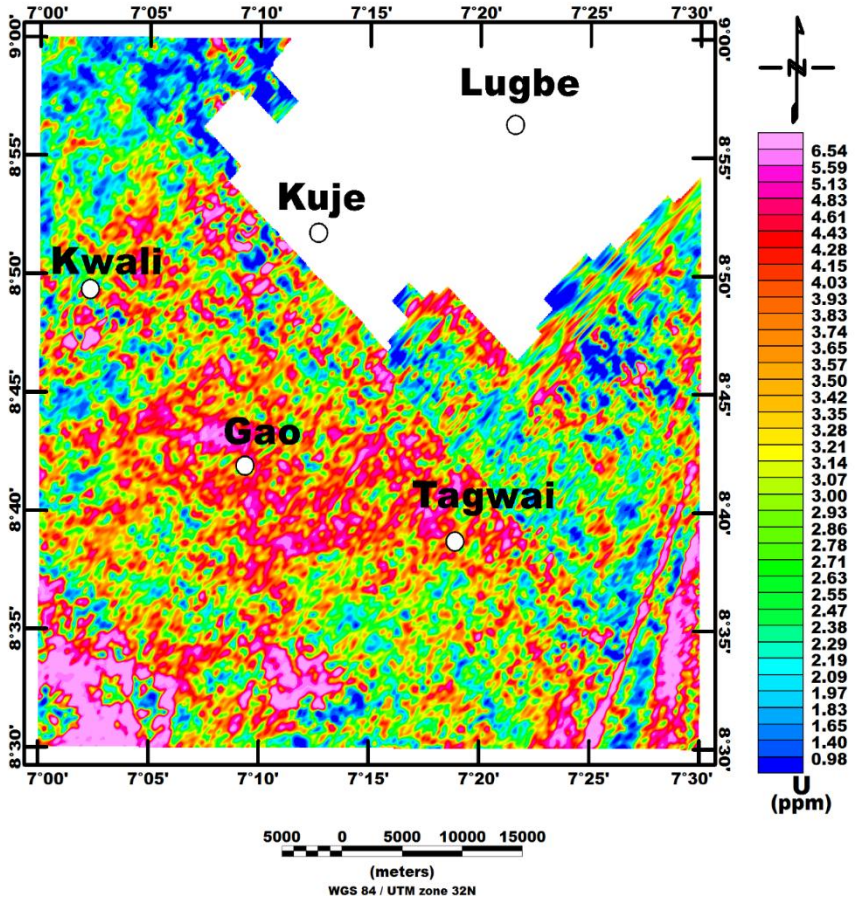


Fig 11. Uranium concentration Map

Conversely, low uranium values characterize the northern sector and areas around north of Kwali and east of Tagwai, corresponding to sedimentary units such as sandstone, shale, and alluvial deposits. The spatial decoupling of uranium from potassium observed in some areas reflects its relative mobility during hydrothermal processes (Airo, 2007).

The ternary radiometric image (K–Th–U) (Figure 12) provides an integrated representation of lithological and alteration patterns. White zones, indicating high concentrations of all three elements, correspond to felsic intrusive and high-grade metamorphic rocks such as granite, migmatite, and granite gneiss, and are prominently developed around Gao and northwest of Tagwai. These zones form linear features trending southeast and coincide with mapped

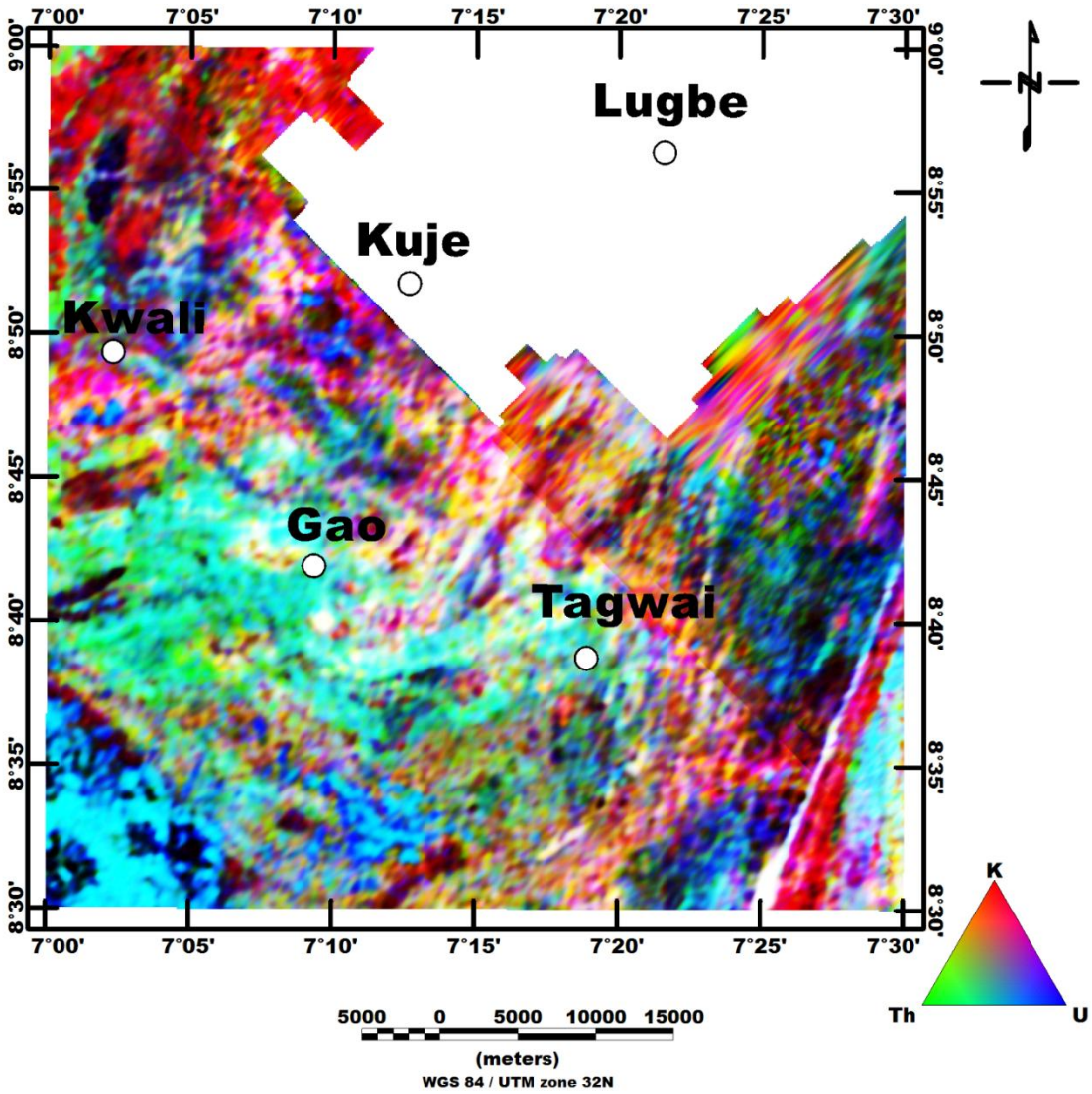


Figure 12. Ternary Map of research site

structural lineaments, suggesting structural control on mineralization and possible emplacement of pegmatitic bodies. Dark zones represent low radioelement concentrations and are associated with sedimentary or low-grade metamorphic rocks, while red-, green-, and blue-dominated zones indicate relative enrichment in potassium, thorium, and uranium, respectively. These spatial patterns demonstrate a strong relationship between radiometric signatures, lithology, and structural architecture.

Radiometric ratio analysis, particularly the K/Th ratio (Figure 13), enhances the detection of hydrothermal alteration zones due to the relative immobility of thorium compared to potassium. In unaltered rocks, K/Th values typically range from 0.17 to 0.20 %/ppm (Hoover & Pierce, 1990; Shives et al., 2000; Dentith & Mudge, 2014). In this study, K/Th ratios range from 0.01 to 0.29 %/ppm, with values exceed approximately 0.17–0.19 %/ppm interpreted as indicative of potassium enrichment associated with hydrothermal alteration. These high-ratio zones are mainly located in the southwestern and northern parts of the study area and correspond to schist belts and banded biotite gneiss units. Their spatial coincidence with mapped lineaments and magnetic anomalies indicates structurally controlled hydrothermal fluid flow. Areas such as northwest of Kuje, the central part of the study area, and southern Tagwai show particularly strong alteration signatures, consistent with previous interpretations (Salako, 2014), and represent potential zones of mineralization.

The integration of radiometric and aeromagnetic datasets further strengthens the interpretation of mineralization potential. Analytic signal processing of the magnetic data enhances anomaly peaks directly over their source bodies, allowing clear delineation of lithological contacts and structural

features (Faruwa et al., 2021; Lawal, 2020). The study area is classified into low (0.003–0.008 nT/m), intermediate (0.009–0.031 nT/m), and high (0.034–0.176 nT/m) magnetic anomaly zones. High magnetic amplitudes are associated with lithologies such as migmatite, banded gneiss, biotite granite, quartzite, and schists, particularly around Kwali, southwestern Gao, and the southern part of the study area, while intermediate zones correspond to younger metasediments such as phyllites. Low magnetic zones coincide with sedimentary terrains, including feldspathic sandstone and siltstone.

The spatial association of high magnetic anomalies, elevated K/Th ratios, and dense structural lineaments suggests zones of hydrothermal alteration and mineralization. These areas likely represent conduits for mineralizing fluids and sites of magmatic intrusion. The presence of porphyritic intrusions, combined with strong structural control and alteration signatures, indicates favorable conditions for the formation of sulfide mineralization, including gold (Au), silver (Ag), copper (Cu), and molybdenum (Mo). Furthermore, hydrothermally altered pegmatitic bodies, identified through moderate analytic signal responses and characteristic signatures on ternary radiometric images, may host rare-metal mineralization such as lithium (Li), tantalum (Ta), niobium (Nb), and beryllium (Be), as well as gemstones.

Field Mapping and Geochemical Assessment

Whole-rock geochemical analysis provides critical insights into elemental distribution, petrogenesis, and geotectonic evolution of crystalline terrains. In this study, major oxides, trace elements were analyzed and presented in tabular and graphical forms (Tables 1– 4; Figures 13–16) using bivariate, binary, and ternary discrimination diagrams. These approaches enable the classification of rock types, interpretation of magma evolution, identification of protoliths, and assessment of mineralization potential within the study area.

The analyzed rocks exhibit a wide compositional range, with SiO_2 values between 51.03% and 75.34%, Al_2O_3 (9.81–22.11%), Fe_2O_3 (0.5–15.23%), K_2O (0.1–11.60%), Na_2O (0.80–8.50%), CaO (0.0–2.60%), MgO (0.0–1.05%), and TiO_2 (Table 1) generally below 3%, alongside trace elements such as Cs, Mn, Sn, Nb, and Ta (Table 2). These geochemical characteristics are consistent with Precambrian basement rocks reported in similar Nigerian terrains, particularly those associated with Pan-African orogenic processes, which are typically enriched in Al_2O_3 and depleted in TiO_2 and certain incompatible elements (Danbatta, 2007). Representative lithologies further reveal that migmatites are enriched in SiO_2 and Al_2O_3 but relatively depleted in MgO, CaO, and alkalis, whereas schists show moderately high silica and iron contents. The overall silica-rich composition supports a predominantly felsic to granitic affinity of the basement rocks (Dada, 2006).

Table 1. Percentage major oxides distributions of rock types

Oxide wt%	Migmatite	Schist	Gneiss		Mean (N=2)	Pegmatite								Mean (N=8)
	L14	L13a	L11	L19		L10	L13b	L20	L21	L22	L23	L24	L25	
SiO2	70.32	66.01	64.3	75.34	69.82	69.7	70	73.01	68.72	69.25	51.03	67.63	67.25	67.07
Al2O3	11.5	10.11	9.81	15.65	12.73	19.15	12.5	15.5	22.11	18.75	16.53	19.17	15.2	17.36
Fe2O3	11.11	14.2	15.23	0.71	7.97	0.85	0.5	12.2	0.8	0.8	7.55	0.64	0.52	2.98
MnO	0.14	0.35	0.35	0.07	0.21	0.15	0.02	0.07	0	0.3	0.28	0.02	0.1	0.12
MgO	0.51	0.89	1.05	0.36	0.71	0	0	0	0	0	0	0	0	0
CaO	1.31	1.2	2.3	2.6	2.45	0	0.4	0	0	0.6	0.2	0	0	0.15
Na2O	1	2.5	2.1	0.8	1.45	1.6	4.5	3.5	2.5	2.6	8.4	3.2	5	3.91
K2O	1.05	0.1	1.3	2.1	1.7	3.5	5.4	5.2	3.2	4.2	11.6	5.2	7.8	5.76
TiO2	1.92	2.8	2.75	0	1.38	0	1.5	0	0.17	0	0	0.17	0.18	0.25
LOI	1.6	1	1.3	1	1.15	2.8	0	0.7	1.8	2	2.8	1	0.58	1.46
Total	100.49	99.19	10.05	9.86	9.96	9.78	9.48	11.02	9.93	9.85	9.84	9.7	9.66	9.91
Al/CNK	8.36	33.7	1.56	3.58	2.57	-	1.29	-	-	2.86	0.85	-	-	-
Al/NK	10.95	40.44	3.59	9.32	6.45	3.42	0.51	0.85	2.76	1.72	0.17	1.15	0.39	1.37

Table 2. Trace elements chemical analysis for the rock types in the study area

Oxide wt%	Migmatite	Schist	Gneiss		Mean (N=2)	Pegmatite								Mean (N=8)
	L14	L13a	L11	L19		L10	L13b	L20	L21	L22	L23	L24	L25	
Cs	3	4	56.5	15	35.75	4.5	5.2	4.8	30.8	13.1	30.3	10.5	5.1	13.04
Ta	0.8	1.2	24.3	4	14.15	901	12285	1720	2048	1147	0.2	3.5	983	2385.96
Rb	90	110	534	300	417	145	165	155	1528	232	1523	210	277	529.38
Be	2	3	196	8	102	4	5	6	5	31	6	12	15	10.5
Sn	1.5	2	170	6	88	12700	4	6	0.5	10	0.5	8	18	1593.38
Nb	8	10	59	18	38.5	0	0	0	909	1258	0	0	0	270.88

Mn*	750	800	310	420	365	620	390	465	85	155	95	770	155	341.88
Ga	16	18	45	22	33.5	18	16	19	12.7	23	12.6	22	24	18.41
Y	20	25	10	30	20	6060	1968	4329	0	6217	8106	20236	25184	9012.5
Zr	150	180	15	100	57.5	0	962	0	888	1184	2738	0	0	721.5
Co	12	14	0.1	6	3.05	12	10	11	0.3	0.5	0.3	8	0.5	5.33
Th	8	10	0.5	6	3.25	8.5	7.2	9.1	0.1	2.2	0.1	4.5	2.5	4.28
U	1.5	2	4.2	1.2	2.7	2.1	1.8	2.5	0.2	0.7	0.1	1.5	1.2	1.26
Li	25	35	350	120	235	25	32	28	139	52	145	45	27	61.63
K (ppm)	8716.68	830.16	10792.08	17433.36	14112.72	29055.6	44828.64	43168.32	26565.12	34866.72	96298.56	43168.32	64752.48	47837.97
Ratio														
Th/U	5.33	5	0.12	5	2.56	4.05	4	3.64	0.5	3.14	1	3	2.08	2.68
Zr/Y	7.5	7.2	1.5	3.33	2.42	0	0.49	0	-	0.19	0.34	0	0	-
K/Cs	2905.56	207.54	191.01	1162.22	676.62	6456.8	8620.89	8993.4	862.5	2661.58	3178.17	4111.27	12696.56	5947.65
Rb/Cs	30	27.5	9.45	20	14.73	32.22	31.73	32.29	49.61	17.71	50.26	20	54.31	36.02
K/Rb	96.85	7.55	20.21	58.11	39.16	200.38	271.69	278.51	17.39	150.29	63.23	205.56	233.76	177.6

Table 3. Enrichment Factor (EF) of Trace elements for the rock samples in the study area according to Taylor and McLennan (1985) Upper Continental Crust (UCC) values

Element	**Sample Mean (ppm)**	**UCC (ppm)**	**Correct EF**	**Enrichment Status**
Cs	13.04	3	4.35	Moderate enrichment
Ta	2385.96	2	1192.98	Extremely high enrichment
Rb	529.38	112	4.73	Moderate enrichment
Be	10.5	2.8	3.75	Moderate enrichment
Sn	1593.38	2.1	758.75	Extremely high enrichment
Nb	270.88	20	13.54	Significant enrichment
Ga	18.41	17	1.08	Minimal enrichment
Y	9012.5	21	429.17	Extremely high enrichment

Zr	721.5	190	3.8	Moderate enrichment
Co	5.33	25	0.21	Depleted
Th	4.28	10.7	0.4	Depleted
U	1.26	2.7	0.47	Depleted
Li	61.63	20	3.08	Moderate enrichment

Table 4. correlation coefficient of the concentrations of trace element of the pegmatites

Element	Cs	Ta	Rb	Be	Sn	Nb	Ga	Y	Zr	Co	Th	U	Li
Cs	1												
Ta	0.68	1											
Rb	0.79	0.71	1										
Be	0.81	0.69	0.86	1									
Sn	0.6	0.74	0.65	0.63	1								
Nb	0.55	0.66	0.59	0.57	0.62	1							
Ga	0.49	0.45	0.54	0.51	0.44	0.41	1						
Y	0.53	0.61	0.56	0.55	0.58	0.6	0.46	1					
Zr	0.38	0.4	0.42	0.39	0.36	0.47	0.35	0.64	1				
Co	-0.41	-0.36	-0.48	-0.44	-0.33	-0.3	-0.28	-0.32	-0.25	1			
Th	-0.35	-0.3	-0.37	-0.36	-0.29	-0.27	-0.24	-0.26	-0.21	0.62	1		
U	-0.32	-0.28	-0.33	-0.31	-0.25	-0.22	-0.2	-0.23	-0.18	0.58	0.71	1	
Li	**0.82**	**0.74**	**0.91**	**0.88**	**0.69**	**0.63**	0.52	0.58	0.41	-0.46	-0.39	-0.34	1

Field mapping indicates that the study area is underlain by a complex Precambrian basement dominated by migmatites and gneisses, with subordinate schists and intruding pegmatites and quartzo-feldspathic dykes. These lithologies exhibit a consistent NE–SW structural trend, which controls both foliation and emplacement of intrusive bodies. Migmatite–gneiss units constitute the majority of the area and represent high-grade metamorphic rocks formed through partial melting and recrystallization of pre-existing protoliths (Figures 13a, 13c, 13d, and 13e). These rocks display characteristic banding (Figure 13c) defined by alternating felsic (quartz–feldspar–muscovite) and mafic (biotite–hornblende) layers, with well-developed foliation reflecting regional tectonic deformation. Schists, though less abundant, are characterized by strong schistosity (Figure 13b) resulting from the alignment of platy minerals such as muscovite, indicating metamorphism of pelitic sedimentary precursors. Pegmatites occur as late-stage intrusive veins (Figure 13f) cutting across all major lithologies, typically coarse-grained and composed of quartz, feldspar, and mica, with field measurements indicating predominant NE–SW trends and steep dips, suggesting structural control during emplacement.

(a)

(b)

(c)

(d)

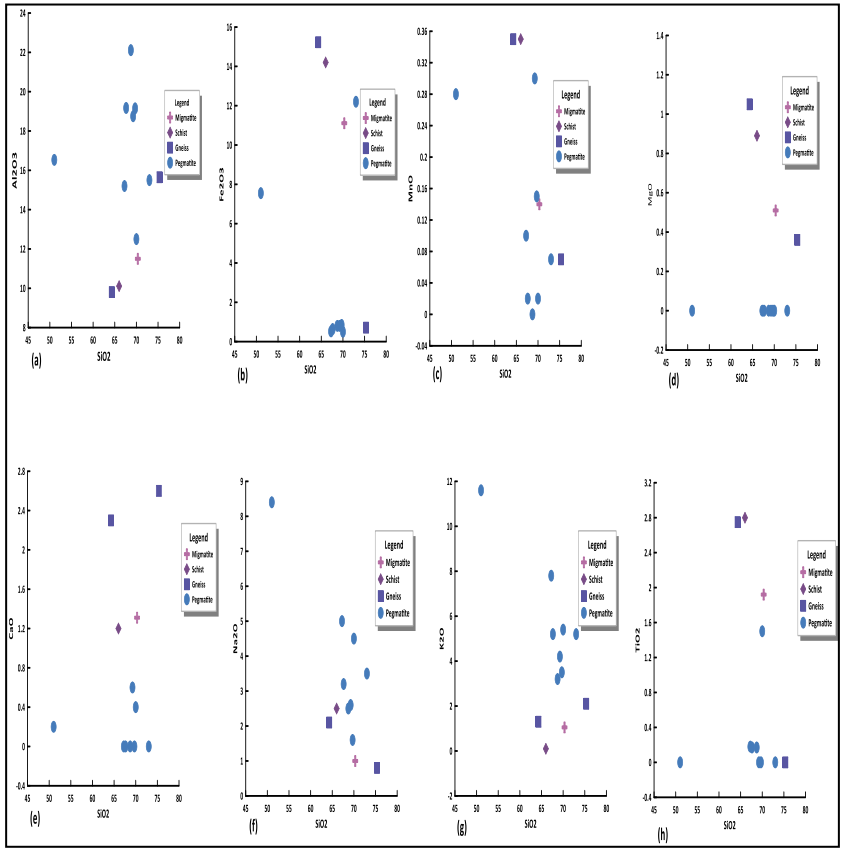
(e)

(f)

Figure 13. Photograph of rock types (a) Migmatite with haphazard foliation (b) pellitic schist with schistose plane (c) Banded Gneiss with melanocratic and leucocratic band of minerals (d) the wavy and folded nature of the bands, showing ductile deformation (e) A thin, whitish quartz vein cross-cuts the foliation, and joint of migmatite-gneissic body (f) sampling pegmatite at river bank

The structural framework of the area reflects multiple deformation phases associated with the Pan-African orogeny. Observable features include foliations, folds, joints, veins, and dykes. Foliation is defined by the alignment of mica and quartz–feldspar bands, while mineral lineation reflects tectonic transport directions. Cross-cutting relationships of veins and dykes indicate late-stage magmatic intrusion along fractures (Figure 13e). The coexistence of ductile structures (folds) and brittle features (joints and faults) indicates a complex deformational history involving varying stress regimes.

Geochemical classification using the Total Alkali–Silica (TAS) diagram (Middlemost, 1985) shows that the migmatites, gneisses, and schists plot within the granite to granodiorite fields, while pegmatites extend into granite, granodiorite, and syenite domains, confirming their felsic composition (Figure 14b). The rocks are generally silica-rich and enriched in Al_2O_3 and alkalis, with aluminium saturation index (ASI) values greater than unity for migmatite, gneiss, and schist, indicating a peraluminous character typical of metasedimentary-derived rocks (Figure 12d). In contrast, some pegmatites exhibit peralkaline tendencies (A/CNK < 1), suggesting derivation from evolved igneous melts (Figure 14d). Elemental variation diagrams reveal negative correlations between SiO_2 and Fe_2O_3, MgO, and TiO_2 (Figure 14a), indicating fractional crystallization involving ferromagnesian minerals such as pyroxene and hornblende. The presence of quartzo-feldspathic veins further supports partial melting (anatexis) during metamorphism (Obiora, 2006). The Modified Alkali-Lime Index (MALI) (Figure 14c) indicates that the rocks span calcic, calc-alkaline, and alkali-calcic series, suggesting contributions from multiple magma sources and complex magmatic evolution (Frost et al., 2001).


Al2O3
Fe2O3
MnO
MgO
CaO
Na2O
K2O
TiO2
SiO2
Legend
Migmatite
Schist
Gneiss
Pegmatite
(a)
(b)
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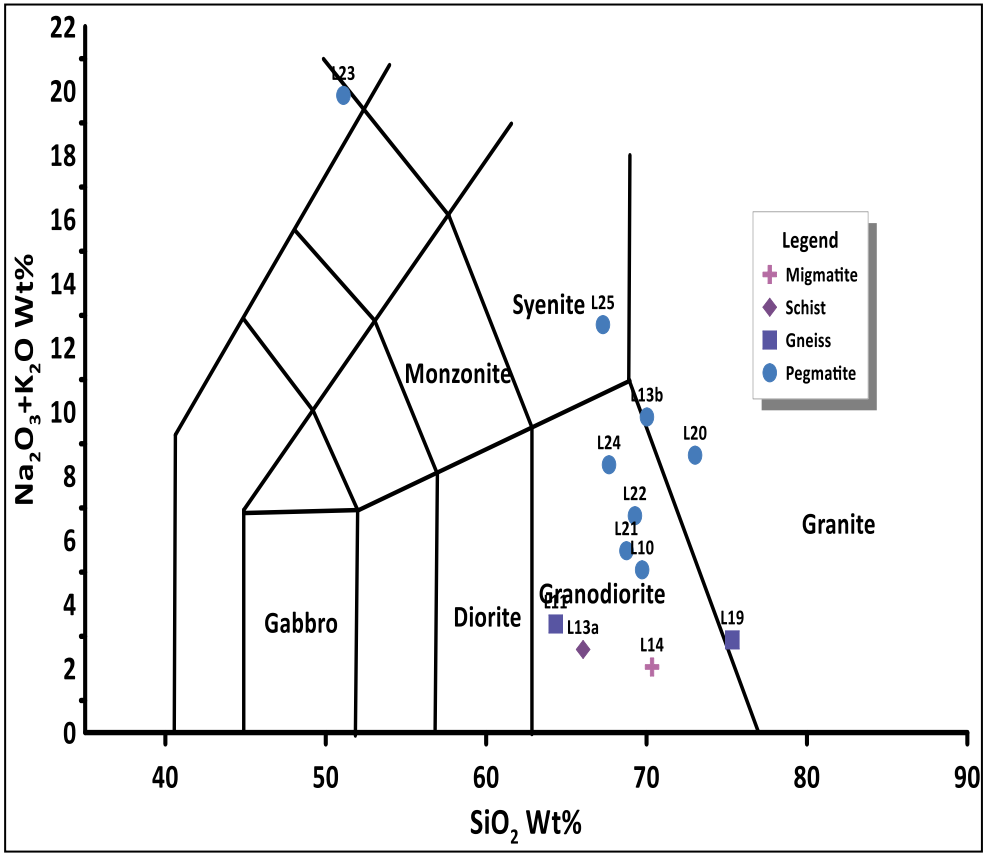
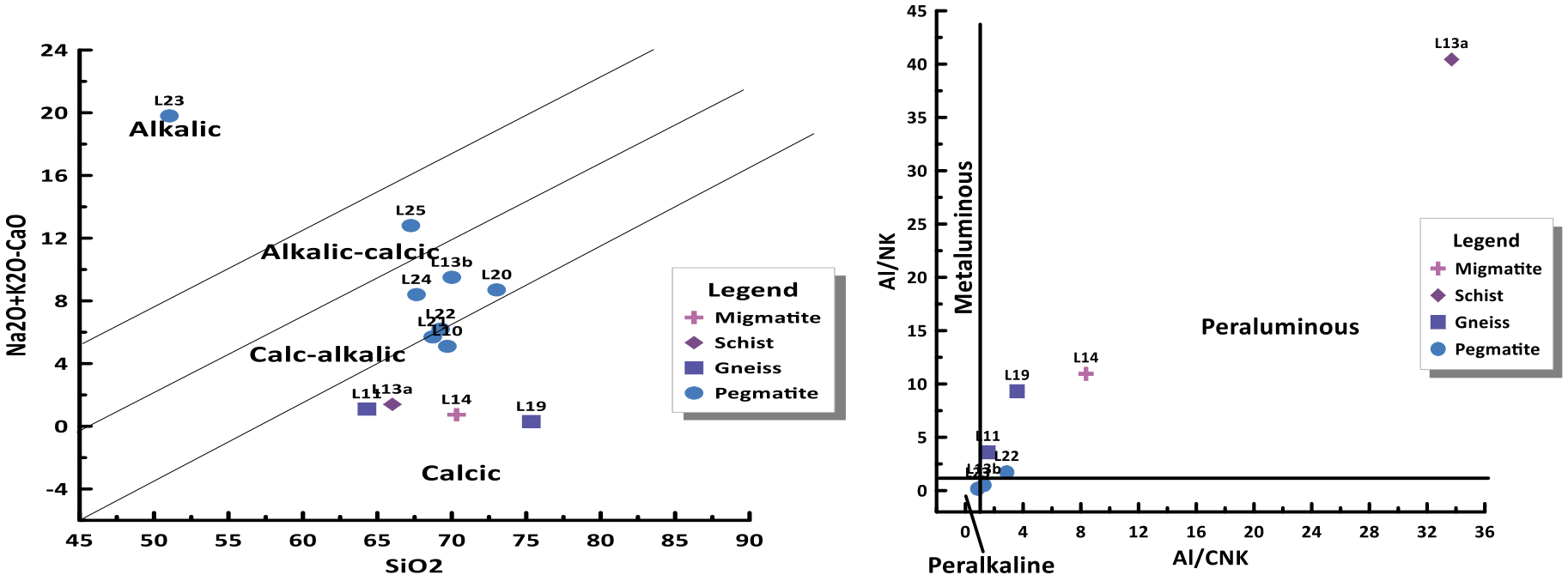
(h)

(a)


Na2O3+K2O Wt%
SiO2 Wt%
Syenite
Monzonite
Granite
Granodiorite
Diorite
Gabbro
L23
L25
L13b
L20
L24
L22
L21
L10
L11
L13a
L14
L19
Legend
Migmatite
Schist
Gneiss
Pegmatite

(b)



(c) (d)

Figure 14. Plot of (a) Harker variation diagrams for the rocks of the study area showing relationship between the pegmatites and the host rocks (b) Total alkali versus silica diagram for all analyzed whole rock samples from the study area (modified after Middlemost, 1994) (c) Plot of Na2O + K2O - CaO vs. SiO2 (modified after Frost et al., 2001) (d) A/NK vs. A/CNK classification diagram (modified after Maniar and Piccoli, 1989)

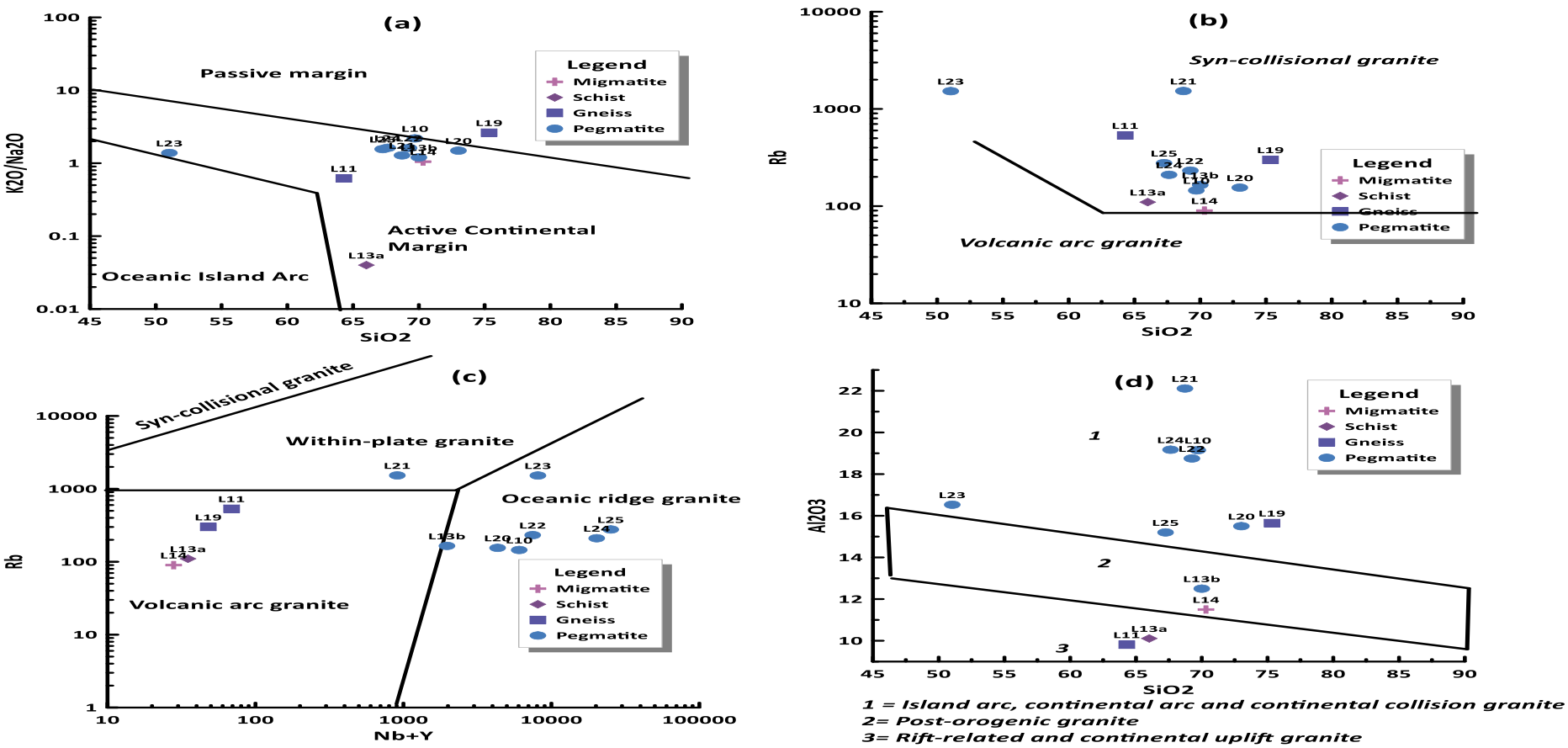
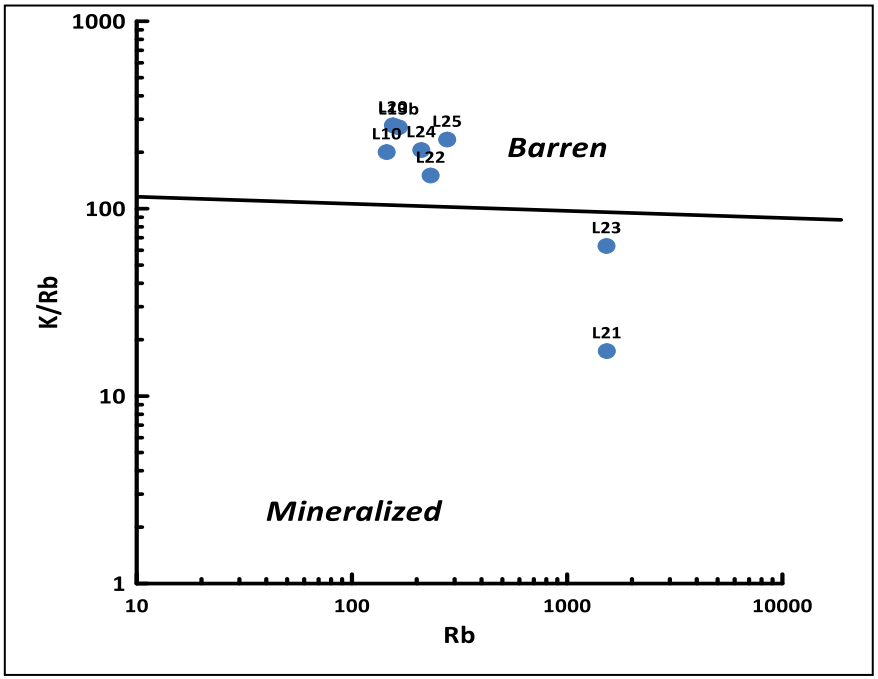
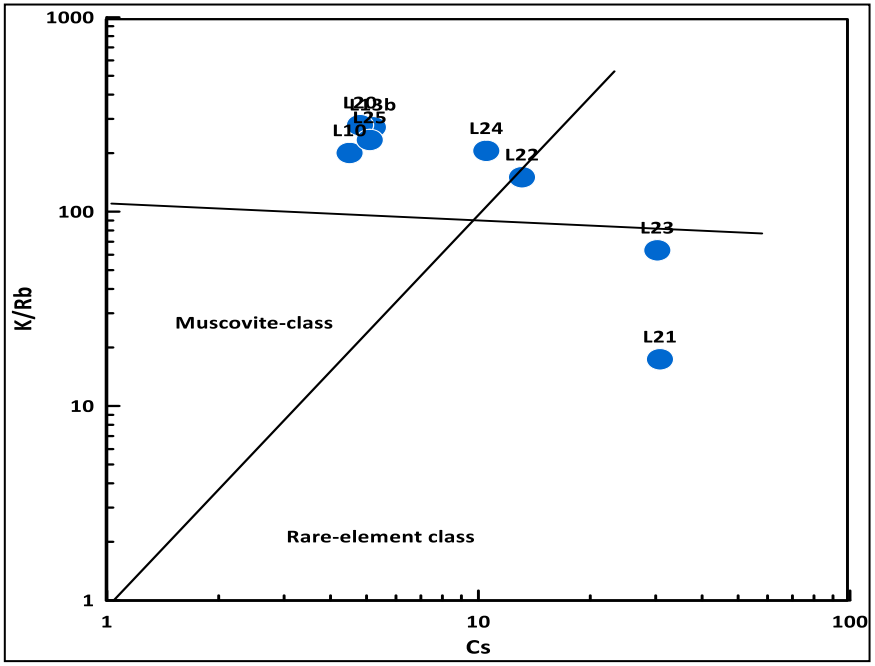


Figure 15. Tectonic discriminant diagram of the study rock types; (a) Plot of K2O/Na2O vs. SiO2 (modified after Lopez de Luchi et al., 2003) (b) Rb vs. SiO2 Discriminant plot (modified after Odewumin and Olarenwaju, 2013) (c) Rb vs. Y+Nb Discriminant plot (modified after Pearce et al., 1984) (d) Al2O3 vs. SiO2 discriminant plot (modified after Maniar and Piccoli, 1989)

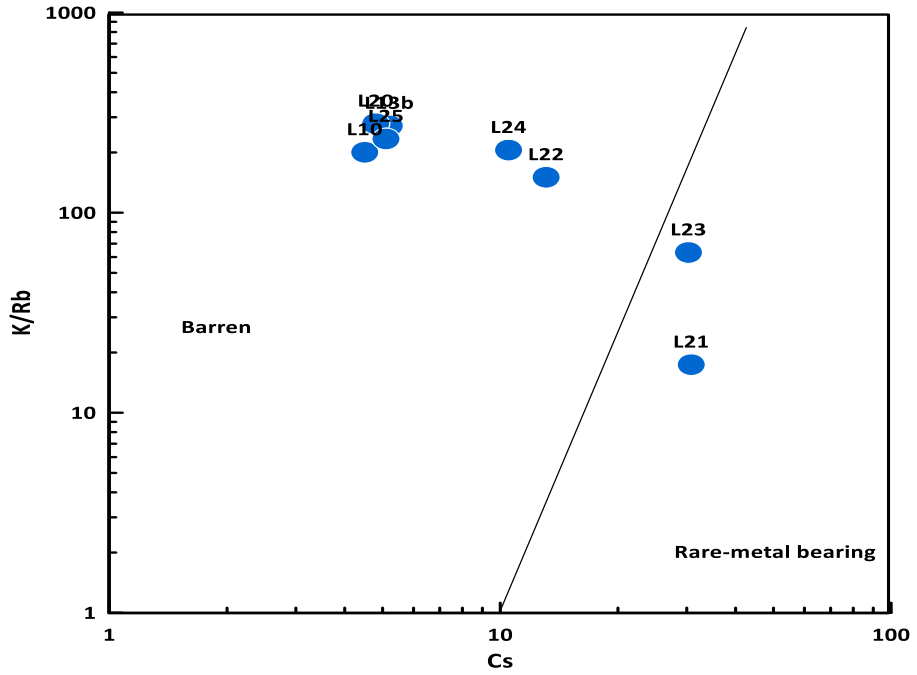
Discrimination diagrams further indicate that the metamorphic rocks were derived from sedimentary to metasedimentary protoliths, as evidenced by their peraluminous nature (Figure 14d) and high silica content, whereas the pegmatites are of igneous origin and represent late-stage crystallization products of granitic magmas. Tectonic discrimination plots (Figure 15) suggest formation predominantly within an active continental margin setting, with characteristics of volcanic arc granites and syn-collisional environments, alongside minor post-orogenic signatures. This indicates prolonged magmatic activity during and after the Pan-African orogeny, with pegmatites belonging to the Older Granite suite associated with late Pan-African magmatism (Küster, 1990; Garba, 2003).


1000
100
10
1
K/Rb
10
100
1000
10000
Rb
Barren
Mineralized
L10
L24
L25
L22
L23
L21

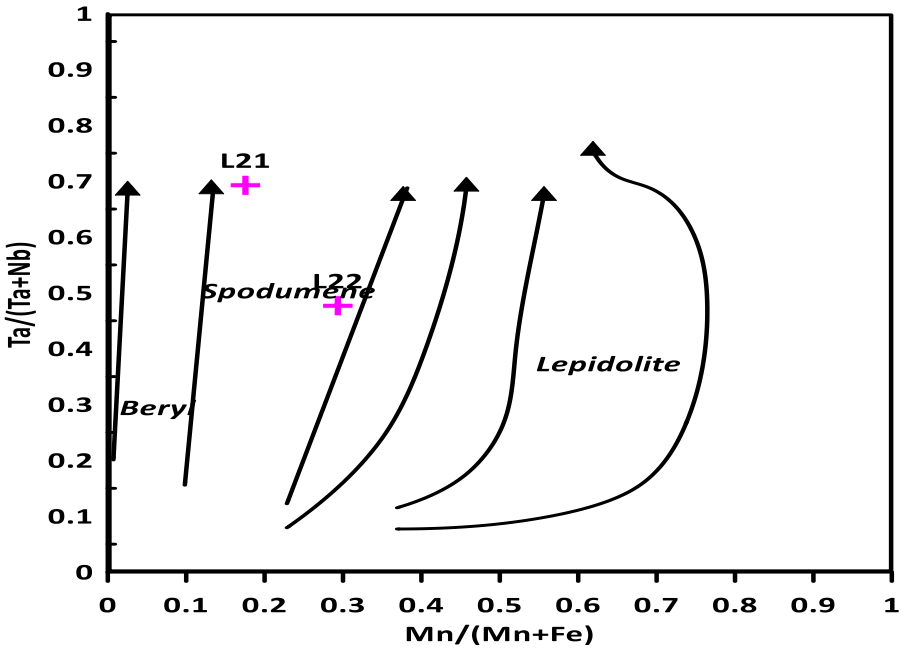
(a)


1000
100
10
1
K/Rb
1
10
100
Cs
Muscovite-class
Rare-element class
L10
L24
L22
L23
L21

(b)



(c)



(d)

Figure 16. Plot of (a) K/Rb versus Rb plot after Staurov et al., (1969) of the rocks in the study area showing the degree of fractionation and mineralization of the pegmatites. (b) K/Rb versus Cs plot after Černý and Burt (1984) of the rocks in the study area showing classification of the pegmatites into muscovite and rare-element class (c) K/Rb versus Cs plot after Černý (1982), of the rocks in the study area showing the discrimination of the pegmatites into barren and rare-metal pegmatites). (d) Ta/(Ta+Nb) vs Mn/(Mn+Fe) variation plots of the Pegmatites (fields adapted from Černý and Ercit, 1989).

Trace element distribution provides further constraints on pegmatite evolution and mineralization potential. Fractionation indices such as K/Rb, Ba/Rb, K/Cs, and Na/K are widely used to assess the degree of magmatic differentiation. Low K/Rb ratios (<100) (Figure 16a) observed in some samples indicate significant fractionation and are commonly associated with rare-metal mineralization (Černý, 1989; London, 2005). Discrimination plots (Rb vs. K/Rb; Cs vs. K/Rb) show that while many pegmatites fall within the muscovite (barren) class, selected samples (e.g L21 and L23) display characteristics of mineralized systems (Figure 14a and 14c). These variations are attributed to magmatic evolution processes, including fractional crystallization and melt-fluid interactions or liquid immiscibility (Thomas & Veksler, 2002). The pegmatites are therefore interpreted as moderately evolved and correspond to Lithium–Cesium–Tantalum (LCT) type rare-metal pegmatites, characterized by enrichment in incompatible elements such as Sn, Ta, Nb, Rb, and Cs. Plot of Ta/(Ta+Nb) vs Mn/(Mn+Fe) variation plots of the Pegmatites (fields adapted from Černý and Ercit, 1989), plotted L21 and L23 Pegmatites within the spodumene region confirming the presence of Lithium bearing pegmatite (Figure 16d). Such geochemical signatures are typical of highly evolved granitic systems and are consistent with findings from similar basement complexes in Nigeria (Chukwu & Obiora, 2021).

Enrichment Factor (EF) analysis, normalized to Al_2O_3 using Upper Continental Crust values (Rudnick & Gao, 2003), further constrains the degree of mineralization (Table 3). Based on the classification of Sutherland (2000), several samples exhibit significant to extreme enrichment. For instance, sample L13b shows exceptionally high enrichment in Ta (EF > 16,000), while samples L10 and L20–L22 display strong enrichment in Ta, Sn, and Y, indicative of highly evolved pegmatitic systems. Lithium and cesium enrichment in samples such as L11 further supports their classification as LCT-type pegmatites. In contrast, samples such as L19 and L24 exhibit relatively low enrichment, suggesting limited mineralization or proximity to background crustal composition.

CONCLUSION AND RECOMMENDATION

Integrated aeromagnetic, aero-radiometric, and whole-rock geochemical analyses provide a comprehensive framework for delineating lithium-bearing pegmatites within Kuje Sheet 207. The area is structurally complex, dominated by northeast–southwest trending lineaments interpreted as shallow faults and shear zones, which acted as conduits for magmatic and hydrothermal fluids during the Pan-African orogeny, controlling pegmatite emplacement and mineralization. Analytic signal mapping identifies high, moderate, and low magnetic domains. High-amplitude anomalies, mainly in the southern sector, correspond to migmatites, gneisses, and biotite-rich units with higher magnetic susceptibility, whereas pegmatites and hydrothermally altered zones exhibit lower responses due to felsic composition and alteration. Euler deconvolution indicates most magnetic sources occur at shallow to intermediate depths (100–300 m), consistent with near-surface intrusions. Analytic signal and derivative filters (first vertical) further delineate lithological boundaries and edges of causative sources, confirming structural control on magma ascent and fluid migration. Aero-radiometric K/Th ratios (>0.17 %/ppm) highlight hydrothermal alteration zones coinciding with dense lineaments and structural intersections, indicating fluid migration along fractures and potential concentration of rare metals. Ternary K–Th–U imaging identifies felsic intrusive and high-grade metamorphic rocks as zones of combined radioelement enrichment, supporting structural control on mineralization. Geochemically, the basement comprises high-silica migmatites, schists, and gneisses intruded by pegmatites (51–73 wt% SiO_2, mean 67 wt%), enriched in K_2O and Na_2O, with low MgO and CaO. TAS classification places both host rocks and pegmatites in granite–granodiorite fields, while aluminium saturation indices indicate peraluminous metamorphic rocks and some peralkaline pegmatites, consistent with evolved igneous origins. Trace-element data reveal extreme fractionation typical of LCT (Li–Cs–Ta) pegmatites, with high enrichment of Ta, Nb, Sn, and Li–Cs–Rb anomalies (Li EF 22.9 in sample L11). Strong correlations between Li and Rb (0.91), Be (0.88), Cs (0.82), and Ta (0.74) indicate magmatic fractionation controls lithium enrichment. The spatial overlap of magnetic discontinuities, shallow intrusions, hydrothermal alteration zones, and geochemically evolved LCT signatures confirms a genetic link between tectonic structures, magmatic differentiation, hydrothermal processes, and lithium enrichment. Kuje Sheet 207 hosts structurally controlled, Pan-African, highly fractionated LCT-type

pegmatites with significant lithium-bearing potential, representing a prime target for rare-metal exploration.

To enhance the understanding and exploration of lithium-bearing pegmatites within Kuje Sheet 207, it is recommended to conduct high-resolution ground magnetic surveys and systematic field verification along the identified aeromagnetic lineaments to refine structural interpretation and validate the continuity, depth, and geometry of pegmatite-hosting structures. Detailed structural and lithological mapping along NE–SW trending shear zones and hydrothermally altered corridors should be coupled with systematic sampling of pegmatites and host rocks for comprehensive geochemical characterization. Radiometric dating methods, such as U–Pb and Ar–Ar, are essential to constrain the timing of pegmatite emplacement and assess their genetic relationship with Pan-African magmatism and tectonism. GIS-based spatial integration of structural lineaments, magnetic depth solutions, radiometric anomalies, and geochemical signatures is recommended to develop predictive models for locating lithium-bearing pegmatites. Finally, extending comparative geochemical and tectonic studies to adjacent rare-metal pegmatite districts will refine the regional classification, metallogenic framework, and lithium potential of Pan-African LCT systems.

THANKS, AND INFORMATION NOTE

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Data Availability Statement: The geophysical datasets used in this study were obtained from NGSA and are subject to institutional access policies. Processed data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest: The authors declare no conflict of interest regarding the publication of this work.

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ASSESSMENT OF GROUNDWATER QUALITY IN COMMUNITIES SURROUNDING ABANDONED QUARRIES IN MPAPE, PART OF ABUJA SHEET 186SE, NIGERIA

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ABSTRACT

Abandoned quarries, particularly those in rapidly developing areas, present significant environmental challenges, especially to surrounding groundwater resources. This study evaluated the quality of groundwater in communities surrounding the abandoned quarries in Mpape, FCT Abuja with emphasis on its suitability for drinking water and other domestic uses. A total of 17 groundwater samples were collected from 5 hand dug wells, 9 bore holes, and 3 from the abandoned quarries. These samples were subjected to both on-site field measurements and further laboratory analysis using Atomic Absorption Spectrophotometry in accordance with standard procedures. The result from the physicochemical analysis of groundwater sample revealed pH values (6.4 to 9.01), range from slightly acidic (<6.5), to moderately alkaline (<8,5). EC (92–1460 µS/cm) and TDS (45–639 mg/L) exceeded permissible limits in a few samples, notably groundwater samples; S5, S6, and S9, indicating elevated mineralization. Turbidity exceeded the 5 NTU guideline only in one location (S4). Nutrient analysis revealed nitrate concentrations (15–150 mg/L), with several samples (S5, S8, S9, S10, S17) surpassing the 50 mg/L limit, suggesting anthropogenic inputs from sewage and agricultural activities. Heavy metals analysis showed elevated concentrations of lead (0.242–0.274 mg/L in S5 and S14), arsenic (up to 0.021 mg/L), and manganese (up to 0.748 mg/L), exceeding both WHO and NSDWQ limits. Microbiological analysis revealed the presence of coliforms and E. coli in the majority of samples, with maximum counts of 571 cfu/100 mL, exceeding the zero-tolerance benchmark. Overall, results indicates that majority of groundwater sources in Mpape are unsuitable for direct consumption. While some samples may be used for non-drinking domestic purposes, widespread contamination by nitrates, heavy metals, and pathogens makes the water unsafe without adequate treatment. The findings highlight the vulnerability of groundwater in quarry-impacted environments and emphasize the urgent need for water treatment interventions, improved sanitation practices, and monitoring to safeguard public health in communities around areas susceptible to contamination.

Keywords: Abandoned Quarry, Mpape, Crushed Rock, Heavy Metals, Microbiological, Contamination, Groundwater.

Introduction

Groundwater is one important natural resource that provides basic support to all forms of life. Particularly, in rapidly growing areas, the demand of these resource for industrialization, agricultural activities, and essential household demands, is inexhaustible. Likewise, the increasing demand for raw materials for construction purposes, mainly in peri-urban areas like Mpape, Federal Capital Territory, Abuja, has led to exhaustive quarrying. Unfortunately, some of these quarries become inactive over the years and become abandoned. These abandonment of quarry sites poses severe risks to environmental quality, particularly the groundwater supplies (Ezeabasili *et al.,* 2013; Bawa & Adesina, 2018).

Mpape is home to a number of nonoperational quarries such as the Crushed Rock and Julius Berger quarries, which are now used as water catchment areas and some sort of attraction. Because of exposed residual geological materials, explosives, and pit flooding, and other anthropogenic means from surrounding settlements these locations could potentially contribute to groundwater contamination.

Although groundwater is heavily relied upon for household purposes in Mpape, little is known about the long-term impact of these quarries on groundwater quality. (Osumeje et al., 2020).

Existing research studies have recorded environmental degradation which has occurred as a result of active and inactive quarrying activities within Abuja. However detailed investigation of the resulting effects of the various abandoned quarry sites on the groundwater systems within the arear remains limited. Given the geological setting of the area and the limited sources of water supply within the area, residents rely heavily on available groundwater, either sourced from hand-dug wells and boreholes, which are susceptible to contamination through these quarry walls, surface runoffs, or any other infiltrating pollutants. Consequently, the Mpape Crushed Rock and Julius Berger quarries which have become inactive and subsequently abandoned over the years, are now partially flooded. Therefore, the need to assess the potential leaching of heavy metals and other microbial pollutants into nearby aquifer systems has become crucial. Essentially, this research study is therefore timely, as it is targeted at generating a baseline data set, essential for future remediation and long-term monitoring efforts.

Furthermore, “Studies have shown that Nigeria urban groundwater quality is influenced by the geology and geochemistry of the environment, rate of urbanization, industrialization, landfill/dumpsite leachates, heavy metals, bacteriological pollution, and effect of seasons.” (Ocheri et al., 2014). Likewise, Oyeku and Eludoyin (2010) investigated the heavy metal contamination of groundwater in a Nigerian urban settlement and established that “Informal e-waste processing was a significant source of contamination".

However, previous studies conducted in the vicinity of Mpape and its surroundings concentrated more on evaluating the quality of soils, surface water, or waste dump leachates (Rabiu, 2022; Okediji, 2023; Hassan & Ashade, 2025), while Studies by Useh et al., in 2025 highlighted that the environmental impact of quarrying often includes the release of hazardous pollutants such as heavy metals and waste materials into nearby soil and water bodies. Therefore, the limitations on the potential direct contamination of groundwater from surrounding abandoned quarry sites remains outstanding. This study thus aim to bridge this knowledge gap by conducting a comprehensive assessment of the groundwater contamination status within Mpape, which is the main source of water for the nearby communities, and by identifying any potential risks to human health and the environment.

Regional geology of the study area

The study area in Mpape is located at the northeastern edge of the Gwagalada plains in Mpape, Federal Capital Territory (FCT), Abuja, near the Tipper Garage. It lies within the watershed of the River Usuma Basin and covers part of the Abuja Sheet 186 SE. The coordinates fall between latitude 9°07′52.8"N – 9°08′57.8"N and longitude 7°28′54"E – 7°30′00"E. Access is provided by paved roads from the central district of Abuja (Adakayi et al., 2015). The inset map at **figure 1** below shows the location of the area as well as the topography and drainage pattern. The area, located within the basement complex of Northcentral Nigeria is underlain mainly by the Precambrian basement complex rocks, typical characteristic of the Abuja geological province, which are known to be vulnerable to weathering and fracturing, thereby creating the pathways for groundwater movement and contaminant mobilization. It is located within the Central Nigeria Precambrian Basement Complex. The geology of the area has been studied and discussed by Oyawoye (1972), McCurry (1976) etc, who described the rocks as comprising mostly granite, gneisses, mica schists, hornblende and feldspathic schists and migmatites. The rocks are highly fractured and jointed showing essentially two fracture patterns, NE – SW and NW – SE. These fractures control the drainage and flow patterns of rivers in the area” (Abam & Ngah, 2013).

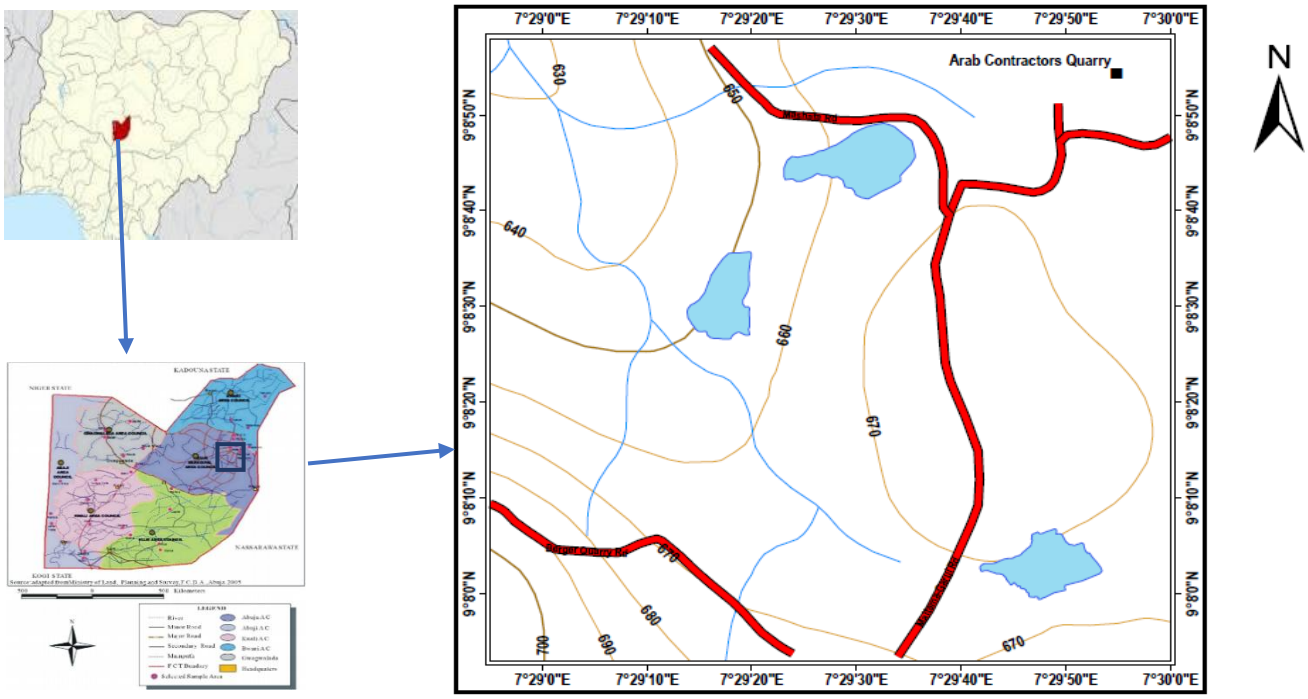


Figure 1.: Inset map of study area location (Source: FCDA, 2005)

Materials and Methods

Groundwater Sampling

Groundwater samples were collected using systematic sampling method, and were subjected to both in-situ field measurements and further laboratory analysis in accordance with standard procedures. The parameters temperature, pH, Electrical Conductivity and Salinity were determined in-situ using (using Pen Type Water Quality Meter (PTWQM) Testing Method). During sampling the probe of the multiparameter meter was inserted directly into the water sample. The meter was turned on and then allowed to stabilize before taken the reading of each of the parameters and documented.

The samples were collected using a 500mL plastic sample bottles, the bottles were thoroughly washed with distilled water and rinsed three times using the sampling water at each sample point before collecting water for the study. The time, date and location of the sampling points were noted and the samples properly labeled before storing them in the insulated cooler, and then transported to the Federal Ministry of Water Resources; National water Quality Reference Laboratory, in Minna for further Analysis.

A combination of elemental, bacteriological, and physicochemical analyses were used to evaluate the quality of groundwater samples collected from the study area. All methods followed standard laboratory analytical protocol to guarantee accuracy and reliability. Water samples were digested to break down complex matrices and convert metals into measurable ionic forms. After acid digestion, the digests were filtered and prepared for heavy metal analysis using Atomic Absorption Spectrophotometry (AAS) under carefully controlled heating conditions and the appropriate spectrometric techniques. Microbial contamination was evaluated using the membrane filtration method. Measured volumes of water were filtered through sterile membrane filters, which were subsequently incubated on selective media to encourage colony formation. After incubation, the resulting colonies were counted to determine the E. coli and total coliform concentrations, which were expressed as colony-forming units per 100 mL (CFU/100 mL). The data obtained were analyzed to assess the spatial variations in microbial load and then compared with permissible limits for potable water. Likewise, fluoride concentrations were determined using colorimetric method. The results were statistically interpreted and evaluated against recommended guideline limits to assess potential health implications. Sodium and potassium ion

concentrations were measured using a flame photometer. Calibration curves were prepared from standard solutions, and sample readings were taken relative to these curves to quantify ion levels. The results were analyzed using descriptive statistics and compared with established drinking water quality benchmarks. All the analytical data generated were then compiled, and tabulated, for descriptive statistical analysis to be done, this included the calculation of the mean values, ranges, and standard deviations. Generally, the obtained results were compared with standards provided by the World Health Organization (WHO), the Nigerian Standard for Drinking Water Quality (NSDWQ), NIS 554:2015.

In other to achieve the aim of study, a total of 17 groundwater samples were collected from 5 hand dug wells (WSP_1-3, 5 and 6), 9 bore holes, and 3 from the abandoned quarries (WSP7_CRI, WSP_13JB and WSP_14JB), with WSP_17 being a control point, the spatial distribution of the sampling points is seen at **figure 2** below.

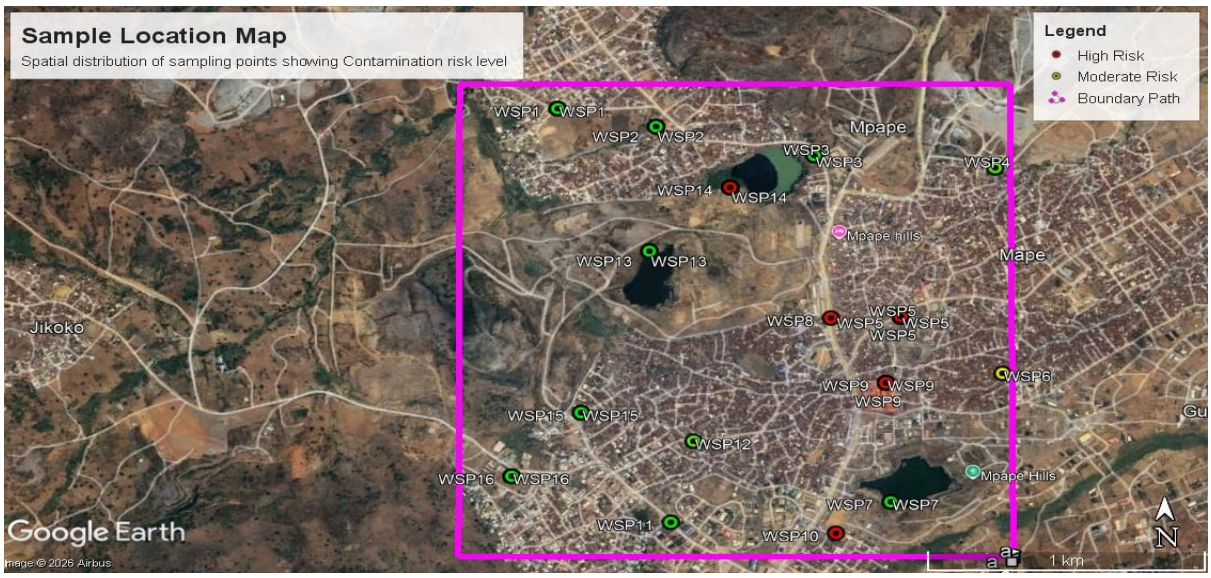


Figure 2: Spatial distribution of sampling points

Results and Discussion

Geology: Geological mapping of the study area was carried out, field observation of the rock types, mineralogy, structures and field relations were studied, as seen in **figure 3**, the field observation identified medium - coarse grained igneous rocks and a coarser granitic rock of mesocratic colour. The rocks are highly fractured and jointed showing essentially two fracture patterns, NE-SW and NW-SE, with most of the structures trending in the NE-SW direction, which comply with the regional geology of Nigerian (pan Africa). Hand specimen samples were collected and subjected to petrographic study. The petrographic analysis further revealed the two rock types; coarse-porphyritic (Felsic, silica-rich) granite, and medium grained (Quartz-rich granite) granite with primary mineral composition of quartz, plagioclase feldspar, orthoclase feldspar, biotite, microcline, and opaque minerals. The dominance of quartz and alkali feldspar, together with the presence of biotite, indicates that both rock types are felsic, calc-alkaline granites. **Figure 4** below shows some of the photomicrographs of the thin section of the rock samples collected while being viewed under both crossed polarized light (A) and the plain polarized light (B). The geological map of the study area, produced on a scale of 1:10,000 is seen at **figure 5,** which shows both rock types, overlain by the ground Water Sampling Points (WSPs).

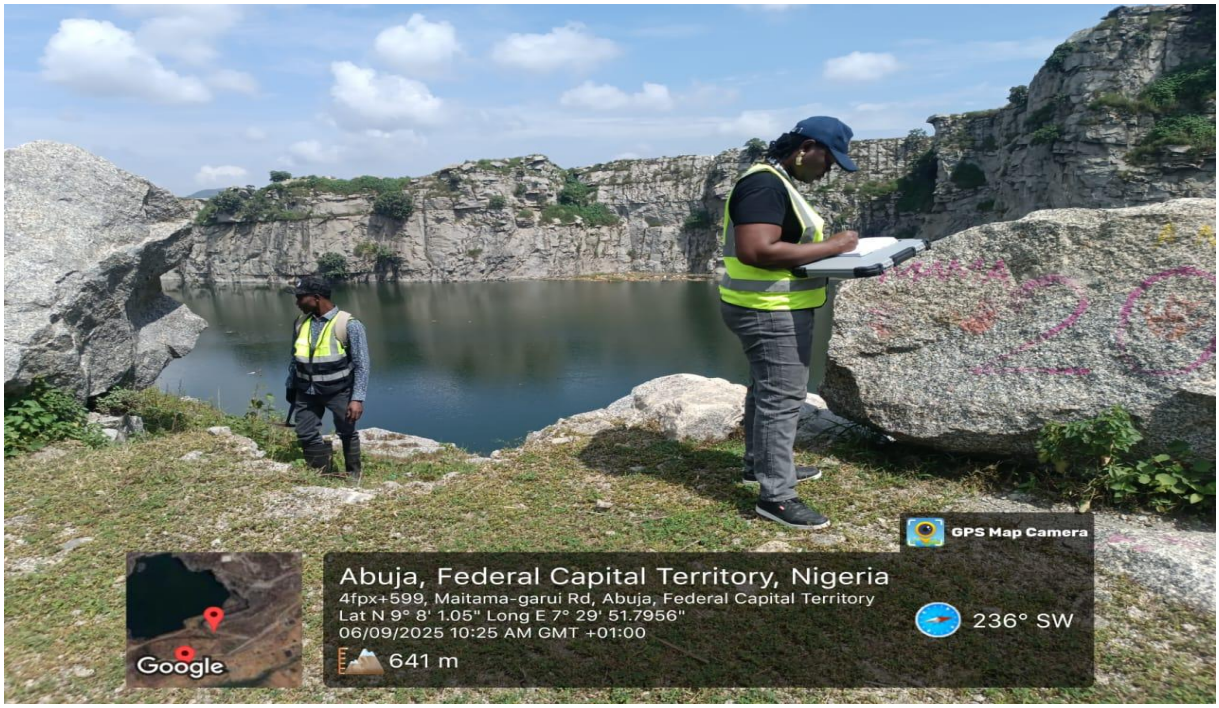
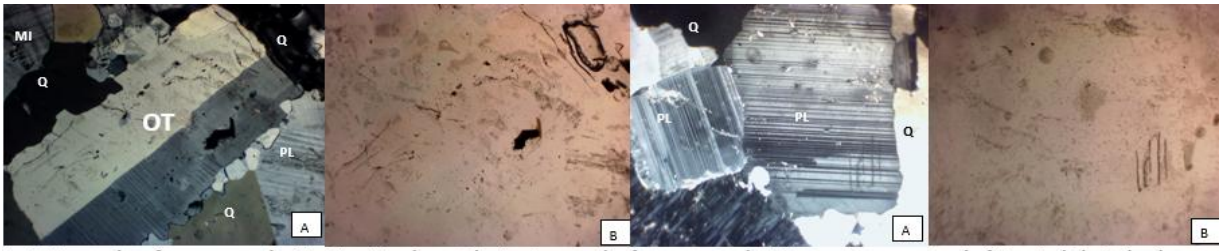
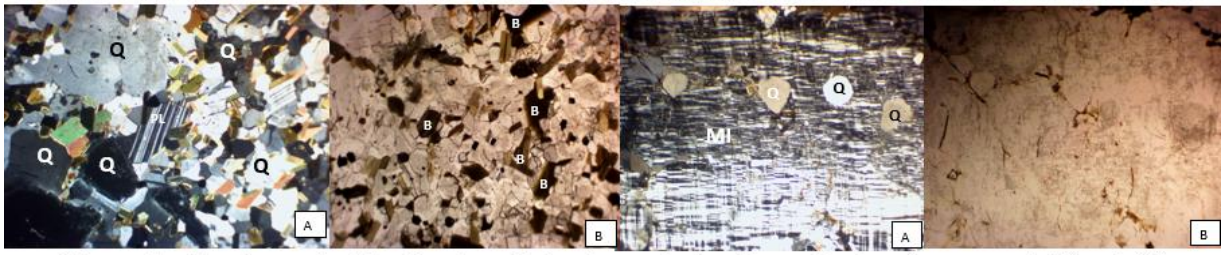


Figure 3: During field observation at the abandoned Crushed rock quarry pit.



Petrography of coarse-porphyritic Granite: shows Photomicrograph of coarse-porphyritic granites composed of Quartz (Q), Orthoclase (OT), Plagioclase (PL), Microcline (MI), Biotite (B) and Opaque (Op) under (A) crossed- polarized light, (B) plain-polarized light (Mag. 20x).



Petrography of medium grained Granite: shows Photomicrograph of medium grained granite composed of Quartz (Q), Plagioclase (PL), Microcline (MI), and Biotite (B) under (A) crossed- polarized light, (B) plain-polarized light (Mag. 20x).

Figure 4: Petrographic study of the rock samples within study area

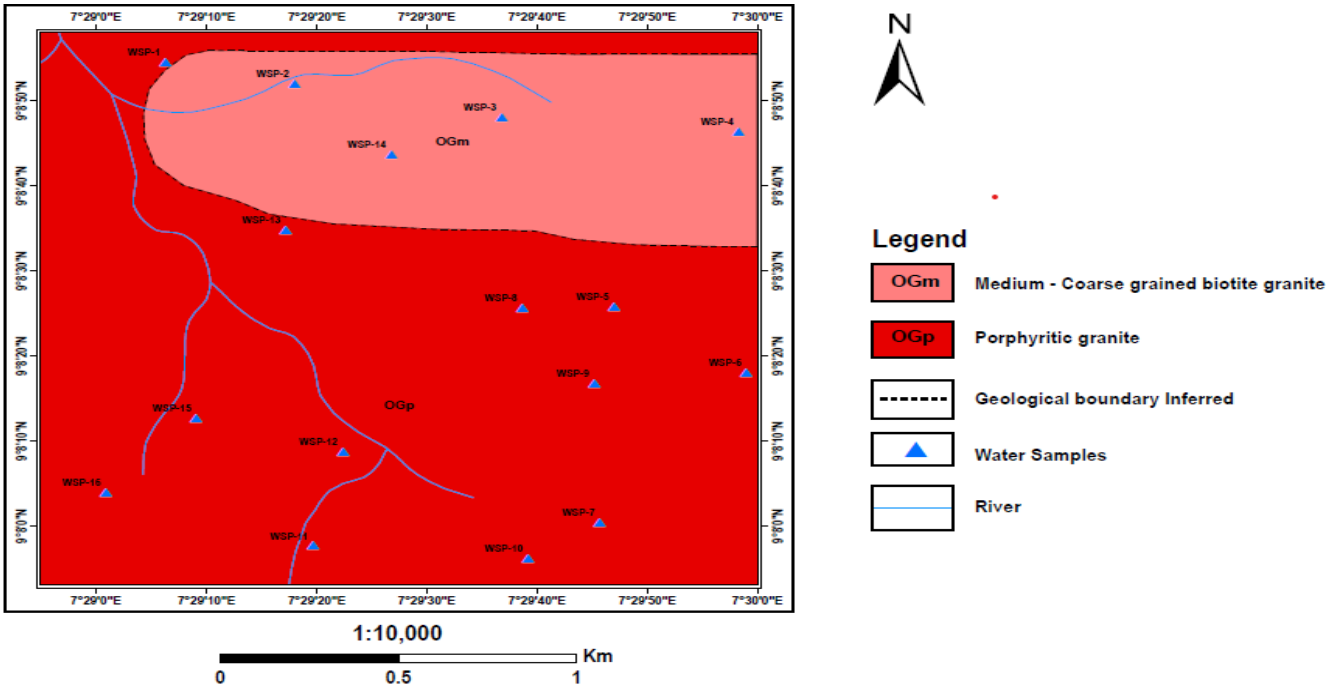


Figure 5: Geological map of the study area, showing the rock types.

Ground Water Quality

In line with the study objectives, the results of the analysis were compared with the World Health Organization (WHO) guideline and the Nigerian Standard for Drinking water Quality (NSDWQ). **Table 1** below shows the comparison of the parameters with WHO guidelines and NSDWQ standard for each Water Sample Point (WSP) 1-17.

Table 1: **Water samples parameter comparison with WHO guidelines and NSDWQ standard**

PARAMETERS	WSP1	WSP2	WSP3	WSP4	WSP5	WSP6	WSP7	WSP8	WSP9	WSP10	WSP11	WSP12	WSP13	WSP14	WSP15	WSP16	WSP17	NSDWQ	WHO
Temp ℃	26.9	26.9	25.8	26.8	23.8	26.1	26.1	26.8	26.9	26.8	26.5	26.8	25.6	26.8	26.6	26.6	26.7	Ambient	Ambient
pH	7.9	8.2	6.9	7	6.8	6.7	7.8	8.5	6.5	6.8	7.6	7.8	8.4	7.6	7.5	6.9	7	6.5-8.5	6.5-8.6
Conductivity (µS/cm)	357	762	389	219	876	1009	227	442	1065	618	345	457	224	293	560	159	87.8	1000	<1000
TDS (mg/L)	215	458	233	131	526	605	136	265	639	371	207	274	134	176	336	95.4	52.7	500	500
Turbidity (NTU)	0	0	0	8	0	0	4	0	0	0	0	0	2	0	5	0	0	5	1
COD (mg/L)	4	20	8	13	28	22	12	53	10	6	11	10	12	8	10	8	10	<10	-
BOD (mg/L)	1.2	9.8	2.4	6.7	10.2	9.7	6.3	20.9	3.8	2.1	4.8	3	4.6	3.1	3.4	2.9	3.2	<2	-
Arsenic (mg/L)	0.013	0.011	0	0	0.021	0	0	0	0	0	0.003	0	0	0.011	0	0	0.004	0.01	0.01
Cadmium (mg/L)	0.002	0	0.003	0	0	0	0	0.002	0	0	0	0	0	0	0	0	0	0.003	0.003
Copper (mg/L)	0.106	0.053	0.049	0.165	0.075	0.105	0.065	0.065	0.115	0.06	0.16	0.054	0.044	0.092	0.06	0.074	0.045	1	5
Iron (mg/L)	0.01	0	0.03	0.07	0	0	0	0.14	0	0	0	0.03	0.1	0.08	0.1	0.14	0	0.3	0.3
Lead (mg/L)	0	0	0	0	0.274	0	0	0	0	0	0	0	0	0.242	0	0	0	0.01	-
Zinc (mg/L)	0.075	0.075	0.153	0.401	0.415	0.101	0.141	0.175	0.312	0.03	0.14	0.075	0.042	1.631	0.132	0.072	0.156	3	3
Chromium (mg/L)	0.034	0.031	0.047	0.04	0.03	0.028	0.032	0.028	0.03	0.031	0.026	0	0	0.035	0.035	0.029	0.032	0.05	-
Nickel (mg/L)	0.018	0.019	0.037	0.069	0.051	0.029	0.019	0.032	0.019	0.02	0.022	0.014	0.015	0.043	0.016	0.012	0.014	0.02	-
Manganese (mg/L)	0.381	0.148	0.546	0.597	0.618	0.497	0.297	0.145	0.532	0.385	0.355	0.648	0.448	0.403	0.549	0.748	0.256	0.2	0.1
Magnesium (mg/L)	3.66	13.4	14.6	20.7	32.9	12.2	7.32	8.54	10.9	9.76	25.6	4.88	7.32	21.9	47.6	30.5	6.1	20	-
Total Hardness (mg/L)	150	245	200	145	230	255	145	185	485	215	195	225	175	215	290	95	55	150	100
Bicarbonate (mg/L)	230	245	120	95	195	110	135	150	125	150	175	165	210	200	220	70	40	-	-
Nitrate (mg/L)	16.4	18.4	20.2	24.6	98.6	43.2	23.4	150	63.3	109	33.5	20.1	15.4	19.8	46.6	34.6	60	50	50
Phosphate (mg/L)	8.25	0.28	0.38	0.59	0.14	0.34	0.15	0.7	0.19	0.15	0.21	0.7	0.22	0.2	0.19	0.52	0.34	.1	.1
Sulphate (mg/L)	27	21	38	0	47	24	18	22	67	26	23	20	13	17	27	8	0	100	250
Sodium (mg/L)	15.3	35.8	27	13.5	45.6	87.5	12.1	19.2	34.2	33	18.7	21.7	7.8	19.1	15.6	14	5.9	200	200
Potassium (mg/L)	5.9	13.8	6.9	3.6	18.2	19	13	4.5	13.4	9.4	6.9	6.6	8.8	15.5	2.3	15.8	7	-	-
Total Coliform (cfu/mL)	334	361	571	0	3	0	218	0	0	1	2	0	41	21	51	38	0	0	0
E coli (cfu/mL)	116	164	284	0	0	0	124	0	0	0	0	0	16	8	18	20	0	0	0

Physicochemical Characteristics: The in-situ physicochemical parameters of the sampled water sources at **Table 2** below reveals that both natural and anthropogenic conditions influence the hydro-chemical environment. The pH values ranged from 6.40 to 9.01; with majority of the samples indicated values within permissible limits (6.5 - 8.5), by both the World Health Organization and the Nigerian Standards Organization. Slight deviations toward acidic (S05, S06) and alkaline (S07, S13) conditions, are indicative of localized geochemical controls, likely attributed to water–rock interactions occurring within the aquifer matrix.

Although slightly above the WHO desirable limit, temperature values (25.4–29.2°C) are consistent with tropical groundwater systems and fall within the NSDWQ acceptable range. Electrical conductivity (EC) values ranged between 92 and 1460 µS/cm, with S05, S06, and S09 showing exceedances. These elevated values, corresponds with increased salinity (47–730 mg/L), thereby suggesting higher ionic concentrations that may be attributed to mineral dissolution and possible anthropogenic sources, particularly from quarry-related activities. The comparative Chart of WHO/NSDWQ thresholds physicochemical properties of the sampled water sources is seen at **figure 6.**

Laboratory analysis of the samples, revealed turbidity exceedances in analysed samples, further indicative of the presence of dissolved suspended particulates, likely as a result of surface runoff infiltration and the vulnerability of shallow aquifer systems, particularly in hand-dug wells and the abandoned quarry pits. (See **table 1** above)

Table 2: Summary of In-situ Analysis (pH, Temperature, EC, and Salinity)

Parameter	**Observed Range**	**WHO Guideline**	**NSDWQ Standard**	**Interpretation**
pH	6.40 – 9.01	6.5 – 8.5	6.5 – 8.5	Most within limits. Slightly Acidic (**S05** @6.40℃, **S06** @6.41℃), and Alkaline (**S07**@9.01℃, **S13**@8.70℃) exceed guideline.
Temperature (°C)	25.4 – 29.2	<25 (desirable)	Ambient	**Within NSDWQ**; slightly above WHO's ideal. Tropical conditions plus shallow aquifers influence.
Electrical Conductivity (µS/cm)	92 – 1460	<1000	1000	S05, S06, S09 exceed both WHO & NSDWQ → high dissolved solids.
Salinity (mg/L)	47 – 730	~500 (derived from EC/TDS)	500	S05, S06, S09 exceed limit → potential taste/irrigation issues.

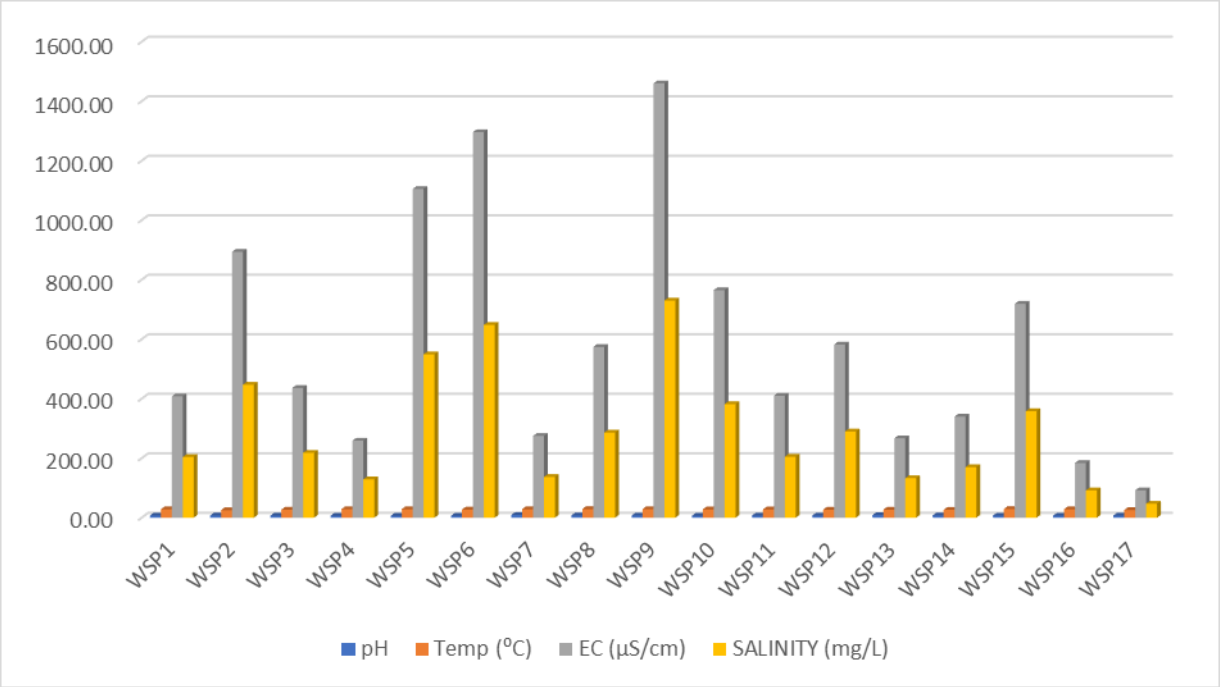


Figure 6: Comparative Chart of WHO/NSDWQ thresholds physicochemical properties of the sampled water sources.

Heavy Metal Distribution: The result of the heavy metal analysis at **Table 3**, indicates varying degrees of contamination across the study area. Lead (Pb) concentrations (ND–0.274 mg/L) significantly exceeded the permissible limit (0.01 mg/L) at S05 and S14, thereby posing serious public health concerns due to its cumulative toxicity. These elevated Pb levels are possibly associated with anthropogenic activities, which includes quarry operations and surface contamination pathways.

The concentrations of Manganese (Mn) from 0.145–0.748 mg/L, exceeded the recommended limits in several locations (S05–S16), indicative of both anthropogenic influences and geogenic contributions from manganese-bearing lithologies. While Arsenic (As) was generally low, it exceeded permissible limits at S05, therby indicating localized contamination with potential long-term health implications. The comparative chart of acceptable standards for Arsenic, Lead and Manganese is seen at **figure 7** while **figure 8** shows the comparative chart of acceptable standards for Arsenic and Manganese.

Chromium (Cr^{6+}) concentrations approached permissible limits but remained within acceptable thresholds, therby suggesting minimal but notable input from anthropogenic sources. Zinc (Zn), copper (Cu), and iron (Fe) concentrations were all within acceptable limits, ponting to limited contamination from these elements. Nickel (Ni) concentrations reached or exceeded the national standards in some samples, therby indicating mixed geogenic and anthropogenic origins.

Table 3: Summary of Analysis of key parameters on study area (Heavy Metals)

Parameter	**WHO/ NSDWQ Limit**	**Study Range / Key Sites**	**Exceedance**	**Remarks / Interpretation**
Chromium (Cr^{6+}) (mg/L)	0.05	0.026–0.047 (S3, S4, S15)	Borderline	Detected near threshold (Potentially from quarry machinery or industrial wastes.
Iron (Fe) (mg/L)	0.3	ND–0.14 (S8, S13)	No	Within limit; indicates oxidation of Fe-bearing rocks.
Lead (Pb) (mg/L)	0.01	ND–0.274 (S5, S14 high)	Yes	Notably high, far above limits, highly toxic, posing serious health risk (neurological, kidney damage).

				Source, linked to industrial residues and waste infiltration.
Manganese (Mn) (mg/L)	0.4	0.145–0.748 (S5–S16)	Yes	Widely elevated at S5–S16; quarry and geogenic influence.
Zinc (Zn) (mg/L)	3.0	0.042–1.631 (S14 high)	No	Generally, Within safe limit but unusually high at S14.
Copper (Cu) (mg/L)	2.0	0.044–0.165	No	Within acceptable range.
Arsenic (As) (mg/L)	0.01	ND–0.021 (S5)	Yes	Detected but low, slightly above limit at S5. chronic exposure risk.
Nickel (Ni) (mg/L)	0.07	0.012–0.069	Partial	Approaches limit; possible lithologic or anthropogenic source.

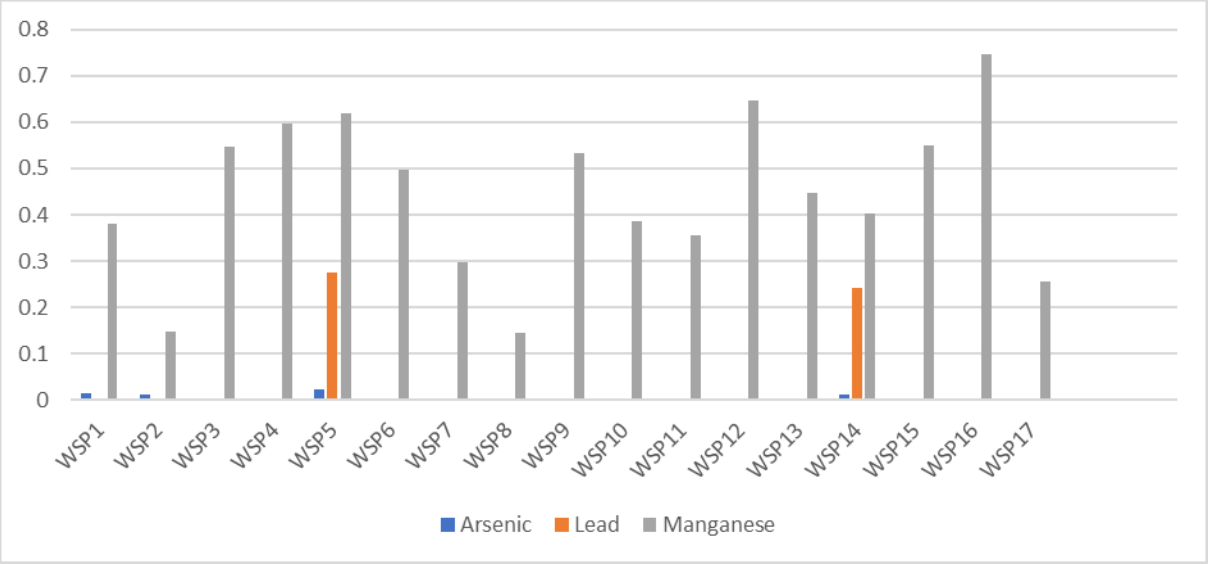


Figure 7: Comparative Chart of standards for Arsenic, Lead and Manganese

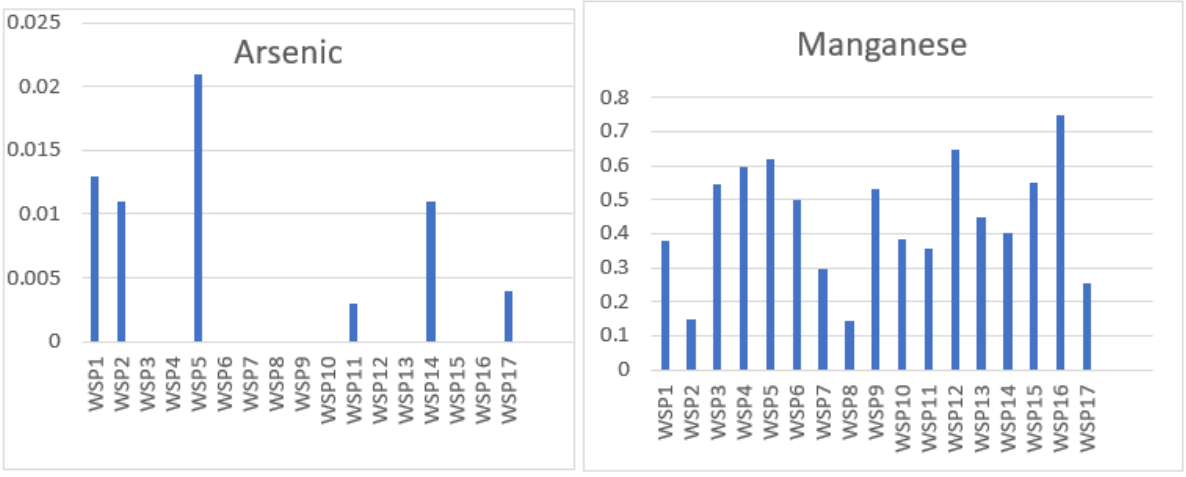


Figure 8: Comparative Chart of standards for Arsenic and Manganese

Microbiological Quality: The Microbiological analysis represented at **Table 4** points to significant contamination across several sampling points. Total coliform counts ranged from 0 to 571 cfu/100 mL,

while Escherichia coli ranged from 0 to 284 cfu/100 mL, both exceeding the zero-tolerance permissible limits as recommended by the World Health Organization and Standards Organisation of Nigeria. **Figure 9** also shows the comparative Chart of acceptable standards for Total Coliform and E.Coli

The presence of coliform bacteria and E. coli further indicates that these samples had faecal contamination, most likely as a result of septic tank leakage, poor sanitation practices, and possible direct surface infiltration into shallow groundwater systems. This is indicative of significant risk of waterborne diseases and also buttress the vulnerability of unprotected water sources.

Table 4: Summary of Analysis of key parameters on study area (Microbiological)

Parameter	**WHO/ NSDWQ Limit**	**Study Range / Key Sites**	**Exceedance**	**Remarks / Interpretation**
Total Coliform (cfu/100mL)	0	0–571 (S3, S2, S1 high)	Yes	Faecal contamination; unsafe for drinking.
E. coli (cfu/100mL)	0	0–284 (S3, S2, S1 high)	Yes	Indicates sewage or septic seepage into groundwater.

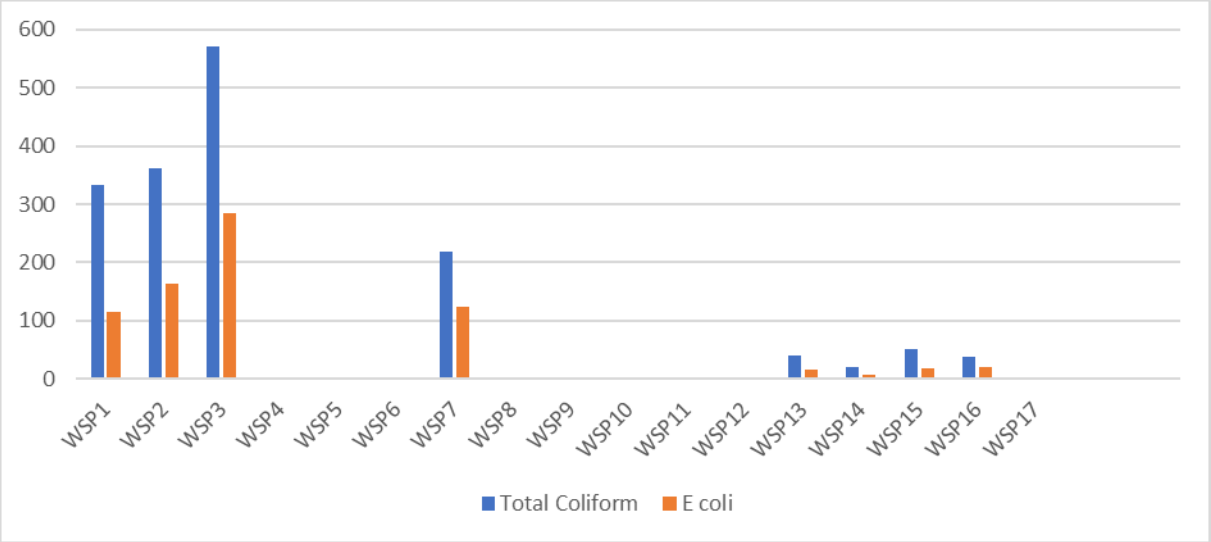


Figure 9: Comparative Chart of standards for Total Coliform and E.Coli

Correlation Analysis: The Pearson correlation matrix at **Figure 10** reveals significant relationships among key water quality parameters. The almost-perfect positive correlation between EC and TDS ($r \approx 1.00$) confirms that total dissolved solids are the primary contributors to electrical conductivity. Strong correlations among total hardness, calcium, and sulphate indicate a common geogenic origin linked to mineral weathering.

Moderate correlations between nitrate, turbidity, COD, and BOD suggest that nutrient enrichment is associated with organic pollution sources, likely from agricultural runoff and domestic waste. The association of Pb with As and Zn indicates a possible shared anthropogenic source, potentially linked to quarrying activities. The strong correlation between total coliform and E. coli ($r \approx 0.99$) confirms a common faecal source.

	Temp	pH	EC	TDS	Turbidity	COD	BOD	As	Cd	Cu	Fe	Pb	Zn	Cr	Nitrate	Mn	Ca	Mg	Total Hardness	Bicarbonate	Nitrate	Phosphate	Sulphate	Na	k	Cl	Total Coliform	E coli
Temp	1.00																											
pH	0.19	1.00																										
EC	-0.22	-0.35	1.00																									
TDS	-0.22	-0.35	**1.00**	1.00																								
Turbidity	0.06	0.03	-0.28	-0.28	1.00																							
COD	-0.22	0.33	0.26	0.26	-0.11	1.00																						
BOD	-0.17	0.35	0.26	0.26	-0.03	**0.98**	1.00																					
As	-0.45	0.06	0.20	0.20	-0.30	0.10	0.07	1.00																				
Cd	0.01	0.18	-0.13	-0.13	-0.22	0.21	0.15	0.00	1.00																			
Cu	0.18	-0.26	0.08	0.08	0.30	-0.09	-0.01	0.02	-0.15	1.00																		
Fe	0.15	0.34	-0.41	-0.41	0.24	0.29	0.25	-0.30	0.13	-0.13	1.00																	
Pb	**-0.57**	-0.14	0.16	0.16	-0.18	0.14	0.09	**0.75**	-0.16	0.01	-0.03	1.00																
Zn	0.01	-0.05	-0.08	-0.08	-0.01	-0.05	-0.06	0.37	-0.13	0.21	0.15	**0.74**	1.00															
Cr	0.07	-0.43	0.04	0.04	0.17	-0.05	-0.01	0.16	0.36	0.25	-0.13	0.11	0.24	1.00														
Nitrate	-0.32	-0.24	0.05	0.05	0.40	0.27	0.30	0.28	0.11	0.47	0.06	**0.50**	0.49	0.43	1.00													
Mn	-0.29	**-0.56**	0.08	0.08	0.18	-0.38	-0.43	-0.11	-0.16	0.17	0.19	0.16	0.02	-0.10	0.18	1.00												
Ca	0.27	0.03	**0.60**	**0.60**	-0.29	0.22	0.22	-0.24	0.05	0.16	-0.22	-0.21	-0.08	-0.28	-0.16	-0.12	1.00											
Mg	-0.27	-0.25	0.08	0.09	0.30	-0.03	-0.05	0.16	-0.26	0.17	0.33	0.36	0.21	0.30	0.23	0.44	-0.39	1.00										
Hardness	0.03	-0.24	**0.82**	**0.81**	-0.11	0.04	0.03	-0.04	-0.12	0.15	-0.22	0.07	0.10	-0.02	-0.03	0.14	**0.78**	0.13	1.00									
Bicarbonate	-0.11	**0.59**	0.24	0.24	-0.06	0.05	0.05	0.49	0.04	-0.09	-0.02	0.27	0.13	-0.22	-0.08	-0.23	0.12	0.15	0.30	1.00								
Nitrate	-0.15	-0.11	0.31	0.31	-0.23	**0.68**	**0.60**	0.02	0.11	-0.14	0.12	0.14	-0.10	0.09	0.11	-0.25	0.22	0.03	0.13	-0.14	1.00							
Phosphate	0.20	0.22	-0.13	-0.13	-0.12	-0.19	-0.21	0.34	0.46	0.17	-0.11	-0.12	-0.13	0.10	-0.12	-0.08	-0.07	-0.29	-0.18	0.30	-0.19	1.00						
Sulphate	-0.30	-0.32	**0.76**	**0.76**	-0.35	0.07	0.02	0.21	0.20	0.04	-0.35	0.22	0.00	0.13	-0.01	0.16	**0.63**	0.08	**0.83**	0.26	0.26	0.02	1.00					
Na	-0.29	-0.42	**0.81**	**0.81**	-0.31	0.26	0.28	0.13	-0.09	0.12	-0.40	0.16	-0.05	0.08	0.17	0.11	0.30	0.01	0.44	0.00	0.18	-0.14	0.41	1.00				
K	-0.40	-0.35	0.46	0.46	-0.41	0.05	0.08	0.37	-0.37	-0.04	-0.26	**0.50**	0.28	0.00	0.04	0.15	0.03	0.04	0.20	-0.05	-0.02	-0.24	0.27	**0.61**	1.00			
Cl	-0.36	-0.46	**0.97**	**0.97**	-0.27	0.25	0.24	0.26	-0.20	0.03	-0.42	0.28	-0.02	0.07	0.10	0.15	0.47	0.17	**0.74**	0.13	0.30	-0.22	**0.72**	**0.83**	0.55	1.00		
Total Coliform	-0.02	0.16	-0.08	-0.07	-0.10	-0.20	-0.17	0.15	**0.67**	-0.26	-0.22	-0.19	-0.18	0.40	-0.05	-0.18	-0.12	-0.19	-0.09	0.23	-0.41	0.35	0.15	-0.05	-0.09	-0.13	1.00	
E coli	-0.06	0.13	-0.09	-0.08	-0.07	-0.18	-0.15	0.08	**0.64**	-0.29	-0.21	-0.19	-0.17	0.41	-0.03	-0.17	-0.12	-0.18	-0.09	0.16	-0.39	0.22	0.14	-0.05	-0.06	-0.12	**0.99**	1.00

Figure 10: Pearson correlation matrix showing linear relationships amongst key parameters

Implications for Water Quality and Use: The integrated approach towards assessing the water quality, indicates that the majority of the water sources within the study area are unsuitable for direct consumption without being treatment. The contamination patterns reveals a combination of geogenic processes and anthropogenic influences, particularly from surrounding abandoned quarry activities, now act as conduits for contaminant accumulation and groundwater infiltration.

Conclusion

This study evaluated the physicochemical, heavy metal, and microbiological characteristics of groundwater and quarry water sources within the study area in Mpape. While nitrate, manganese, lead, and microbiological indicators exhibited significant exceedances, other parameters, such as pH, sulphate, sodium, and certain trace metals, remained within permissible limits.

The majority of the water sources are considered as unsafe for human consumption without any form of treatment, owing to the elevated concentrations of toxic heavy metals, such as lead, and the prevalent presence of E. coli and total coliform that were widespread across majority of the samples. These findings highlights both the influence of anthropogenic activities, particularly the abandoned quarry operations, and natural geological processes on groundwater quality.

Recommendations

To ensure safety and proper measures are put in place to mitigate the risk posed by groundwater contamination in the study area, the need for effective management of water resources in the study area, requiring immediate and well-coordinated interventions becomes essential. Therefore, water meant for home use should go through the proper treatment, such as disinfection and, where needed, heavy metal removal. Given that abandoned quarry sites currently act as conduits for pollutant infiltration into groundwater systems, these must be properly rehabilitated. Regular monitoring of water quality should be instituted to track changes over time and ensure compliance with established standards set by the World Health Organization and the Standards Organisation of Nigeria. In addition, improvements in sanitation infrastructure and waste management practices are essential to reduce faecal contamination of water sources. Regulatory agencies must also strengthen the enforcement of environmental guidelines governing mining and groundwater protection.

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Ref: A.26

İlgili makama;

ULUSLARARASI MEZOPOTAMYA BİLİMSEL ARAŞTIRMALAR KONGRESİ 04-05 Nisan 2026 tarihleri arasında Diyarbakır'da 17 farklı ülkenin akademisyen/araştırmacılarının katılımıyla gerçekleşmiştir. Kongre kapsamında sunumu yapılan 45 bildirinin 17 adeti Türkiye'den katılımcılar tarafından; 28 bildiri ise 16 ülkeden katılımcılar tarafından sunulmuştur. Kongre 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen "Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışında en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır." değişikliğine uygun düzenlenmiştir.

Bilgilerinize arz edilir,

Saygılarımla,

Sefa Salih BİLDİRİCİ
HEAD OF İSARC