ABSTRACT BOOK
CONFERENCE PROCEEDINGS

SCEE
SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING

ICWEES 2025

5th NUST Flagship International Conference

Water, Energy, and Environment for Sustainability

School of Civil and Environmental Engineering, SCEE
National University of Sciences and Technology (NUST), Pakistan

ABSTRACT BOOK

5TH NUST FLAGSHIP

INTERNATIONAL CONFERENCE ON

WATER, ENERGY, AND ENVIRONMENTAL SUSTAINABILITY

September 24-25, 2025

ICWEES 2025 -

Advancing Sustainability: Synergizing Built Environment, Water & AI

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING (SCEE)
NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY (NUST)

In collaboration with

EDITED BY

Dr. Iram Gul
Assistant Professor
Institute of Environmental Sciences and Engineering (IESE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)

Dr. Tayyaba Asim
Associate Professor
Institute of Environmental Sciences and Engineering (IESE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)

Dr. Hamza Farooq Gabriel
Professor
NUST Institute of Civil Engineering (NICE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)

LAYOUT AND COMPOSED BY:

Dr. Iram Gul
Assistant Professor
Institute of Environmental Sciences and Engineering (IESE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)

CONFERENCE SECRETARIAT

School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST), Islamabad

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PATRON-IN-CHIEF

- Prof. Dr. Muhammad Irfan, Principal & Dean (SCEE), NUST
  Email: pscee@nust.edu.pk

CONVENER

- Prof. Dr. Muhammad Arshad, Associate Dean, SCEE (IESE), NUST
  Email: marshad@iese.nust.edu.pk

FOCAL PERSONS

- Dr. Tayyaba Asim, Associate Professor, SCEE (IESE), NUST
  Email: tasim@iese.nust.edu.pk

- Dr. Zain Maqsood, HoD Research (SCEE), NUST
  Email: zmaqsood@nice.nust.edu.pk

ORGANIZING COMMITTEE

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• Dr. Hamza Farooq Gabriel	Professor, SCEE (NICE)
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• Dr. Muhammad Ali Tahir	HoD RS & GIS, SCEE (IGIS)
• Dr. Hamza Farooq Gabriel	Professor, SCEE (NICE)
• Dr. Khurram Yousuf	Associate Professor (ASAB

CONFERENCE THEMES

- AI-Driven Sustainable Solutions
- Climate Resilience and Environmental Sustainability
- GeoAI and Smart Cities
- Sustainable Built Environment
- Integrated Water Resources Management
- Water-Energy-Food-Ecosystem Nexus

PREFACE

It gives me immense pleasure to present the proceedings of the International Conference on Water, Environment, Energy, and Society (ICWEES-2025). With the theme "Synergizing Built Environment, Water & AI", the conference brings together researchers, practitioners, and policymakers to share knowledge and propose solutions to the urgent challenges of our interconnected world. Climate change, urbanization, and population growth have intensified pressures on water, energy, and environmental systems, as seen in recent devastating floods and rising vulnerabilities. These challenges underscore the need for innovative strategies, resilient planning, and collaborative action.

Emerging technologies such as artificial intelligence, big data analytics, remote sensing, and smart infrastructure are transforming disaster preparedness, resource efficiency, and urban planning. Yet, their impact depends on effective implementation through integrated policies and practices. The future demands that research and innovation translate into action for sustainable water management, energy security, and environmental resilience.

A sustainable built environment is vital to reducing emissions, conserving resources, and enhancing urban livability. Designing cities with energy-efficient systems, eco-friendly materials, and adaptive planning ensures resilience against climate risks while fostering healthier, greener communities. Equally important is strengthening climate resilience through low-carbon development, nature-based solutions, and policies that safeguard ecosystems and vulnerable populations.

Water remains central to survival and progress, but increasing demand and climate variability have made its sustainable management critical. Integrated approaches that balance consumption with conservation, protect watersheds, and promote recycling and reuse are essential to ensure food security, industrial growth, and healthy ecosystems. Closely tied to this is the water–energy–food–ecosystem nexus, where sustainability must be pursued through coordinated governance and cross-sectoral innovations.

AI, geo-intelligence, and smart-city solutions are opening unprecedented opportunities to optimize systems, reduce inefficiencies, and improve decision-making. From predictive modeling for disaster management to real-time monitoring of urban infrastructure, these tools can reshape how societies balance growth with ecological responsibility. Harnessing them wisely can accelerate our transition to a resilient and sustainable future.

I extend my gratitude to the contributors, reviewers, sponsors, and participants whose dedication has shaped this conference. Their collective efforts exemplify the spirit of collaboration that sustainability requires. It is my hope that the ideas shared in these proceedings will inspire meaningful actions, bold innovations, and enduring partnerships. Let this body of knowledge ignite curiosity, empower decision-makers, and encourage communities to work together in building a just, inclusive, and prosperous tomorrow.

Dr. Muhammad Irfan
Principal & Dean, School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)
Islamabad, Pakistan

MESSAGE BY CONFERENCE CONVENER

International Conference on Water, Energy, and Environmental Sustainability (ICWEES), organized by the School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Islamabad is a flagship conference started in 2021 and is being conducted on yearly basis, making this session the 5th one. This flagship conference has become a recognized platform where distinguished scientists, engineers, academicians, industry experts, policymakers, and young researchers converge to share knowledge and explore sustainable solutions for complex global challenges.

The themes of water, energy, and environment are deeply interconnected and central to sustainable development. With the accelerating impacts of climate change, growing population pressures, and rapid urbanization, societies are confronted with water scarcity, food and energy insecurity, environmental degradation, and ecosystem vulnerability. These challenges demand integrated, multidisciplinary, and innovative approaches. In this spirit, ICWEES fosters dialogue, inspires innovation, and strengthens partnerships for sustainable futures.

This year's conference features keynote addresses by eminent scholars and practitioners, technical sessions covering a wide spectrum of research areas, and interactive discussions to stimulate collaborative thinking. The contributions in this abstract book highlight cutting-edge research and emerging trends in water resource management, renewable energy systems, climate change adaptation, environmental remediation, and sustainable infrastructure development, all aligned with the United Nations Sustainable Development Goals (SDGs).

I am confident that the deliberations over these two days will enrich our collective understanding and generate actionable strategies for policy, practice, and research. I extend my deepest appreciation to our national and international invited speakers, guests, participants, and to the organizing team, sponsors, and volunteers whose dedication has made this event possible.

On behalf of the organizing team, I welcome you all to ICWEES 2025 and invite you to actively engage in the discussions, exchange ideas, and explore collaborations. May this conference inspire us to reaffirm our commitment to sustainable development and to work collectively toward safeguarding the planet for present and future generations.

Dr. Muhammad Arshad
Associate Dean, Institute of Environmental Science and Engineering (IESE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)
Islamabad, Pakistan

5th FLAGSHIP INTERNATIONAL CONFERENCE (ICWEES)

Advancing Sustainability: Synergizing Built Environment, Water & AI

24th - 25th September 2025

Venue – SCEE Seminar Hall

School of Civil and Environmental Engineering (SCEE),

National University of Science and Technology (NUST), Islamabad

Day/Date	Time	Activities	Contributor
Wednesday, 24th September 2025	0900 – 1000	**Registration (SCEE Entrance)**	
	1000-1010	**Recitation and National Anthem (SCEE Seminar Hall)**	
	1010 – 1020	**Opening remarks by Patron-in-Chief (SCEE Seminar Hall)**	**Dr. Muhammad Irfan (Principal and Dean SCEE)**
	1020-1030	**Welcome Address by Pro Rector**	
	1030-1045	**Address by the Chief Guest**	
	1045-1100	**Distribution of Shields and Group Photo**	
	Break 1100 – 1130		
	Key Note Address		
	1130 – 1200	Assessing the resilience of buried steel pipeline networks under seismic loading	**Prof. Dr. Muhammad Masood Rafi** (Professor & Chairman, Dept. of Earthquake Eng. NED University of Eng. & Tech. Karachi)
	1200-1220	Hydrogen as a Clean Energy Vector for Pakistan: Fundamentals, Techno-Economics, and Infrastructure Pathways	**Dr. Shahid Rasul** (Northumbria University | Founder, IONIST | Executive Director)

1220-1240		Sustainable management of municipal solid waste: environmental and economic analysis through the lens of decoupling method.	**Dr Anna Kurbatova** (Associate Professor, Institute of Environmental Engineering, RUDN University)
1240-1300		Role of trees in environmental amelioration and sustainability: case studies of agroforestry and urban forestry in Pakistan	**Dr. Muhammad Farrakh Nawaz** (Director, Associate Professor, Institute of Environmental Studies University of Karachi)
Lunch/Prayer break 1300 – 1400			
Presentations 1400 – 1630			
Technical Session 1			
Conference Chair: Prof. Dr Wajid Nasim Jatoi **Conference Co-Chair: Dr Khurram Yousaf**			**Hall-1**
1.	1400-1415	Artificial Pollination in Orchards: Scope and Future Challenges with Respect to Climate Change and Agrochemical Usage	**Dr. Tahir Iqbal** Chairman, Dept. of Farm Machinery & Precision Eng. UAAR, Pakistan
2.	1415-1430	Future risk assessment by estimating historical heat wave trends with projected heat accumulation using SimCLIM climate model in Pakistan	**Prof. Dr. Wajid Nasim Jatoi** Director ICCFS & Professor, Dept. of Agronomy, The Islamia University of Bahawalpur
3.	1430-1440	Multi-Method Computational Assessment of CO2 Adsorption on Pristine and Organosilane Modified MCM-41 Mesoporous Silica	**Rabbia Unain** SINES-NUST
4.	1440-1450	Optimizing Photocatalytic Degradation of Reactive Black 5 using Fluorescent Carbon Quantum Dots-Sensitized Titanium Dioxide Nanocomposites	**Eyman Karlal** CUI Abbottabad Campus
5.	1450-1500	Geo-Environmental Assessment of Active Deformation in the Hindu Kush Using Surface Dynamic Modeling for Sustainable Landscape	**Anam Munawar** Institute of Space Science, University of the Punjab, Lahore

		Management"	
6.	1500-1510	Towards a Climate-Resilient Hindukush: Assessing Environmental Stability in Northern Pakistan	**Amna Aslam** Institute of Geography, University of the Punjab, Lahore
7.	1510-1520	Designing Bacterial Cellulose–Nickel Ferrite Composites: Toward Efficient and Eco-Friendly CO_2 Adsorption	**Yasir Malik** CUI Abbottabad Campus
8.	1520-1530	Climate-Resilient Soil Restoration via Microbial-Assisted Phytoextraction	**Huma Mumtaz** SCEE (IESE)
9.	1530-1540	Advances and Challenges in the Implementation of Intelligent Drainage Systems for Urban Flood Mitigation: A Mini-Review of Practical Strategies in Pakistan's Local and Commercial Areas	**Hilal Khan** SCEE (IESE)
10.	1550-1600	Decoding Uplift and Erosion: A Remote Sensing and Geomorphic Analysis of the Nanga Parbat Haramosh Massif Zone	**Rukhsar Shahzadi** Institute of Space Science, University of the Punjab, Lahore
Poster Session: 1600-1630 **Panel of Judges** **1. Dr. Anna Kurbatova** **2. Dr. Shahid Rasul** **3. Dr. Muhammad Usman**			
Dispersal			
Technical Session 2			
Conference Chair: Dr. Nisar Ali Khan **Conference Co-chair: Dr. M Usman Hassan**			**Hall-2**
1.	1400-1415	Artificial Intelligence in Civil Engineering: From Automation to Augmentation for Sustainable Development	**Dr. Naveed Anwar (Online)** Adjunct faculty, Asian Institute of Technology, Founder and CEO, CSI Bangkok
2.	1415-1430	Study of the energy efficient building materials for Pakistan's construction industry	**Dr. Nisar Ali Khan** Dept. of Civil Eng., Islamic International Univ. Islamabad

	3.	1430-1440	Pose Based Detection of Physical Mobility Impairments via Modified HRNet	**Muhammad Saad** (NUST)
	4.	1440-1450	A Novel AI-Powered Edge–Cloud Dashboard for Bearing Fault Diagnosis	**Syed Maaz Hassan** SMME-NUST
	5.	1450-1500	A Deep Learning Framework for Real-Time Speed Violation Detection and Automated E-Challan Generation using YOLOv8, DeepSORT, and EasyOCR	**Javed Hussain Shar** Sindh Madressatul Islam University
	6.	1500-1510	Enhanced Visible Light-Driven Photodegradation of Reactive Yellow 145 Using Cu-Doped TiO_2 for Sustainable Textile Wastewater Treatment.	**Safdar Abbas Kazmi** CUI Abbottabad Campus
	7.	1510-1520	Optimization of a moving Bed Sequencing Batch Reactor for Treating Oil Refinery Waste Water	**Momina Maheen** (NUST)
	8.	1520-1530	Exploring Artificial Intelligence-Driven Sustainable Solutions for Climate Change: A Qualitative Thematic Analysis	**Dr. Fatima Abrar** Lahore Business School, The University of Lahore
	9.	1530-1540	Machine Learning-Enabled Retrofitting for Buildings: A Component-Specific Framework for Diverse Climates	**Asim Sultan (recorded lecture)** University of Rasul, Mandi Bahauddin
	10.	1540-1550	An IoT-Based Automated Air Cooling System for Safer Marine Engine Rooms	**Eesha Akhtar Iqbal** NUST (PNEC)
	11.	1550-1600	Development of ML based predictive model for the Co-Pyrolysis of Agricultural Biomass (Rice husk) and Plastic Waste (Polystyrene).	**Umer Aziz** University Of Engineering & Technology, Taxila
	Poster Session-1600-1630 **Panel of Judges** **1. Dr. Anna Kurbatova** **2. Dr. Shahid Rasul** **3. Dr. Muhammad Usman**			

Day/Date	Time	Activity	Contributor
		Dispersal	
Thursday, 25th September, 2025		Presentations 0930-1100	
		Technical Session 3	
		Conference Chair: Dr. Imran Azam **Conference Co-chair: Dr. Fouzia Perveen Malik**	**Hall-1**
	1. 0930-0945	Flood management in Pakistan with structural and non-structural measures under climatic extremes	**Dr. M Imran Azam** (Manager, Freshwater Water Stewardship and Replenishment WWF, Pakistan)
	2. 0945-1000	Ecosystem functioning, agriculture and food system sustainability	**Prof. Dr. Muhammad Arif Ali** Dept. of Environmental Sciences, Faculty of Science, Bahauddin Zakariya University, Multan
	3. 1000-1010	Eco-Innovative Photocatalytic Composites: Integration of GQD/TiO2 into Recycled Aggregate Concrete, for Pollutant Removal	**Nfor Elvis** CUI Abbottabad Campus
	4. 1010-1020	AI-Driven Retrofitting Strategies for Energy Efficiency in Healthcare Facilities	**Era Saeed** NUST
	5. 1020-1030	Sustainable Recovery of Copper, Aluminum and Lead from E-Waste Using Chemical Leaching, Precipitation and Electrowinning	**Hanzallah Abid** SCEE (IESE)
	6. 1030-1040	CFD Study of Iodine Removal in a Multi-Venturi Scrubber for Environmental Remediation	**Muhammad Bilal Niaz** Pakistan Institute of Engineering and Applied Sciences (PIEAS)
	7. 1040-	Salt-Enhanced	**Muhammad Younas Afzal**

	1050	Photocatalytic Degradation and Mineralization of RB5 Dye by Nickel Sulfide Nanoparticles: Insights from DLS and DFT Studies	CUI Abbottabad Campus
8.	1050-1100	GIS-Based Mapping and Analysis of Water-Stressed Communities Near Glacial Regions: A Case Study of Hunza Valley	**Hassan Ali** CUST-Islamabad
9.	1100-1110	In-situ Bio-decomposition of Crop Residue and its Effect on Soil Health and Brinjal Growth	**Syeda Mehak Hasnain** SCEE(IESE)
Break 1100-1125			
Technical Session 5			
Conference Chair: Dr. Muhammad Bilal **Conference Co-chair: Dr. Manzar Sohai**			**Hall-1**
	1130-1145	Understanding Photodegradation of Textile Dye Using NiS and ZnS Nanocomposite: Insights from Dynamic Light Scattering and Theoretical Modeling	**Professor Dr. Muhammad Bilal** (Dept. of Environmental Sciences, COMSATS University, Abbottabad Campus)
	1145-1155	Fauji Cement Decarbonization Levers and Challenges	**Naveed Ashraf Cheema** Manager HSE& Sustainability, Fauji Cement Company Limited.
	1155-1205	Nanoparticle Engineering for High-Efficiency, Stable Perovskite Solar Cells	**Dr. Ahson Jabbar Shaikh** CUI Abbottabad Campus
	1205-1215	Beyond the Grid: Decentralized Renewable Energy Solutions for Rural Pakistan	**Ibaad Ullah** (NUST)
	1215-1225	Navigating the Air Pollution Crisis: A Scientific and	**Dr. Zaeem Bin Babar** University of the Punjab, Lahore

		Policy Roadmap for Pakistan	
	1225-1235	Accident Analysis on Construction Sites in Pakistan: Causes and Prevention Strategies	**Muhammad Shahram Akbar (Recorded lecture)** (NUST)
	1235-1245	Traffic Congestion Prediction Using Ai and Machine Learning	**Bilal Awan presented by Muhammad Umar Waleed** UET Taxila
	1245-1255	Feasibility Investigation of Frictional Base Isolation Material For Masonry Buildings	**Imran Ullah** SCEE (NICE)
Lunch/Prayer Breal 1300-1400			
Technical Session 7			
Conference Chair: Prof. Dr. Muhammad Atiq ur Rehman Tariq Conference Co-chair: Prof. Dr. Imran Hashmi			**Hall-1**
1.	1400-14:15	Water Policy for a Sustainable Future: Key Challenges and Solutions	**Prof. Dr. Muhammad Atiq ur Rehman Tariq** (Director, CEWRE UET, Lahore)
2.	1415-1430	Assessing pollutant removal in municipal wastewater using indigenous floating treatment wetlands: a nature-based solution of wastewater treatment for agriculture	**Dr. Fiaz Ahmed** Associate Professor, BZU Multan (Dept. of Agricultural Engineering)
3.	1415-1425	Water Quality Assessment and Nature-Based Restoration of University Lakes	**Arooj Fatima** (NUST)
4.	1425-1435	An insight into the Role of Fibers and Issues in Advancing Sustainable Infrastructure with Engineered Cementitious Composites	**Waqas Malik** CUST-Islamabad

5.	1435-1445	Using machine learning models to predict the removal efficiency of an integrated constructed wetland (ICW) and assessing its water quality	**Shaiza Siddiqui** (NUST)
6.	1445-1455	Forecasting Groundwater Consumption for an Urban Environment Using Machine Learning Techniques	**Muhammad Usama** (NUST)
7.	1455-1505	Strategies for Water Savings and Agricultural Enhancements in support of the UAE Water Security Strategy 2036 and National Food Security Strategy 2051	**Khalil Ur Rehman Butt** Al Nakhli Sector, The Private Office of Ruler of Dubai. UAE
8.	1505-1515	Study on Water Foot Prints for Sustainable Water Resource Management in Agricultural Crop Production System	**Waqar Ahmed Pahore** Faculty of Agriculture Science, The University of Larkano
Technical Session 4			
Conference Chair: Dr. Hammad Majeed **Conference Co-chair: Dr. Shakeel Ahmed**			**Hall-2**
1.	0930-0945	Monitoring, modelling and performance evaluation of mar techniques for sustainable urban water resources	**Prof. Dr. Habib ur Rehman (Online)** Dean, Faculty of Engineering & Technology, University of Lahore
2.	0945-1000	AI Driven Industry 6.0 Intelligent Manufacturing for Textile Processing Circular Economy to Save Water & Energy	**Dr. Hammad Majeed** Head Of Chemistry, UMT Lahore
3.	1000-1010	Assessment of Micro plastics in Wetlands, with Physical and Chemical	**Iqra Younis** SCEE (IESE)

		Analysis of Water Quality Parameters	
4.	1010-1020	A Systematic Review of the Use of Ambient Vibration Analysis for Masonry Structures	**Muhammad Hamza** (NUST)
5.	1020-1030	Identification of Key Barriers to Construction 4.0 in Smart Cities: A case study from the construction industry of Pakistan.	**Maria Zulfiqar** National University of Technology (NUTECH)
6.	1030-1040	RSM-Guided Synthesis and Optimization of GQD/ZnO Nanoadsorbents for Efficient Removal of Textile Dye from Aqueous Solution	**Ayesha Arshad** CUI Abbottabad Campus
7.	1040-1050	Performance Evaluation of Acetone-Treated Expanded Polystyrene Angular Light Weight Aggregates for Rigid Pavements.	**Azan Hassan Khan** SCEE (NICE)
8.	1050-1100	Thermal-Hydraulic Performance Enhancement of Finned Plates Through the Placement of Geometrical Protrusions on Fin Edges: A Computational Study	**Zargham Ahmad** SMME-NUST
9.	1100-1110	Eco-Engineered Green Walls and Roofs: Low-Tech Plant-Based Solutions for Sustainable Urban Resilience in Semi-Arid Climates	**Abid Hussain (Recorded)** Thal University Bhakkar
10.	1110-1120	Assessment of Self-Cleaning Performance and Photocatalytic activity of Photocatalytic Concrete.	Maaz Khan Ghulam Ishaq Khan Institute of Engineering Sciences and Technology
Break 1120-1130			

Technical Session 6			
Conference Chair: Prof. Dr. M Shoaib Conference Co-chair: Dr Muhammad Usman			**Hall 2**
1.	1130-1145	Application of Machine Learning Approaches for Runoff Estimation: A Case Study from Pakistan	**Prof. Dr. M Shoaib** Professor & Chairman, FAS&T, BZU Multan (Dept. of Agricultural Eng.)
2.	1155-1205	Vibration Control through Nonlinear Vibration Absorbers	**Aqib Najeeb (Recorded lecture)** Tongji University, Shanghai, China.
3.	1205-1215	Greening Campuses: Carbon Footprint Analysis for an Educational Institution in Islamabad	**Sanober Sahar** Allama Iqbal Open University
4.	1215-1225	Sustainable Smart Car Parking Multistory Building	**Rizwan Ullah** Pakistan Institute of Engineering and Applied Sciences (PIEAS)
5.	1225-1235	Optimised Energy Dissipation in Buildings Using Efficient Base Isolation Systems: A Literature Based Analysis	**Syed Abbas Gillani** CUST-Islamabad
6.	1235-1245	Bioaccumulation of Heavy Metals in Native Plant Species: Implications for Environmental Sustainability	**Ayesha Safdar** University of Gujrat
7.	1245-1255	Ergonomics in Construction Industry: Evaluating Quick Postural Training Effectiveness for Bricklayers in Pakistan.	**Abdullah Adnan** (NUST)
Lunch/ Prayer Break 13:00-14:30			
Technical Sessiom-8			
Conference Chair: Prof. Dr. Hamza Farooq Gabriel Conference Co-chair: Prof. Dr. Fahim Khokhar			**Hall-2**

1.	1400-1415	Enhancing Disaster Resilience in Pakistan: A UNESCO-Inspired Approach to Water-Related Disaster Management	**Prof Dr. Shahbaz Khan (Online)** Director and UNESCO Representative to the People's Republic of China, the Democratic People's Republic of Korea, Japan, Mongolia and the Republic of Korea
2.	1415-1425	Spatiotemporal Trends in Precipitation and Their Implications for Water Security in Pakistan (1984–2024)	**Maria Bibi** SCEE (IESE)
3.	1425-1435	Microbiome-Guided Functional Foods: From Faecalibacterium duncaniae to Prevotella copri: A Platform for Sustainable Gut Health and Early Cancer Prevention	**Aamna Dilshad** ASAB-NUST
4.	1435-1445	Environmental and Metabolic Stimulants Enhance Quorum Sensing, Virulence, and Xanthan Gum Production in Xanthomonas campestris: Implications for Sustainable Industrial Fermentation	**Muhammad Abdullah** ASAB-NUST
5.	1445-1455	Exploring the Interactive Toxicity of Microplastics and Pathogenic Bacteria in Aquatic Organisms	**Mahnoor Akbar** SCEE (IESE)
6.	1455-1505	Assessing the Removal Efficiency of High-density Polyethylene Microplastics from Water Using Electrocoagulation	**Dr. Hira Amjad** Pakistan Navy Engineering College, NUST Karachi
7.	1505-1515	Bioavailable Fraction of Selected Antibiotics in Agricultural Soil and its Implication for Microbial Nitrogen Cycling	**Marium Fiaz** SCEE (IESE)

	Closing Ceremony & Prize Distribution 1515-1630		Hall-1
Day/Date	**Time**	**Activity**	**Contributor**
	1515-1530	Overview of the Conference Activities	**Prof. Dr. Muhammad Arshad** Associate Dean SCEE(IESE), Convener IC-WEES2025
	15-30-15-45	Address by the Sponsors	
	15-45-1550	Closing Remarks	
	1550-1620	Distribution of Shields, Certificates and Prizes	
	1620	Group Photo	
		Dispersal	

CONTENTS

ICWEES-S01

Sustainable Management of Municipal Solid Waste: Environmental and Economic Analysis Through the Lens of the Decoupling Method

A.I.Kurbatova[1], E.V.Savenkova[1], H.Abu-Qdais[2]
[1] RUDN University named after Patrice Lumumba, Moscow, Russian Federation
[2] Civil Engineering Department, Jordan University of Science and Technology, P.O.Box 3030, Irbid 22110, Jordan
Corresponding E-mail: savenkova-ev@rudn.ru; kurbatova-ai@rudn.ru

The sphere of municipal solid waste management has a significant impact on the environment. This includes greenhouse gas emissions, soil and water pollution, and depletion of natural resources. The Moscow Region, as one of the most urbanized regions of Russia, is facing a number of serious challenges in this area, from waste accumulation to the need for recycling and reducing the negative impact on the environment. The purpose of the study: Assessment of resource efficiency and environmental impact of the municipal solid waste (MSW) management industry in the Moscow Region using the decoupling method to identify the degree of economic sustainability of the MSW management system. As a result of the work, it was revealed that the decoupling index for the Moscow region in the period 2020-2021 is below 0 in two indicators, which indicates absolute decoupling, which is due to a decrease in the formation and, as a result, burial of MSW and indicates a clear mismatch. In the period 2021-2022 by volume MSW sent for burial in the Moscow region DI= -1.91 is an absolute decoupling, due to the absence of landfills by 2022, the launch of new waste sorting and processing complexes, and stricter requirements for waste disposal and the growth of recycling. But in terms of the volume of formed MSW decoupling is relative, DI= 0.11, which is associated with an increase in the formation of MSW volumes. In 2022-2023, there is an absolute decoupling in terms of the volume of MSW generated, which may be related to consumer behavior of the population due to deepening economic sanctions, but relative decoupling is observed for waste sent. It can be assumed that this growth is related to import substitution. Despite the existing burden, the Moscow Region is taking active measures to strengthen the environmental and economic sustainability of the waste management system, which creates the prerequisites for further achieving absolute separation and indicates the transition to a more rational, technological and environmentally oriented model.

ICWEES-S02

Hydrogen As a Clean Energy Vector for Pakistan: Fundamentals, Techno-Economics, And Infrastructure Pathways

Dr Shahid Rasul

Northumbria University, Newcastle Upon Tyne, UK

Corresponding E-mail: shahid.rasul@northumbria.ac.uk

Hydrogen, particularly when produced via low-carbon pathways such as water electrolysis powered by renewable energy, represents a promising vector for Pakistan's clean energy transition. This keynote explores the fundamental electrochemical principles underpinning hydrogen generation—including proton exchange membrane (PEM), alkaline, and solid oxide electrolyser cell (SOEC) technologies—and assesses their viability under Pakistan's solar-rich but grid-inconsistent landscape. A detailed techno-economic analysis will be presented, examining the levelized cost of hydrogen (LCOH) under varying assumptions for capital expenditure (CAPEX), electrolyser efficiency, capacity factors, and electricity price volatility. Cost-sensitivity to balance-of-plant components, stack degradation rates, and water availability will be discussed, alongside prospects for cost reduction through domestic manufacturing of electrolyser components. The talk will also evaluate hydrogen storage modalities—compressed gas, cryogenic liquid, and metal hydrides—alongside transport logistics and safety considerations. Sectoral integration opportunities, such as co-electrolysis of CO_2 and H_2O for synthetic fuels, green ammonia production, and hydrogen-enriched gas turbines, will be contextualized within Pakistan's industrial and agricultural economy. Finally, policy frameworks, regulatory gaps, and infrastructure challenges will be analysed, with recommendations for developing a coherent hydrogen strategy aligned with SDG 7 and national net-zero ambitions. The session aims to provide a technically grounded roadmap to position Pakistan as a regional hydrogen innovation hub through coordinated R&D, industrial synergies, and international collaboration.

ICWEES-S03

Artificial Intelligence in Civil Engineering: From Automation to Augmentation for Sustainable Development

Dr. Naveed Anwar

Asian Institute of Technology, Founder and CEO, CSI Bangkok

Corresponding Email: dr.naveedanwar@gmail.com

Artificial Intelligence (AI) is redefining civil engineering by shifting the paradigm from automating routine tasks to augmenting complex decision-making across the project lifecycle. This presentation explores the transformative impact of AI applications on civil infrastructure, focusing on how machine learning, computer vision, and intelligent sensing are embedded into design, construction, monitoring, and asset management processes. Through real-world examples and case studies, we demonstrate how AI enables predictive maintenance, seismic resilience assessments, structural health monitoring, and generative design optimization, thereby enhancing sustainability, safety, and performance of the built environment. Integration with digital twins, BIM-based simulations, and UAV-captured datasets showcases how AI serves as a catalyst for real-time, data-informed engineering practices. The session will address implementation challenges, data quality concerns, and the need for domain-informed AI models. It will also offer a forward-looking perspective on equipping the next generation of civil engineers with AI literacy, interdisciplinary thinking, and ethical frameworks to support sustainable and intelligent infrastructure systems.

ICWEES-S04

Harvesting Peace in a Changing Climate; Food security, Climate resilience, and the lessons from from the 2025 Pakistan Floods

Prof. Dr Shahbaz Khan

Director and UNESCO Representative to the People's Republic of China, the Democratic People's Republic of Korea, Japan, Mongolia and the Republic of Korea

Corresponding Email: s.khan@unesco.org

This paper examines the foundational nexus between food security and peace, a relationship now dangerously amplified by climate change. Conflict is the primary driver of global hunger, while food insecurity can catalyze the grievances that fuel violence. The devastating 2025 floods in Pakistan serve as a stark illustration of this amplified threat. Striking a nation already facing a "polycrisis" and acute food insecurity for 11 million people, the floods submerged Pakistan's agricultural heartland, causing an estimated $1.4 billion in damage and destroying up to 60% of the rice crop. This catastrophe displaced nearly two million people and disrupted the education of millions of children, planting the seeds of long-term instability. In response, this analysis advocates for a paradigm shift from reactive humanitarian aid to proactive, systemic resilience-building, highlighting the UNESCO approach. UNESCO's mandate addresses the root causes of vulnerability by developing the "software" of resilience: the human and institutional capacities built through science, education, and culture. On-the-ground actions in Pakistan, such as mobilizing emergency funds to protect flood-damaged World Heritage sites like Mohenjo-Daro, exemplify how preserving shared heritage reinforces social cohesion and contributes directly to peacebuilding. The paper concludes with a call for integrated action, positing that investing in climate adaptation, sustainable agriculture, and education is a core conflict-prevention strategy, essential for transforming the vicious cycle of disaster and conflict into a virtuous one of knowledge, resilience, and peace.

ICWEES-S05

Monitoring, Modelling and Performance Evaluation of Mar Techniques for Sustainable Urban Water Resources

HABIB-UR-REHMAN

Dean Faculty of Engineering and Technology, The University of Lahore

Corresponding E-mail: habib.rehman@ce.uol.edu.pk

The groundwater table in Lahore is rapidly declining due to the effects of increasing urban development and groundwater abstraction at unsustainable rates. The abstraction rate of groundwater in Lahore has increased to 1061 MGD (55.905 cumecs) in 2022 from 44.6 MGD (2.35 cumecs) in 1960. As managed aquifer recharge (MAR) has the potential to reduce this declining trend, two trial MAR schemes have been presented in this paper. First one is using four recharge wells was established at Junaid Jamshaid Stadium of UET Lahore. A flow meter and observation wells were installed for monitoring of groundwater recharge through the recharge wells and a numerical model was established to assess the effects of the recharge wells on depletion rates. Before the installation of recharge wells, the average depletion rate for groundwater was 0.87 m per year, of which the rate was - 0.074 m per was in summer season and 1.05 m per winter season. After installing the recharge wells, the model showed that the average depletion rate for groundwater was 0.72 m per winter season based on the 2-month data that showed the reduced depletion rate due to the installation of large diameter recharge wells. Then, scenario modelling was carried out using the same rainfall data for both the cases, i.e., without and with recharge wells. It was analyzed that the depletion rate could be reduced by 16.45% and 39.24% by installing four and ten recharge wells, respectively. The study underlines the importance of groundwater recharge through large diameter recharge wells to reduce the depletion rate of Lahore's aquifer. Another MAR technique used was the infiltration galleries to accelerate the groundwater recharge. In order to complete the research, temporal distribution was plotted on ArcMap. HEC-HMS was used for the calculation of discharges which were verified with analytical methods. Groundwater model prepared on Visual MODFLOW was calibrated and validated. The results indicate that due to groundwater overexploitation water levels continue to decrease with the passage of time. The average simulated water table decline is 1.1 meter per year in the study area. So, in order to

overcome this crisis, infiltration galleries were proposed and designed in the study area. It was seen that these infiltration galleries allow recharging the groundwater at better rate. As the model results showed that depletion rate of groundwater reduces and the groundwater level is about 0.3m higher when there are infiltration galleries. At the end a survey results about the working status of all recharging wells installed in Lahore are presented.

ICWEES-S06

Water Policy for A Sustainable Future: Key Challenges and Solutions

Muhammad Atiq ur Rehman Tariq

Director, CEWRE UET, Lahore

Corresponding E-mail: atiq.tariq@cewre.edu.pk

Water is a vital resource, yet we face many challenges in managing it effectively. This lecture will focus on the importance of water policy in ensuring sustainable water use, addressing water scarcity, and promoting equitable access for all. We will discuss the role of government policies, the importance of sound management strategies, and the need for coordinated efforts between policymakers, scientists, and society. Key points to be covered:

- **The Need for Effective Water Policies**: Understanding the importance of having clear, comprehensive policies to manage water resources sustainably.
- **Addressing Water Scarcity**: How policies can help manage limited water resources and reduce the impact of water scarcity on agriculture, industry, and daily life.
- **Water Distribution and Equity**: Ensuring that water resources are distributed fairly, especially in regions that face chronic water shortages.
- **Integrating Climate Change into Water Policy**: How water policies must adapt to the changing climate to ensure long-term water security.
- **Collaboration for Better Water Management**: The role of various stakeholders, including government bodies, local communities, and industries, in improving water management and policy enforcement.

ICWEES-S07

Assessing The Resilience of Buried Steel Pipeline Networks Under Seismic Loading

Muhammad Masood Rafi, Muhammad Saim, Aslam Faqeer Mohammad, Camillo Nuti, Alessandro Rasulo

Department of Earthquake Eng. NED University of Eng. & Tech. Karachi

Corresponding Email: rafi-m@neduet.edu.pk

Buried steel pipelines are vital for energy transportation but are vulnerable to seismic-induced ground movements, posing serious risks to public safety and infrastructure reliability. This study evaluates the seismic vulnerability of buried pipelines using incremental dynamic analysis, focusing on how pipe geometry, burial depth, soil type, steel grade and branching configurations influence seismic performance. Results show that lower diameter-to-thickness ratios, higher-grade steels (X60-X70) and stiffer soils enhance seismic resilience. Shallow burial depths reduce strain concentrations, while branching (especially at acute angles) increases vulnerability at junctions. Fragility functions developed through logistic regression capture the combined effects of these parameters, offering a robust framework for seismic risk assessment. The findings are particularly relevant for expanding gas networks in seismically active regions like Pakistan, and can inform design, retrofitting and disaster planning efforts by infrastructure agencies and regulatory bodies. This work supports the development of more resilient underground energy networks in earthquake-prone areas.

ICWEES-S08

Study of the Energy Efficient Building Materials for Pakistan's Construction Industry

Nisar Ali Khan

Department of Civil Engineering, Faculty of Engineering & Technology, International Islamic University, Islamabad 44000, Pakistan

Corresponding E-mail: nisar.ali@iiu.edu.pk

The increase in the popularity of using environmentally friendly, low cost and light weight construction materials in building industry has brought about the need to investigate how this can be achieved by benefiting the environment as well as maintaining the material requirements affirmed in standards. Recycling of waste generated from industrial and agricultural activities as building material appears to be viable solution to such pollution problem but also to the problem of economic design of the building. Bricks are widely used in construction and building material around the world. This project attempts to develop bricks from waste materials that are present in the environment without causing any damage to the environment. The main objective of this project is to prepare bricks by using the waste materials and to conduct field and laboratory tests on them. The bricks are prepared by using waste materials like coconut fiber, rice husk, fly ash, tea waste, corn husk and sugarcane straw ash as an additive to the clay.

ICWEES-S09

Artificial Pollination in Orchards: Scope and Future Challenges with Respect to Climate Change and Agrochemical Usage

Tahir Iqbal

Dept. of Farm Machinery & Precision Eng. UAAR, Pakistan

Corresponding E-mail: tahir.iqbal@uaar.edu.pk

Artificial pollination is becoming increasingly vital in modern orchard management as a response to declining natural pollinator populations and the need for reliable crop yields. This study examines various artificial pollination techniques, including manual, mechanical, and UAV-based methods, assessing their efficiency, scalability, and environmental impact. Special attention is given to challenges posed by climate change and agrochemical use, both of which threaten pollination success. The paper integrates empirical research and statistical analyses to highlight the efficacy of different pollination methods. Findings suggest that UAV-based pollination offers precision and scalability but requires improvements in pollen viability and regulatory approval. Moreover, emerging technologies such as AI-driven pollination systems, pollen viability enhancers, and electrostatic pollination techniques are discussed. The study concludes that integrating artificial intelligence, robotics, and sustainable agricultural practices will be essential for long-term artificial pollination success. Additionally, interdisciplinary collaboration among agronomists, engineers, and environmental scientists is necessary to develop adaptive strategies for artificial pollination.

ICWEES-S10

Flood Management in Pakistan with Structural and Non-Structural Measures Under Climatic Extremes

*M. Imran Azam, Masood Arshad, Sohail Ali Naqvi, Sajjad Ahmed **

**WWF-Pakistan inside Ali Institute of Education Ferozpur Road, Lahore Pakistan*

Corresponding E-mail: miazam@wwf.org.pk

In Pakistan, haphazard city development is a major issue that contributes to a number of severe problems, particularly urban floods. Every year during the monsoon season, flooding causes serious destruction throughout the country. Climate change is causing severe floods, which are exacerbated in Upper Indus Basin (UIB) by glaciers melting and extreme events in the lower part of the country. When compared to the 30-year average, Pakistan's rainfall during the most recent monsoon was 67% above normal. This led to flooding and landslides, which had detrimental effects on infrastructure, human life, and property. Both structural and non-structural flood prevention solutions need to be developed in Pakistan. Flood Mapping along the whole Indus River and its tributaries (Swat, Kabul, Panjkora etc) restricting/prohibiting by law permanent settlements in high and medium flood risk areas. We must strengthen our ability to protect and manage floods in the country, including the restoration of existing wetlands, wise urban development planning, better preparedness and relief services, and increased coordination between the various provincial and federal departments involved in water management and flood protection.

ICWEES-S11

Role of Trees in Environmental Amelioration and Sustainability: Case Studies of Agroforestry and Urban Forestry in Pakistan

Muhammad Farrakh Nawaz[1,2], Sadaf Gul[3], Ghulam Yasin[4], Shazia Afzal[4], Muhammad Asif[2], Muhammad Azeem Sabir[5] and Muhammad Talha Bin Yousaf[6]*

[1]Institute of Environmental Studies, University of Karachi, Karachi.

[2]Department of Forestry and Range Management, University of Agriculture, Faisalabad

[3]Department of Botany, University of Karachi, Karachi

[4]Department of Forestry and Range Management, Bahauddin Zakariya University, Multan

[5]Institute of Forest Sciences, The Islamia University of Bahawalpur, Bahawalpur

[6]Department of Forestry, College of Agriculure, University of Sargodha, Sargodha

***Corresponding Email**: kf_uaf@yahoo.com

Trees are integral part of diverse ecosystems and they play a very crucial role in environmental amelioration. Economically, they are only given worth for the production of wood and non-wood products, however, their environmental services, which are difficult to quantify, are more valuable than salable products, particularly, in degraded environments. This study is summary of several doctoral studies to quantify the role of trees in agroforestry and urban environments. Several studies were carried in field, pot experiments and under controlled hydroponic conditions. It was observed that trees can sequester atmospheric carbon from 0.5 to 3 MgC/ha and can play major role in climate change mitigation. Trees in urban environments significantly reduce the levels of particulate matter, dust, noise and other harmful gases. In the case of marginal sandy soils, it was observed that trees only stabilized the soils and reduced the sand dunes but also improved the soil health by increasing the nutrients availability. However, in case of compacted soils, trees reduced the compactness of soils. Furthermore, it was observed that trees efficiently remediated the soil through phyto-extraction of heavy metals and lowering of soil salinity. However, it was observed that trees vary in their capability of providing services depending upon trees species, tree density, and soil and climatic conditions. So, selection of appropriate tree species for a sleeted site play a significant role in objective oriented results.

ICWEES-S12

Understanding Photodegradation of Textile Dye Using Nis and ZnS Nanocomposite: Insights from Dynamic Light Scattering and Theoretical Modeling

Muhammad Bilal[1], Muhammad Younas Afzal2, Hamza Khan2, Nadia Riaz[1], Muhammad Saqib Khan3, Ahson Jabbar Shaikh[1]*

1Department of Environmental Sciences, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, Pakistan

2Department of Chemistry, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, Pakistan

3Department of Biomedical Sciences, Pak-Austria Fachhochschule: Institute of Applied Sciences and Technology, Haripur, Pakistan

Corresponding Email: Prof. Dr. Muhammad Bilal: +92 333 5411536; mbilal@cuiatd.edu.pk

This study reports the synthesis and comprehensive characterization of pure NiS, ZnS, and their nanocomposite NiS-ZnS via chemical precipitation and co-precipitation methods, optimized through control of salt concentrations and experimental parameters. A 50:50 nanocomposite was synthesized to achieve stability and enhanced photocatalytic performance. The influence of precursor salt ratios, pH, temperature, sodium sulfide addition timing, and stabilizer concentration on nanocomposite formation was systematically investigated. X-ray diffraction analysis revealed average crystallite sizes of 21.63 nm for NiS, 3.19 nm for ZnS, and 12.99 nm for the nanocomposite. Scanning electron microscopy showed agglomerated NiS nanoclusters, spherical ZnS particles, and a combination of morphologies in the nanocomposite. BET surface area measurements indicated mesoporosity with a surface area of 65.3 m^2/g. Optical characterization (UV-Vis absorption and photoluminescence spectroscopy) confirmed the successful synthesis of the nanoparticles and nanocomposite, with an indirect band gap of 2.95 eV derived from Tauc's plot. The photocatalytic activity was evaluated under visible light irradiation, demonstrating significant degradation of non-azo dye crystal violet. The degradation efficiency was assessed in the presence of various salts (NaCl, $CaCl_2$, Na_2SO_4, $NaNO_3$, $AgNO_3$) and organic scavengers. Dynamic light scattering (DLS) measurements tracked changes in hydrodynamic radius (HR) and zeta potential of the nanocomposite during dye degradation in different salt media, confirming

interactions between the nanocomposite and dye molecules and elucidating degradation mechanisms. Theoretical investigations supported experimental findings, providing insights into charge transfer processes and surface interactions. Overall, the NiS-ZnS nanocomposite exhibits promising photocatalytic potential for dye remediation applications.

ICWEES-S13

Ecosystem Functioning, Agriculture and Food System Sustainability

Muhammad Arif Ali[1,2]

[1]*Department of Environmental Sciences, Bahauddin Zakariya University Multan*

[2]*Department of Soil Science, Bahauddin Zakariya University Multan*

Corresponding E-mail: arif1056@bzu.edu.pk

Urbanization is one of the major threats to soil resources. With the passage of time, an increased population in urban settings is generating sewage wastewater. Such wastewater is discharged untreated in the peri urban areas without prior treatment. In this way heavy metals concentrations like chromium are increasing in these soils. The high concentrations of metals create problems both by changing soil ecosystem and ecosystem functioning which includes microbial population and their functions. Similarly, climate change induced abiotic stresses are also significantly affecting the biological functioning of the soil. Soil organisms thus need strict supervision to function. Soil mixing is one of the strategies to increase microbial biodiversity to improve soil health and plant productivity. Microorganisms like mycorrhizae are used to evaluate its functions and effectiveness to help the plant in acquiring mineral nutrients.

ICWEES-S14

Ai Driven Industry 6.0 Intelligent Manufacturing for Textile Processing Circular Economy to Save Water & Energy

Hammad Majeed

Department of Chemistry, UMT Lahore

Corresponding E-mail: dyeing@gmail.com

The textile industry, responsible for approximately 93 billion cubic meters of annual water consumption and 10% (1.07 billion tons) of global carbon emissions, responsible for waste fabric dumping landfilling, faces urgent demands to adopt circular economy models to mitigate water scarcity, energy overuse, and climate impacts. The bridges among Industry 6.0 frameworks with AI, IoT, blockchain, and cyber-physical systems, with circular economy principles to redefine textile processing sustainability. By integrating AI driven predictive analytics, manufacturers can reduce water use by 30 to 50 % in dyeing and finishing, while machine learning optimized heat recovery systems can lower energy demand by 25 to 40 %. Industry 6.0's digital twin technology enables real time simulation of closed loop systems and AI-guided wastewater treatment (enhancing reuse rates to 70 to 80 %). Close loop water can reuse mercerizing discharge as a feed water for bleaching and scouring process. AI powered waste sorting with 99% fabric- type identification accuracy, and supercritical CO_2 dyeing creates a climate-resilient, circular textile economy. quantum computing and nanotechnology are enhancing material science innovations for lower-impact fiber production. Blockchain ensures traceability of recycled inputs, aligning with SDG 12 (Responsible Consumption) and SDG 6 (Clean Water). Intelligent manufacturing further supports SDG 7 (Affordable Energy) through renewable energy microgrids powered by AI demand forecasting, reducing grid reliance by 35 %. Case studies highlight textile mills, which reduced freshwater withdrawals by 50 % using IoT sensors. Cross disciplinary science, from biocatalysis to nanofiltration membranes (90 % salt rejection for zero liquid discharge) demonstrates the role of applied sciences in scaling CE solutions. This paradigm shift could save more than 230 trillion liters of water and 1.5 gigatons of CO2 annually by 2030, directly advancing SDGs 6, 7, 9, 12, and 13. The fusion of Industry 6.0, AI, and circular economy positions the textile sector as a leader in planetary stewardship while fostering economic resilience. Our prime focus is net zero carbon

emission, net zero water wastage, net zero trash, hyper automation, use of AI in all fields with customized user and ecofriendly sustainable industrial production.

ICWEES-S15

Assessing Pollutant Removal in Municipal Wastewater Using Indigenous Floating Treatment Wetlands: A Nature-Based Solution of Wastewater Treatment for Agriculture

Fiaz Ahmad

Department of Agricultural Engineering, Bahauddin Zakariya University, Multan 60800, Pakistan

Corresponding E-mail: fiazahmad@bzu.edu.pk

A pilot-scale floating treatment wetland (FTW) system was designed, built, and run continuously for municipal wastewater treatment with native macrophyte. The FTW system was evaluated based on the removal efficiency of pollution indicators such as chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), electrical conductivity (EC), total phosphorus (TP), total nitrogen (TN) and sulphates. The optimal COD, BOD, TSS, TN, and TP removal rates for Common Read supported on floating mats in a single step were 74.9%, 74.8%, 79.4%, 38.04%, and 35.3%, respectively. Effluent criteria for COD, BOD, TSS, and TDS were satisfied under optimum settings. The evaluation of wastewater treatment parameters in the FTW can provide useful information for improving removal efficiency and water quality. The findings imply that native macrophyte in the FTW may be able to treat municipal wastewater to provide eco-friendly effluent.

ICWEES-S16

Future Risk Assessment by Estimating Historical Heat Wave Trends with Projected Heat Accumulation Using Simclim Climate Model in Pakistan

Wajid Nasim Jatoi [a,b,c,d,], Asad Amin [a], Shah Fahadd [e]*

[a] Department of Environmental Sciences, COMSATS Institute of Information Technology, Vehari 61100, Pakistan

[b]CIHEAM-Institute Agronomique Mediterraneen de Montpellier (IAMM), Montpellier 34090, France

[c] CSIRO Ecosystems Sciences and Sustainable Agriculture Flagship, Toowoomba, QLD 4350, Australia

[d]Department of Agronomy, Faculty of Agriculture & Environment, The Islamia University of Bahawalpur (IUB), Pakistan

[e]Department of Agriculture, The University of Swabi, Pakistan e College of Plant Science and Technology, Huazhong Agricultural University, Wuhan, Hubei, China

Corresponding E-mail: wajidnaseem2001@gmail.com

Climate change has adverse effects at global, regional and local level. Heat wave events have serious contribution for global warming and natural hazards in Pakistan. Historical (1997–2015) heat wave were analyzed over different provinces (Punjab, Sindh and Baluchistan) of Pakistan to identify the maximum temperature trend. Heat accumulation in Pakistan were simulated by the General Circulation Model (GCM) combined with 3 GHG (Green House Gases) Representative Concentration Pathways (RCPs) (RCP-4.5, 6.0, and 8.5) by using SimCLIM model (statistical downscaling model for future trend projections). Heat accumulation was projected for year 2030, 2060, and 2090 for seasonal and annual analysis in Pakistan. Heat accumulation were projected to increase by the baseline year (1995) was represented in percentage change. Projection shows that Sindh and southern Punjab was mostly affected by heat accumulation. This study identified the rising trend of heat wave over the period (1997–2015) for Punjab, Sindh and Baluchistan (provinces of Pakistan), which identified that most of the meteorological stations in Punjab and Sindh are highly prone to heat waves. According to model projection; future trend of annual heat accumulation, in 2030 was increased 17%, 26%, and 32% but for 2060 the trends were reported

by 54%, 49%, and 86% for 2090 showed highest upto 62%, 75%, and 140% for RCP 4.5, RCP-6.0, and RCP-8.5, respectively. While seasonal trends of heat accumulation were projected to maximum values for monsoon and followed by pre-monsoon and post monsoon. Heat accumulation in monsoon may affect the agricultural activities in the region under study

ICWEES-S17

Application of Machine Learning Approaches for Runoff Estimation: A Case Study from Pakistan

Prof. Dr. Muhammad Shoaib

Department of Agricultural Engineering, Bahauddin Zakariaya University, Multan-Pakistan

Corresponding E-mail: muhammadshoaib@bzu.edu.pk

Accurate surface runoff estimation is critical for planning and designing various water resource infrastructure and management strategies, such as flood control systems, urban stormwater drainage, sewer network design, agricultural irrigation planning, and integrated watershed management. The rainfall-runoff transformation process is intrinsically complicated and nonlinear, driven by a wide range of interacting hydrological, meteorological, and geomorphological variables. These include precipitation intensity and duration, soil infiltration capacity, land use patterns, slope features, evapotranspiration rates, and the dynamic interactions of surface and groundwater. Traditional hydrological models for simulating this transformation process can be broadly classified into physically based models and data-driven models. Physically based models attempt to simulate hydrological processes using the principles of fluid dynamics and mass conservation. While these models offer valuable insights into the underlying physics of runoff generation, they often require extensive spatial and temporal datasets, detailed parameterization, and significant computational resources. This makes their application challenging, particularly in data-scarce regions such as many parts of Pakistan. In contrast, data-driven approaches, particularly those based on machine learning (ML) and artificial intelligence (AI), have emerged as powerful tools for hydrological modeling in recent years. These methods are capable of learning complex nonlinear relationships directly from historical data without requiring explicit knowledge of the physical processes involved. ML techniques are especially well-suited for runoff estimation due to their adaptability, accuracy, and ability to handle noise and missing data. This study focuses on the application and comparison of various machine learning and deep learning algorithms for runoff prediction using historical rainfall and hydrological data from a selected catchment in Pakistan. The goal is to evaluate the effectiveness and accuracy of these models in capturing the

rainfall-runoff dynamics under local hydrological conditions. The models evaluated in this study include:

• Feed-Forward Neural Network (FFNN): A basic form of artificial neural network where connections between nodes do not form cycles, widely used for regression and classification tasks.

• Long Short-Term Memory Neural Network (LSTM-NN): A type of recurrent neural network (RNN) specifically designed to model sequential data and temporal dependencies, making it highly effective for time-series prediction.

• Adaptive Neuro-Fuzzy Inference System (ANFIS): A hybrid intelligent system combining the learning capabilities of neural networks with the fuzzy logic approach to model complex systems.

• Decision Tree-based Models:

o Fine Tree (FT), Medium Tree (MT), Coarse Tree (CT) – Variants of decision trees differing in granularity and depth.

o Single Decision Tree (SDT) – A basic tree model for classification or regression.

o Tree Boost (TB) – An ensemble technique that builds multiple trees sequentially to improve performance.

o Decision Tree Forest (DTF) – A bagging approach that builds multiple trees in parallel and aggregates their predictions for improved accuracy and generalization.

The performance of each model is evaluated using appropriate statistical metrics such as the Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Nash-Sutcliffe Efficiency (NSE). The study provides comparative insights into which models perform best under local conditions and highlights the potential of ML approaches as viable tools for hydrological forecasting in Pakistan. By leveraging modern data-driven methods, this research aims to contribute to more reliable, cost-effective, and scalable runoff prediction techniques, ultimately supporting better decision-making in flood risk management, agricultural planning, and sustainable water resources development in semi-arid and monsoon-prone regions.

ICWEES-01

Pose Based Detection of Physical Mobility Impairments via Modified HRNet

Muhammad Saad Salahuddin, Imran Usman

Department of Computer Science, National University of Sciences and Technology (NUST), Pakistan

Corresponding E-mail: msaadsalahuddin8@gmail.com

Our method supports AI-driven urban sustainability by offering a low cost, contactless approach for identifying individuals with physical impairments in public infrastructure. This can aid in evaluating barrier free access and inclusive design in cities and campuses. We propose a pose-based framework for detecting physical mobility impairments using RGB video from public or semi-structured environments. In contrast to prior works focused solely on wheelchair detection, our method aims to identify a wider spectrum of mobility limitations such as joint stiffness, asymmetrical gait, and nonstandard postures. The system comprises of a modified High-Resolution Network (HRNet) with dual branch processing to handle both standing and seated individuals while preserving spatial accuracy in pose estimation. This design allows for general purpose detection of visible movement impairments without relying on wearables or depth sensors. The method is intended for integration with existing surveillance or monitoring systems to support accessibility audits in smart city environments. We demonstrate the feasibility of our approach through preliminary experiments on a small set of curated video clips simulating urban conditions.

ICWEES-02

A Novel AI-Powered Edge–Cloud Dashboard for Bearing Fault Diagnosis

Syed Maaz Hasan

Corresponding E-mail: maaz.hasan@smme.nust.edu.pk

This study introduces an innovative AI-Enhanced Edge–Cloud Dashboard for Bearing Fault Diagnosis, which amalgamates real-time vibration data collection, edge machine learning, and cloud-based deep learning into a cohesive predictive maintenance framework. At the edge layer, a Raspberry Pi-based client, integrated with an ADC, conducts high-frequency signal sampling, implements Fast Fourier Transform (FFT) for feature extraction, and executes lightweight Random Forest (RF) and Support Vector Machine (SVM) models via ONNX runtime for low-latency fault classification. Processed features, raw references, and prediction outcomes are conveyed by JSON to a cloud-based PHP API on a Hostinger VPS, supported by a MySQL database. Convolutional neural networks (CNNs) are used at the cloud layer for advanced diagnostics. These networks are trained and validated using bearing vibration datasets to produce train and validation loss metrics for assessing model performance. Continuous condition monitoring and early problem identification are made possible by a web-based dashboard that shows real-time trends, fault probability, and quick-summary analytics. This two-pronged strategy offers a scalable and effective solution for predictive maintenance on rotating machinery by fusing the precision of cloud-based deep learning with the responsiveness of edge analytics.

ICWEES-03

AI-Driven Retrofitting Strategies for Energy Efficiency in Healthcare Facilities"

Era Saeed[1], Asim Sultan[2], Muhammad Atif Javed[1], Dr. Nafeesa Sultan[1]

[1]National University of Technology, Islamabad, Pakistan

[2]Univeristy of Rasul, Mandi Bahauddin, Pakistan

Corresponding E-mail: erasaeed159@gmail.com

Hospitals in Pakistan are among the highest energy consumers due to their continuous operations. Conventional retrofitting approaches fail to process complex data and to provide climate responsive solutions. This study integrates Artificial Intelligence (AI) with Building Information Modeling (BIM) to develop a predictive retrofit framework. Supervised machine learning algorithms including Random Forest and XGBoost Classifiers were trained on a custom dataset to recommend optimal retrofitting measures. The recommended interventions including insulation, glazing upgrade and shading device were simulated using Autodesk Revit and Insight. These retrofits resulted in a 32.7% savings in Energy Use Intensity (EUI), 15% drop in total carbon emissions and an estimated payback period of approximately two years. The proposed AI-BIM framework offers a scalable, data-driven solution for energy efficient retrofitting. It enhances decision making and aligns with global sustainability goals in the healthcare sector.

ICWEES-04

Exploring Artificial Intelligence-Driven Sustainable Solutions for Climate Change: A Qualitative Thematic Analysis

Dr. Fatima Abrar, Assistant Professor, Lahore Business School, The University of Lahore, Pakistan

Dr. Muhammad Mursaleen, Assistant Professor, Lahore Business School, The University of Lahore, Pakistan,

Dr. Mahmood Rehmani, Associate Professor, Lahore Business School, The University of Lahore, Pakistan

Corresponding E-mail: fatima.abrar@lbs.uol.edu.pk, muhammad.mursaleen@lbs.uol.edu.pk, mahmood.rehmani@lbs.uol.edu.pk

Climate change is one of the substantial problems in major pressing challenges globally requiring innovative mechanisms which integrates policy, technology and community engagement. Focusing on updated technologies, Artificial intelligence has emerged as the transformative tool and encompasses potential regarding climate action, however, its application in real-world focusing on sustainable solutions prevails underexplored concerning qualitative approach in techniques of climate modelling, prediction, risk and adaptation planning. This research is rooted with Socio-Technical Systems Theory and Sustainable Development Goals (SDGs) as 3 (Good health and wellbeing), 11 (Sustainable Cities and Communities), 13 (Climate Action), and examines that how AI can contribute immensely for mitigation of climate change, grounded on stakeholder experience who are engaging actively in sustainability initiatives. Following qualitative research, data was collected through semi-structured interviews from 30 participants involving experts of environmental policy, AI developers and users, renewable energy engineers, and representatives of NGOs focused on climate-focused techniques. Themes are formulated on AI use in increasing efficiency and optimizing resources, enhancing climate resilience through AI and challenges of ethical considerations in equitable AI adoption considering climates strategies for policy and governance. Interviews are transcribed and analyzed with NVIVO 15, in which themes are generated to explore recurring insights and patterns. Findings highlight that AI can be strengthen significantly in climate action for enhancing decision-making, enabling efficiency of adaptive strategies and fosters collaborative interventions extending over sectors. Nevertheless,

participants accentuated on utilizing transparent framework of governance, data policies relying on inclusivity and also ensures capacity-building for mutual benefits and equitable contribution of AI. This research contributes significantly on the discourse of AI-driven sustainability through stakeholder approach and yielding evidence-based insights of thematic analysis. It highlights to align technological innovation with environmental and social concerns following AI integration, not solely as a tool but also catalyst for low-carbon, climate-adaptive and sustainable future.

ICWEES-05

Machine Learning-Enabled Retrofitting for Buildings: A Component-Specific Framework for Diverse Climates

Era Saeed[1], Asim Sultan[2], Muhammad Atif Javed[1], Dr. Nafeesa Sultan[1]

[1]National University of Technology, Islamabad, Pakistan

[2]Univeristy of Rasul, Mandi Bahauddin, Pakistan

Corresponding E-mail: asimsultan@putrasul.edu.pk

The building sector of Pakistan accounts for over half of the country's electricity consumption; however, conventional retrofitting approaches often fail to address climate specific inefficiencies. This study proposes an AI-based framework to optimize building energy retrofits using supervised machine learning techniques. The framework employs algorithms include Random Forest and XGBoost, trained on a dataset of 718 cases sourced from existing literature representing tropical, dry, moderate and continental climate zones. A user-friendly interface enables stakeholders to input building parameters and receive optimal retrofit recommendations for essential components such as walls, windows, roof, shades, HVAC systems, lighting and air tightness. The prediction accuracies obtained for each component were as follows: 92% for windows, 84.6% for walls, 85.4% for roofs, 90% for shade, 80% for lights, and 100% for air tightness. This data-driven approach aims to enhance energy efficiency and to promote sustainable practices in Pakistan's built environment, leading to lower operational costs and reduce environment impact.

ICWEES-06

Towards Net-Zero Carbon Buildings in Pakistan: A Preliminary Integrated Design Framework

Syed Qasim Ali Shah, Noor Haleem, Chaudhri Abdur Raheem, Ibaad Ullah Khan, M. Mohid Shakeel*

Institute of Environmental Sciences and Engineering, National University of Sciences and Technology, Sector H-12, Islamabad-44000, Pakistan

Corresponding E-mail: nhaleem@iese.nust.edu.pk

Pakistan's rapidly growing urbanization is placing unprecedented pressure on national energy resources and driving up carbon emissions. This challenge is intensified by inefficient building designs and reliance on fossil-fuel-based electricity. Moving toward net-zero carbon buildings, structures that generate enough renewable energy annually to balance their total consumption, require a multi-layer approach that integrates passive design, renewable energy systems, and smart energy management. This study helps develop a framework suited to Pakistan's varied climatic zones. Passive measures, such as optimal building orientation, high-performance envelopes, effective shading, and natural ventilation, can lower operational energy demand by 20–40%. Renewable solutions, particularly photovoltaic (PV) systems paired with hybrid storage, can offset 50–100% of the remaining load, while solar thermal, geothermal, and hybrid technologies offer 20–90% reductions depending on site conditions. Smart energy management, through automation, predictive controls, and demand response, can deliver a further 10–25% savings by increasing self-consumption and smoothing demand peaks. Drawing on evidence from Pakistan and similar climates, the proposed framework integrates climate-responsive design, renewable energy optimization, and intelligent demand management. It provides architects, engineers, policymakers, and urban planners with a practical, scalable pathway to achieve net-zero performance, while addressing the technical, economic, and policy dimensions critical for sustainable urban development.

ICWEES-07

Fauji Cement Decarbonization Levers & Challenges

Naveed Ashraf Cheema

Corresponding E-mail: naveed.cheema@fccl.com.pk

The cement sector is known for emitting GHG emissions significantly at global and national level. There are many companies at global level, implementing GHG protocols and committed with science-based targets initiatives. The Pakistan's NDC is also focused on carbon reductions (50% reduction against base year 2015 by 2030) and launched SPRAR6C (Supporting Preparedness for Article 6 cooperation, Pris Agreement) program including cement sector for motivation. The 1.50C ambition is aligned at international level but unfortunately due to regulatory restrictions, unavailability of alternate fuels, lack of incentives and customer-driven market Pakistan Cement Sector is still lagging far behind and needs attention as serious challenges are coming ahead after the implementation of CBAM (Carbon-border Adjustment Mechanism) implementation. Fauji Cement installed 1st captive solar plant of 12.5 MW in Pakistan during FY 2018-19 and now enhanced renewable energy up-to 68 MWp and 64 MW of reusable energy by installing 05 Waste Heat Recovery Plants (50% RE in power Mix & 20% RE sources in Energy Mix). FCCL is actively engaged and contributing positively to the climate change by continually improving decarbonization levers e.g., increasing the share of renewable energy in energy mix (>50%), improving process thermal efficiencies, using alternate fuels to optimizing thermal substitution rates (up-to 15%), building biodiversity-positive circular economy, transitioning to low-carbon products (PAMIR, Askari Green) etc. The Scope 01 and Scope 02 emissions are calculated and near-term strategies are in place to ensure that our strategies are aligned with decarbonization levers at all levels.

ICWEES-08

Multi-Method Computational Assessment of CO2 Adsorption on Pristine and Organosilane Modified MCM-41 Mesoporous Silica

*Rabbia Unain, Fouzia Perveen1, **

School of Interdisciplinary Engineering and Sciences (SINES), National University of Sciences and Technology (NUST), Sector H-12, 44000 Islamabad, Pakistan.

Corresponding E-mail: fouzia@sines.nust.edu.pk

Advanced adsorbent materials for efficient CO_2 separation from industrial gas streams such as flue gas and natural gas sweetening were investigated using combined Monte Carlo (MC), Grand Canonical Monte Carlo (GCMC), and Molecular Dynamic (MD) simulations. Due to the significant increase in CO2 binding as a result of secondary amine functionalization (NN-TMS), comparison of the total adsorption energy and the per-molecule adsorption energy of all functionalities (NN-TMS, OH-TMS, and pristine) using MC simulations has improved each other and shown that secondary amine functionalization (NN-TMS) achieves higher total adsorption energy (-85.58 kcal/ mol) compared to hydroxyl-functionalized (OH-TMS) and pristine materials and The adsorption isotherms estimated by GCMC exhibited an 18.7 percent increase in a maximum CO2 loading of the NN-TMS in comparison to the pristine MCM-41 at 298 K and 109 kPa with an adsorption capacity equal to 5.291 mmol/g. Stronger and energetically more favorable interactions were validated between NN-TMS across the temperatures examined with the help of isosteric heat analysis. These results were also confirmed by MD simulation where shorter distances between CO2 and the surface and increased ordering of the molecular structure have been observed in NN-TMS functionalized surfaces. OH-TMS showed a modest enhancement on the ordering of CO2, but the much stronger adsorption strengths and capacities were lower because of the lesser chemical attractions. The multi-scale simulation outcomes define a NN-TMS treatment as being the most efficient functionalization method that can be used to enhance the CO2 capture performance on MCM-41 based adsorbents. These results present invaluable insights for the rational development of highly efficient adsorbents, particularly for applications in CO_2 separation from flue gas and natural gas sweetening.

ICWEES-09

Decoding Uplift and Erosion: A Remote Sensing and Geomorphic Analysis of the Nanga Parbat Haramosh Massif Zone

Rukhsar Shahzadi and Syed Amer Mahmood

Institute of Space Science, University of Punjab, Lahore

The Nanga Parbat Haramosh Massif Zone (NPHMZ), positioned at the tectonically dynamic junction of the western Himalayas, represents one of Earth's fastest uplifting regions, with vertical motions ranging between 12–14 mm annually. This study integrates geomorphometric evaluation with remote sensing and machine learning to model neotectonic deformation and quantify associated erosion risks across the NPHMZ. Using Shuttle Radar Topography Mission (SRTM) data, a suite of geomorphic indices, such as Hack's Gradient Index, Local Base Level (LBL), and Relative Relief, was derived to delineate uplift trends, structural disturbances, and incision patterns. Spatial correlations were observed between these indices and fault systems, including the Main Mantle Thrust (MMT), Main Karakoram Thrust (MKT), and the Sassi Raikot Fault Zone (SRFZ), revealing localized deformation signatures. To assess erosion susceptibility, the Revised Universal Soil Loss Equation (RUSLE) was employed using geospatial inputs for topography, rainfall erosivity, soil erodibility, and land cover. Land Use/Land Cover (LULC) classification derived via Google Earth Engine, identified grasslands as dominant (43%), followed by forests (15%) and barren surfaces (12%), each contributing distinctly to the soil loss gradient. Annual erosion estimates ranged from negligible to over 63,000 tons per hectare per year, with extreme values concentrated along steep, deforested slopes subject to intense orographic rainfall and tectonic displacement. This integrative framework demonstrates the synergy between tectonic uplift and geomorphic response, emphasizing the value of remote sensing in monitoring active landscapes. The study not only advances scientific understanding of crustal deformation but also offers practical insights for erosion mitigation, sustainable land management, and infrastructure resilience in the Nanga Parbat Haramosh region.

ICWEES-10

Optimizing Photocatalytic Degradation of Reactive Black 5 using Fluorescent Carbon Quantum Dots-Sensitized Titanium Dioxide Nanocomposites

Eyman[1], Muhammad Saqib khan[2], Rizwana Sarwar[3] Muhammad Bilal[1], Nfor Elvis Nfor 1, Safdar Abbas Kazmi 1, Nadia Riaz[1]*

[1]Department of Environmental Sciences, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

2Department of Environmental Sciences, Institute of Environmental Sciences and Engineering, SCEE, NUST 4440, Islamabad

[3]Department of Chemistry, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

Corresponding E-mail: nadiariazz@cuiatd.edu.pk/ nadiariazz@gmail.com

This study investigated the photocatalytic degradation of model pollutant Ramazol Black 5 (RB5) textile dye under visible light irradiation using various CQD-sensitized titanium dioxide (TiO_2) nanocomposites. Fish scales were used as a carbon precursor to produce carbon quantum dots, which were intended to be used as sensitizers to improve the effectiveness of titania and as efficient photocatalysts for water pollutant degradation. Carbon quantum dots have a variety of uses, including drug delivery, bioimaging, gas detection, and catalysis. The study emphasizes the long-term viability and efficacy of employing fish scales as a carbon source, providing a feasible solution to wastewater pollution and assisting with waste management in fisheries. This novel method has the potential to considerably improve the photocatalytic activity of carbon quantum dot/TiO_2 nanocomposites, lowering their negative environmental impact. Different CQDs/TiO_2 with 1%, 2%, 5%,10% 20% and 30% wt% loading at a calcination temperature of 300°C..Key findings indicate that the RB5 photo-degradation efficiency increases with longer irradiation times, achieving complete removal (100%) in 60 minutes. The effectiveness of degradation diminishes with higher initial dye concentrations, with 100% removal efficiency at 10 mg/L, decreasing to 44.64% at 200 mg/L. The photocatalytic activity significantly improves with increased doses of the 2CQD-T-3 photocatalyst, achieving over 100% efficiency at doses of 1.5 mg/mL and higher. The reaction solution pH also plays a crucial role, with optimal decolorization efficiency observed

at acidic pH levels of 2, 4, and 6, while alkaline conditions (pH 10) result in a marked reduction in efficiency to around 70%. These findings highlight the potential of CQDs/TiO_2 composites as effective, eco-friendly, and recyclable materials for wastewater treatment applications, providing insights into optimizing synthesis and operational parameters for enhanced photocatalytic performance.

ICWEES-11

Geo-Environmental Assessment of Active Deformation in the Hindu Kush Using Surface Dynamic Modeling for Sustainable Landscape Management

Anam Munawwar and Syed Amer Mahmood

Institute of space science, University of the Punjab, Lahore, Pakistan

Corresponding E-mail: anam_munawar12@yahoo.com

This investigation presents a semi-automated geomorphometric analysis based on digital elevation models (DEMs) to evaluate the impact of neotectonic activity on landscape evolution within the Hindu Kush region (NW Pakistan and NE Afghanistan). By integrating river morphometric indices, surface dynamics, and polynomial trend surface modeling, this study investigates spatial variations in rock uplift and their correlation with river morphology. A key objective is to assess whether the region's erosional and uplift processes are in dynamic equilibrium or reflect ongoing tectonic disequilibrium. The neotectonic imprint is captured through channel steepness, stream gradient indices, isobase mapping, vertical dissection, incision depth, drainage density, trend surface anomalies, and the transverse topographic symmetry factor (T-index). The results reveal active tectonic uplift, particularly along the eastern and western margins of the Hindu Kush, where steepness and stream gradient indices align with major fault traces. These high-relief zones exhibit disequilibrated river profiles, indicating tectonic forcing. Notably, the asymmetry factor analysis delineates widespread block tilting, suggesting fault reactivation and directional drainage migration. Drainage patterns derived from automated lineament analysis correspond well with tectonic structures. A pronounced NW–SE alignment of isobase lines, especially along the Panjsher–Surobi–Kabul River axis, highlights the dextral Surobi fault and potential river capture processes. Trend surface anomalies spatially correlate with other morphometric indicators, reinforcing tectonic interpretations. These findings attribute recent deformation in the region to the continued convergence of the Indo-Pakistan and Eurasian plates, influencing major strike-slip and thrust fault systems, including the Main Karakoram Thrust (MKT), Main Mantle Thrust (MMT), and Main Boundary Thrust (MBT). This study underscores the value of DEM-derived river profile analysis, symmetry metrics, and surface modeling in detecting active tectonics. From an environmental sustainability perspective, such tectonic insights are vital for sustainable land use

planning, natural hazard assessment, and the long-term resilience of mountainous ecosystems and human settlements within this seismically active terrain.

ICWEES-12

Towards a Climate-Resilient Hindukush: Assessing Environmental Stability in Northern Pakistan

Amna Aslam[1], Munawar Sabir[2], Syed Amer Mahmood[3]

[1,2)] Institute of Geography, University of the Punjab, Lahore

[3)] Institute of Space Science, University of the Punjab, Lahore

Corresponding E-mail: amnaresearch2019@gmail.com

The Hindukush region in Pakistan stands as a vital ecological and climatic stronghold but is increasingly threatened by environmental challenges such as glacial melting, land degradation, shifting weather patterns, and socio-economic pressures. This research seeks to carry out an in-depth geospatial analysis of climate resilience and environmental sustainability across the region by employing advanced tools in Remote Sensing, Geographic Information Systems (GIS), and GeoAI (Geospatial Artificial Intelligence). The study will merge long-term satellite observations with climatic datasets and socio-ecological variables to evaluate transformations in land use and land cover, vegetation vigor, glacial dynamics, and drought-related stress indicators from 2010 to 2024. Key indicators including NDVI, LAI, NPP, snow and glacier coverage, precipitation anomalies, and land surface temperature will be assessed alongside anthropogenic factors such as population density and infrastructure development. State-of-the-art machine learning algorithms like Random Forest and XGBoost will be utilized to delineate climate-sensitive zones, while sustainability metrics will help gauge ecosystem resilience.The findings from this work aim to guide local authorities, decision-makers, and development partners in formulating spatially-informed interventions for climate adaptation, ecological restoration, and sustainable development. Additionally, the study is designed to support the achievement of Sustainable Development Goals, specifically SDG 13 (Climate Action) and SDG 15 (Life on Land), and to serve as a transferable methodology for assessing resilience in other mountainous ecosystems.

ICWEES-13

Designing Bacterial Cellulose–Nickel Ferrite Composites: Toward Efficient and Eco-Friendly CO_2 Adsorption

Yasir Malik[1] and Romana Khan[2]

[1,2] Department of Environmental Sciences, CUI Islamabad Abbottabad Campus

Corresponding E-mail: Yasirmlk11471@gmail.com, romanakhan@cuiatd.edu.pk

Challenges posed by climate change and global warming demand urgent and prompt actions across the globe in the form of carbon capture and storage (CCS). Assessing the gravity of the challenges current study contributed in synthesis and analysis of bacterial cellulose-nickel ferrite composites (BC-NiFx) with varying nickel ferrite content from 1-5 wt % to capture CO_2. *Gluconacetobacter xylinus* (KCCM 40407) species of bacteria was used for bacterial cellulose (BC) synthesis while nickel ferrite was synthesized using co precipitation method. BC-nickel ferrite composites were synthesised by wet impregnation method. Physico-chemical techniques such as Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS) and X-ray Diffraction (XRD) not only confirmed the successful formation of the designed material but also helped to understand the surface chemistry of adsorption. To evaluate the potential adsorption of CO_2 continuous flow reactor was used. Titrimetric method and CO_2 analyser were used to measure the adsorption of CO_2. Results demonstrated significant enhancement of CO_2 adsorption as compared to pristine BC. It was also revealed that adsorption capacity was directly linked with nickel ferrite content in the composite. Maximum adsorption capacity of 51mg was measured by BC-NiF5 at 1 atm and 25 °C. This method not only precisely quantified the CO_2 adsorption but also highlighted the potential of composite material in CCS technologies designed for emission reduction from potential anthropogenic sources in Pakistan. Study recommends the study of adsorption capacity of these adsorbent materials at various temperature and pressure conditions.

ICWEES-14

Climate-Resilient Soil Restoration via Microbial-Assisted Phytoextraction

*Huma Mumtaz, Muhammad Arshad, Zeshan, Syeda Irsa Mazhar, Iram Gul**

Institute of Environmental Science and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology

Corresponding E-mail: igul@iese.nust.edu.pk

Through both natural and industrial processes, heavy metals such as cadmium, lead, and zinc contaminate soil, air, and water, creating major health concerns. These chronic pollutants build up in the food chain and cause diseases like renal damage, neurological disorders, and cancer. Sustainable methods like phytoremediation and bioremediation offer eco-friendly alternatives to costly, inefficient, and environmentally harmful conventional methods for heavy metal removal in contaminated soils. The study was conducted to analyze the effectiveness of plant-microbe synergy in promoting the phytoextraction of lead (Pb), cadmium (Cd), and zinc (Zn). Inoculation of the particular microbial species was added to each of the eight treatments, which were administered in triplicate. Under single metal stress, microbial treatments increased biomass, relative water content, and chlorophyll content, all of which improved plant growth. These treatments, however, demonstrated higher toxicity under combined metal exposure when compared to plants cultivated in metal-contaminated soil without microbial administration. These hardy microbial strains can ensure reliable remediation results by increasing plant survival and metal uptake efficiency in challenging conditions. Their use can also extend phytoextraction to dry and semi-arid areas, where traditional techniques frequently fall short because of stress brought on by the climate. And the use of microbial consortia could also be advantageous for metal tolerance and plant growth in the future.

ICWEES-15

Carbon Capture, Utilization, and Storage: Technologies, Challenges, and Pathways to Net-Zero

Chaudhri Abdur Raheem , Noor Haleem, Muhammad Fahim Khokhar*, Syed Qasim Ali Shah, Ibaad Ullah Khan, M. Mohid Shakeel*

Institute of Environmental Sciences and Engineering, National University of Sciences and Technology, Sector H-12, Islamabad-44000, Pakistan

Corresponding Email: nhaleem@iese.nust.edu.pk; fahim.khokhar@iese.nust.edu.pk

Rising atmospheric carbon dioxide (CO_2) concentrations, from pre-industrial levels of ~280 ppm to over 422 ppm in 2024, are a significant driver of global warming and climate change. The International Panel on Climate Change (IPCC) emphasizes the need for a 50–80% reduction in emissions by 2050 to limit warming to below 2°C, hence Carbon capture, utilization, and storage (CCUS) technologies are crucial in meeting this challenge. This review presents an in-depth assessment of key CO_2 capture methods of both conventional and emerging technologies, examining their operational principles, efficiencies, scalability, and limitations. Particular attention is given to materials that enhance capture efficiency, lower regeneration energy requirements, and improve the cost-effectiveness and durability of capture materials. However, challenges such as high capital and operational costs, energy intensity, material degradation, and limited CO_2 transport infrastructure hinder widespread adoption. Addressing these barriers requires supportive policy frameworks, investment incentives, and coordinated infrastructure development. The findings underscore CCUS as a critical, scalable, and complementary solution alongside renewable energy expansion and energy efficiency improvements to achieve global net-zero emission targets.

ICWEES-16

A Review of Virtual Reality Applications for Enhancing Safety Management in the Construction Industry

Hilal Khan, Khursheed Ahmad, Muhammad Usman Hassan

NUST Institute of Civil Engineering (NICE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad 44000, Pakistan

Corresponding Email: hkhan.ms24nice@student.nust.edu.pk

The construction sector consistently ranks among the most hazardous industries worldwide, with high rates of accidents and fatalities attributed to inadequate hazard recognition, insufficient training, and unsafe on-site behaviours. Virtual Reality (VR) has emerged as a transformative technology for safety management, offering immersive, interactive, and risk-free training environments. This review synthesizes peer-reviewed research from the past decade, examining VR-based safety interventions across hazard identification, behavioral training, emergency preparedness, and ergonomics assessment. The analysis covers hardware and software advancements, including head-mounted displays, motion tracking, game engines, and integration with Building Information Modeling (BIM) and Artificial Intelligence (AI) for adaptive learning. Findings indicate that VR training improves hazard recognition accuracy by **30–50%** and retention rates by **over 35%** compared to conventional methods. However, challenges remain in terms of high development costs, lack of standardized evaluation metrics, and limited scalability to diverse project contexts. The study identifies future research opportunities in AI-driven adaptive VR training, multi-user collaborative simulations, and integration with real-time site data from IoT sensors. By consolidating technological trends, performance outcomes, and implementation barriers, this review underscores VR's potential as a critical enabler of proactive, data-driven safety cultures in construction.

ICWEES-17

Eco-Innovative Photocatalytic Composites: Integration of GQD/TiO_2 into Recycled Aggregate Concrete, for Pollutant Removal

*N. Elvis Nfor[1], Eyman[1], Safdar Abbas Kazmi[1], Muhammad Saqib Khan[2], Muhammad Bilal[1], Muhammad Fasial Javaid[2], Rizwana Sarwar[3], Nadia Riaz[1]**

[1]Department of Environmental Sciences, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

[2]Department of Environmental Sciences, Institute of Environmental Science and Engineering, NUST, 44000, Islamabad, Pakistan

[3]Department of Civil Engineering Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, Swabi, KPK, Pakistan

[4]Department of Chemistry, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

Corresponding Email: nadiariazz@cuiatd.edu.pk/ nadiariazz@gmail.com

This study tackles the pressing need for sustainable building materials by fabricating photocatalytic concrete that uses recycled aggregates, titanium dioxide (TiO_2), and graphene quantum dots (GQD). This innovative approach not only conserves resources but also treats wastewater simultaneously. TiO_2 is known for its photocatalytic properties, effectively breaking down stubborn pollutants like Reactive Black 5 (RB5) dye and harmful microbes when exposed to light. Meanwhile, GQD boosts the absorption of visible light, reduces TiO_2's bandgap, and enhances the separation of charge carriers. By substituting natural aggregates with recycled ones, we can cut down on raw material extraction, lessen environmental impact, and promote the principles of a circular economy. The GQD/TiO_2 composites, containing 1–20 mol% GQD, were synthesized and thermally treated at temperatures between 300, 400, and 500 °C, and their structural, optical, and photocatalytic properties were analyzed using XRD, FTIR, and UV–Vis DRS techniques. The composite with 15 mol% GQD showed the best performance in degrading RB5, achieving nearly complete removal in just 80 minutes under simulated sunlight. This success is attributed to improved light harvesting, more active sites, and reduced electron–hole recombination. Response Surface Methodology (RSM) and ANOVA results confirmed significant

correlations between parameters ($p < 0.05$), validating the accuracy of the model. This transformation turns concrete from a mere building material into a proactive player in combating pollution and preserving our ecosystems.

ICWEES-18

Enhanced Visible Light-Driven Photodegradation of Reactive Yellow 145 Using Cu-Doped TiO_2 for Sustainable Textile Wastewater Treatment

*Safdar Abbas Kazmi[1], N. Elvis Nfor[1], Eyman[1],, Muhammad Saqib Khan[2], Muhammad Arshad[2], Muhammad Bilal[1], Nadia Riaz[1]**

[1]Department of Environmental Sciences, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

[2]Department of Environmental Sciences, Institute of Environmental Science and Engineering, NUST, 44000, Islamabad, Pakistan

[3]Department of Chemistry, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

Corresponding Email: nadiariazz@gmail.com; nadiariazz@cuiatd.edu.pk

The textile industry is notorious for producing a significant amount of wastewater filled with complex organic dyes, which creates serious environmental issues. Recently, heterogeneous photocatalysis has gained attention as a promising method for tackling textile wastewater. This research zeroes in on the use of a Cu-doped TiO_2 (Cu/TiO_2) photocatalyst to break down Reactive Yellow 145 when exposed to visible light. Titanium dioxide (TiO_2) is a popular choice for photocatalysis because it's stable, non-toxic, and effective. However, its wide bandgap energy of 3.2 eV means it can only be activated by UV light, which limits its use in visible light applications. To address this challenge, adding copper (Cu) to TiO_2 boosts its photocatalytic performance in the visible spectrum, making it more effective at breaking down organic pollutants. The Cu/TiO_2 photocatalyst was created using a sol-gel method with different amounts of Cu and was thoroughly analyzed for its structural, optical, and photocatalytic characteristics. The experiments for photodegradation were carried out under visible light. Impressively, the Cu/TiO_2 photocatalyst showed improved photocatalytic activity, successfully degrading Reactive Yellow 145 in just 60 minutes. This study underscores the potential of Cu-doped TiO_2 as a viable photocatalyst for treating wastewater from the textile industry using visible light. The insights gained from this research could pave the way for developing sustainable and effective wastewater treatment solutions, helping to reduce environmental pollution and encourage eco-friendly practices.

ICWEES-19

Sustainable Recovery of Copper, Aluminum, and Lead from E-Waste Using Chemical Leaching, Precipitation, and Electrowinning

Hanzallah Abid, Aleena Ejaz, Tehreem Tariq Shamsi

[1]*University of Engineering and Technology, Taxila, Pakistan*

Corresponding Email: hanzallah.abid12@gmail.com

Electronic waste (e-waste) is an emerging global concern due to its complex composition of toxic substances and recoverable metals. This study investigates the recovery of copper, aluminum and lead from selected e-waste components including printed circuit boards (PCBs), remote control boards and keyboard chips using a combined hydrometallurgical approach. Initial leaching experiments were conducted using hydrochloric acid (HCl) and nitric acid (HNO_3), with nitric acid yielding superior filtration characteristics and higher metal extraction efficiency. Controlled variables included leaching duration, pH and agitation, with atomic absorption spectroscopy (AAS) employed to quantify metal concentrations. Leaching efficiencies for copper, aluminum and lead were determined to be 27.93%, 66.66% and 15.86%, respectively. Subsequent precipitation using sodium hydroxide (NaOH) achieved 100% lead recovery, with moderate recovery of aluminum (30%) and copper (3.14%). Electrowinning further improved aluminum recovery to 51%, while copper and lead recoveries remained limited at 5.32% and 7.6%, respectively. The results underscore the viability of nitric acid-based leaching for e-waste recycling and highlight process limitations in precipitation and electrowinning stages. This study demonstrates a resource-efficient and environmentally responsible methodology for metal recovery from e-waste, supporting circular economy objectives and contributing to Sustainable Development Goals (SDGs) related to responsible consumption and industrial innovation.

ICWEES-20

Nanoparticle Engineering for High-Efficiency, Stable Perovskite Solar Cells

Ahson Jabbar Shaikh

Department of Chemistry, COMSATS University Islamabad - Abbottabad Campus, Abbottabad - 22060, KPK, Pakistan.

Corresponding Email: ahson@cuiatd.edu,pk; ahsonjabbar@hotmail.com

Perovskite solar cells (PSCs) have emerged as a leading photovoltaic technology due to their high-power conversion efficiencies (PCE) and cost-effective fabrication. However, interfacial losses at the hole transport layer (HTL)–electrode interface often limit device performance and stability. In this study, zinc sulfide (ZnS), copper sulfide (CuS), and composite ZnS-CuS nanoparticles were synthesized and optimized via a co-precipitation method and applied as an additional interfacial HTL layer between spiro-OMeTAD and Ag electrodes in n-i-p PSCs. Structural (XRD, SEM), optical (UV-Vis/Tauc's plot), electrochemical (CV, EIS), and computational analyses confirmed that increasing CuS content decreased the band gap, optimized E_{HOMO} alignment, and reduced interfacial resistance, enabling more efficient hole transport. Device performance improved significantly, with PCE increasing from 13.65% (reference) to 15.21% for pure CuS, driven by enhanced current density, fill factor, and reduced R_s and R_{ct}. This interfacial engineering approach offers a cost-effective and scalable strategy for boosting PSC efficiency and stability, advancing their potential role in sustainable energy systems.

ICWEES-21

Salt-Enhanced Photocatalytic Degradation and Mineralization of RB5 Dye by Nickel Sulfide Nanoparticles: Insights from DLS and DFT Studies

Muhammad Younas Afzal

Corresponding Email: younasafzal321@gmail.com

This study presents the photocatalytic degradation of RB5 dye using nickel sulfide nanoparticles (NiS NPs) in the presence of various salts. Dynamic light scattering (DLS), though rarely applied in dye degradation studies, was employed alongside zeta potential measurements to gain deeper insights into the degradation process. The hydrodynamic radius (HR) of NiS increased significantly from 244.97 ± 31 nm to 1325.43 ± 531 nm upon interaction with NaCl, achieving 99% RB5 removal through •OH, O_2^{-}•, and Cl• radical pathways. This value further rose to 1882 ± 385 nm, indicating the deposition of degraded and mineralized dye products on the catalyst surface. In contrast, $AgNO_3$ exhibited minimal interaction, increasing the HR only to 672.6 ± 339 nm, with a reduced degradation efficiency of 40%. Zeta potential measurements confirmed that NiS NPs carry a negative surface charge and remain effective in RB5 degradation with NaCl, although their overall colloidal stability decreases in the presence of salts. Radical trapping experiments validated the generation of reactive species, while the Langmuir–Hinshelwood kinetic model confirmed that adsorption precedes photocatalytic degradation. XRD analysis revealed an average crystallite size of 7.08 nm with a rhombohedral crystal structure. SEM images showed agglomerated nanoclusters, and BET surface analysis confirmed the mesoporous nature of NiS with a surface area of 161 m^2/g. Optical studies (UV–Vis and PL) highlighted interactions between NiS NPs, RB5, and salts. HPLC and TOC analyses confirmed effective RB5 degradation and mineralization, respectively. Theoretical calculations indicated that the N–N site is the preferred interaction point for RB5 on NiS NPs, with a cage-like structural configuration proving optimal for photocatalysis, supported by a measured bandgap energy of 2.11 eV. FTIR analysis verified the structural stability of NiS NPs over 10 reuse cycles, maintaining over 85% degradation efficiency. Overall, these findings demonstrate the high efficiency, reusability, and practical potential of NiS NPs for the removal of toxic dyes from wastewater.

ICWEES-22

CFD Study of Iodine Removal in a Multi-Venturi Scrubber for Environmental Remediation

Muhammad Bilal Niaz, Jawaria Ahad, Khalid Waheed, Masroor Ahmad, Amjad Farooq, Shafiq ur Rehman

Department of Nuclear Engineering

Pakistan Institute of Engineering & Applied Sciences

Corresponding Email: bilalniaz81@gmail.com

Nuclear power plants are a reliable source of low carbon energy and play an important role in transition towards sustainable energy systems. Severe accidents in nuclear power plants can lead to release of radioactive iodine from reactor containment that poses a serious threat to environment and human health as it causes thyroid cancer. After severe accidents like TMI, Chernobyl and Fukushima, passive safety systems such as **Filtered Containment Venting System (FCVS)** were introduced**.** This system is designed to prevent over pressurization by safely venting the air from the containment, filter the radioactive contaminants like iodine that are present in this air and then release the clean air into the environment. After Fukushima, a pilot scale facility of FCVS that employs venturi scrubber was built at PIEAS to conduct research on iodine removal and for indigenous development of this system. Optimization of scrubbers is vital to maximize its iodine removal efficiency. This study presents a computational fluid dynamics (CFD) analysis of iodine capture in a Multi-Venturi Scrubber system. The system was comprised of two to four Venturi tubes arranged in parallel, with air mass flow rates between 8 to 12 kg/min and inlet iodine concentrations ranging from 30 to 90 parts per million (ppm). A multiphase Eulerian model with a custom UDF in ANSYS Fluent was used to simulate iodine transfer from air to water in the Venturi throat, accounting for diffusion, convection, and local flow conditions. Key parameters studied include the number of Venturis, droplet diameter, inlet concentration of iodine and mass flow rate of air. Results showed that droplet diameter decreases with increase in mass flow rate of air. However, iodine removal efficiency increases with increase in number of venturis, mass flow rate of air and inlet concentration of iodine. Maximum removal efficiency of 99.4% was achieved.

ICWEES-23

Beyond the Grid: Decentralized Renewable Energy Solutions for Rural Pakistan

Ibaad Ullah Khan, Noor Haleem, Syed Qasim Ali Shah, Muhammad Mohid Shakeel Khan, Abdur Raheem*

Institute of Environmental Sciences and Engineering, National University of Sciences and Technology, Sector H-12, Islamabad-44000, Pakistan

Large areas of Rural Pakistan remained underserved by the National electricity grid, with many communities experiencing persistent energy poverty, only ~56% of households have electricity, highlighting the need for alternatives since centralized grid expansion is slow and costly. This paper evaluates the potential for decentralized renewable energy (DRE) systems, specifically solar photovoltaics (PV), Micro-Hydro, and biomass, for rural electrification. The analysis focuses on solar PV, micro-hydro, and biomass technologies, examining their technical feasibility and socio-economic impacts in Pakistan's low-income, dispersed communities. Representative case studies (e.g., a micro-hydro project in Chitral and solar mini grids in Sindh) illustrate practical deployments. Results indicate that Pakistan's abundant renewable resources, approximately 9.5 hours/day of solar insolation and plentiful mountain water and biomass, provide high technical potential for solar PV, micro-hydro, and biomass systems. Beyond technical feasibility, deploying these DRE systems yields clear socio-economic benefits. However, key barriers to DRE adoption include financing gaps, policy/regulatory hurdles, and gaps in local technical capacity. Drawing from both technical assessments and implementation case reports, this study outlines an enabling framework for scaling DRE adoption. Recommended measures include targeted incentives, streamlined regulatory processes, and participatory community engagement to enhance long-term sustainability. Aligning these initiatives with Pakistan's renewable energy targets and the UN Sustainable Development Goal 7 could accelerate equitable energy access while supporting climate-resilient rural development.

ICWEES-24

In-situ Bio-decomposition of Crop Residue and its Effect on Soil Health and Brinjal Growth

Syeda Mehak Hasnain, Muhammad Arshad

Institute of Environmental Sciences and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology, Islamabad, Pakistan

Corresponding Email: syedamehakhasnain110@gmail.com**,** marshad@iese.nust.edu.pk

Stubble burning is a major driver of seasonal air quality deterioration in South Asia, with Pakistan's rice–wheat and sugarcane production contributing significantly to recurring smog events. The country produces approximately 69 million tons of crop residues annually, of which open-field burning is estimated to contribute around 20% of the national air pollution load. This practice emits fine particulates and reactive gases that reduce visibility, disrupt transportation, and increase the prevalence of respiratory and cardiovascular diseases. Despite existing regulations and penalties, it persists due to its speed, low cost, and ease of implementation, underscoring the urgent need for sustainable and scalable residue management solutions. This study evaluates the in-situ biodegradation of rice straw and sugarcane residue under controlled greenhouse conditions as an environmentally friendly alternative to burning. A microbial inoculum comprising two native bacterial strains (*Bacillus subtilis* and *Bacillus pumilus*) and a fungus (*Trichoderma spp.*) was applied to accelerate decomposition. Residue mass loss was measured over a 25-day period to assess decomposition efficiency. The results revealed that *B. pumilus* achieved the highest dcomposition rates, reaching 58% for sugarcane residue and 51% for rice straw. The microbial consortium followed closely with rates of 49% and 48.5%, respectively. All treatments significantly enhanced the growth and biomass of brinjal (*Solanum melongena*) compared to the untreated control, indicating improved soil fertility and nutrient availability. The findings demonstrate that targeted microbial applications can serve as a cost-effective, eco-friendly, and agronomically beneficial solution for crop residue management. This approach not only reduces pollutant emissions but also improves soil health and crop productivity. The results provide a strong basis for future field-scale studies aimed at optimizing microbial consortia for diverse agro-climatic regions in Pakistan and beyond.

ICWEES-25

Navigating the Air Pollution Crisis: A Scientific and Policy Roadmap for Pakistan

Zaeem Bin Babar

Institute of Energy and Environmental Engineering, University of the Punjab, Lahore, Pakistan

Corresponding Email: zaeem.ieee@pu.edu.pk

This study offers a comprehensive assessment of the severe air quality issues facing the nation. It details the complex pathways and mechanisms of smog formation, particularly highlighting the high concentrations of $PM_{2.5}$ that have placed several Pakistani cities among the most polluted in the world. The analysis draws on specific regional studies to provide a clear picture of the problem's scale. The current work then systematically identifies the major sources of air pollution in Pakistan, including industrial emissions, vehicular exhaust, agricultural burning, and poor waste management practices. Moving beyond the assessment, it provides a scientific and policy-based roadmap for effective mitigation. It outlines a two-pronged approach that combines technical interventions—such as the adoption of cleaner fuels, improved vehicle emission standards, and the use of low-cost sensors for widespread monitoring—with robust policy-based interventions. These policy recommendations include the implementation of stricter environmental regulations, the promotion of public awareness through media campaigns, and the establishment of outreach programs in educational institutions. This study also emphasizes the critical need for citizen engagement and advocacy to drive long-term, sustainable change. In conclusion, this roadmap provides a clear and actionable strategy for tackling Pakistan's air pollution crisis, aiming to improve public health, environmental quality, and overall economic resilience.

ICWEES-26

Genesis, Distribution and Economic Significance of Barite Deposits Hosted in Tanawal Formation, Burner District, Pakistan: Petrographic and Geochemical Perspectives

*Ijaz Ullah Khan, Saeed Ullah Khan, Shakil Ahmad, Imran Ahmad**

Department of Geology, University of Malakand, Chakdarrah (Dir, Lower), Khyber Pakhtunkhwa, Pakistan

Corresponding Email: imran_geo@uom.edu.pk

Barite (barium sulfate, BaSO4) is essential to the oil and gas industry being a key ingredient in the drilling mud. Elemental barium also finds applications in materials like optical glass, ceramic glazes, and paints. Barite deposits are classified into four main types: bedded-sedimentary, bedded-volcanic, vein, cavity-fill and metasomatic, and residual. The current study is based on exploring the geological and geochemical conditions that control the formation of barite deposits in the metamorphic terrain of Lesser Himalayas exposed in Khanano Dheri Buner area, Pakistan, focusing on their economic potential and extraction feasibility, as well as their relationship with other economic minerals in the region. This research shows that barite formation is closely linked to the tectono-metamorphic evolution of the region, particularly during the Indo-Eurasian plate collision. The deposits are mainly hydrothermal vein deposits, where barite precipitated in the cooling stage of the upwelling hydrothermal fluids. This study provides an overview on the genesis of barite deposits in tectonically deformed zone of the Himalayas, focusing on the tectonic evolution, geological history, and stratigraphic framework of the investigated area. Extensive field work activity, random sampling, petrographic analysis and geochemical investigations were adopted as basic methodology for achieving the main objective of this research work. Analytical data interpretation indicates that the barite deposits are epigenetic formed as a result of hydrothermal activity along the faults and fractures in Permian age failed rift system of Peshawar basin and adjoining areas. Integrated petrographic and geochemical analysis was crucial in understanding the geology and geochemistry of the barite deposits. The geochemical analysis revealed significant variations in oxide concentrations across different samples. There is an inverse relationship between barium oxide (BaO) and sulfur trioxide (SO3), exhibiting that increase in BaO concentrations causes decrease in SO3 levels as observed, representing geochemically

incompatibility. Cross plot of copper oxide (CuO) vs iron oxide (FeO) demonstrates inverse relationship, indicating geochemical incompatibility between Cu and Fe in the studied samples. SrO concentrations decrease with decreasing CaO, exhibiting direct relationship and appropriate geochemical compatibility between Ca and Sr. The compatibility of CuO and ZnO varies across the samples, showing direct relationship and similar geochemical compatibility. K2O concentrations are generally higher compared to FeO in most samples, but they indicate similar increase and decrease in the studied samples, demonstrates a geochemical compatibility between K and Fe. SrO levels decrease consistently up to IBS-4, with a sudden rise at IBS-5, represents some sort of contamination while sample preparations. ZnO levels remain relatively constant across all the samples and its relationship in cross plot with SrO is inverse. CuO concentration decreases with increasing contents of CaO, exhibiting inverse relationship as well as geochemical incompatibility in the investigated samples. Understanding these geochemical variations and their implications for qualitative and quantitative analysis of barite is critically essential for assessing the economic potential of these deposits in the investigated area (Buner) and guiding future exploration and mining activities. This study highlights the potential for further exploration and economic development of barite deposits in this region.

ICWEES-27

Utilizing Polyvinyl Chloride In Self Compacted Concrete

Talha Waheed[1], Atif Mehmood, Muhammad Usman, Muhammad Sohail and Muhammad Qasim Bilal

National University of Sciences and Technology

Corresponding Email: twaheed.bece22nice@student.nust.edu.pk

Placement of fresh concrete in congested rebar leads to honeycombing thus compromising the quality of concrete. Self-consolidating/compacting concrete resolves this issue by introducing more ratio of fines. Since plastic requires hundreds of years to degrade and contributes to long-term environmental pollution, its reuse in concrete provides a sustainable solution. This study investigates the use of Polyvinyl Chloride (PVC) scrap as a partial replacement of fines aggregate in the development of eco-friendly Self-Compacting Concrete (SCC). The primary objective of this research is to develop an eco-friendly mix by replacing fines that maintains desirable workability and mechanical strength. For this purpose, various trial mixes were made and tested to achieve the desired workability without compromising strength. Fresh properties of the concrete mix were evaluated by tests including V-Funnel test, L-Box test and slump flow test to ensure that the concrete mix has required flowability. Optimum results were achieved with 10-20% replacement of fine aggregates with PVC scrap, with 28-day strength more than 3000 psi(20.68 MPa) and passing ability greater than 80% along with acceptable value of v funnel test, showing that the mix has desired mechanical and flow properties. This research concludes that addition of PVC scrap is an eco-friendly alternative to develop green concrete, the reuse of PVC (a plastic material) in concrete not only reduces environmental pollution but also proves to be an innovative material in construction industry contributing to plastic waste management and green construction practices.

ICWEES-28

Seismic-Resilient Structural Designs in Construction Management: Lessons from Pakistan and Japan

Mohammad Qasim Bilal, Chaudhry Muhammad Shahram Akbar, Muhammad Ziyad

NUST School of Civil and Environmental Engineering, National University of Sciences and Technology NUST H-12, Islamabad, Pakistan

Corresponding Email: Engr.qasim.bilal@gmail.com, shahramkhan056@gmail.com, muhammadziyad2345@gmail.com

The seismic resilience of structures critically depends on robust design standards and effective construction management. This comparative study examines Pakistan and Japan, two tectonically active countries with divergent outcomes in earthquakes to identify best practices. We synthesize quantitative data from major earthquakes (e.g., 2005 in Pakistan, 2011 in Japan) and review engineering and policy research on building codes, materials, and retrofitting. The analysis highlights that Japan's strict, continually updated codes and quality control (e.g. licensed Kenchikushi inspections) have kept casualties low, whereas Pakistan's relatively recent codes (first promulgated in 2007) and enforcement gaps leave many buildings vulnerable. Lessons include the importance of early retrofitting (as enacted after 1995 Kobe) and the adoption of isolation/damping technologies. Quantitative comparisons and case studies indicate that strengthening codes and compliance can dramatically reduce damage and loss of life in seismic events.

ICWEES-29

Environment-Friendly Sustainable Approach for Building Rural Entertainment and Educational Outreach

Fahad Ahmed, Waqas Khalid and Muhammad Sajid*

[1] School of Mechanical and Manufacturing Engineering (SMME), National University of Sciences and Technology (NUST), H-12 Main Campus, Islamabad, Pakistan

Pakistan.

fahmedphd20smme@student.nust.edu.pk, waqaskhalid@smme.nust.edu.pk,

Corresponding Email: m.sajid@smme.nust.edu.pk

Environmental friendly, sustainable platforms are revolutionizing the way communities access essential services, particularly in underserved and low-income areas where traditional infrastructure often falls short, to meet the community requirements. This research paper investigates the potential of a green energy based customized smart solution, designed to provide mobile infotainment, for improving, quality of living for children in low-income communities, and at the same time, promising a sustainable built environment. Smart-Wheels, uses concept of an intelligent mobile platform, which utilizes solar potential in rural areas, for functioning of a compact information and entertainment package, housing a mobile library, gaming zone, movie theatre and a blend of different interactive activities. The research focusses on the cost effective design of a smart vehicle, to offer a real time platform, for enhanced learning and recreational facilities, for kids, of under-privileged communities. It assesses the optimized design, cost-effectiveness and societal impact of Smart-Wheels in comparison to conventional approaches involving separate facilities for education and entertainment, at the cost of increased environmental pollution. With increased cost of separate facilities, Smart-Wheels significantly offer rich dividends over separate non-smart facilities, due to reduced cost per kid, which is a fraction of the conventional model. Notably, Smart-Wheels operates on solar power, contributing to sustainability and reducing environmental hazard impact. Concept of Smart-Wheels is based on an intelligent model, which can be integrated with artificial intelligence, to forecast availability of solar potential in a particular area, for cost-effectiveness, and efficient resources' utilization. Survey based techniques and quantitative methods, are adopted for comparative analysis, on the activities.

Results of the study survey and questionnaires, also bring out comparative analysis of children activities in their leisure and satisfaction level achieved, by virtue of this this, innovative environmental friendly sustainable solution as an infotainment platform. Clean energy management software tool will aldifferent tools like RETScreen, will be used for comparative analysis of environmental emission of this sustainable environmental friendly solution with conventional solutions, with same dividends or facilities for rural outreach, with aim of giving a technical feasibility of developing more sustainable and environmental friendly solutions.

ICWEES-30

Environmental and Metabolic Stimulants Enhance Quorum Sensing, Virulence, and Xanthan Gum Production in *Xanthomonas campestris*: Implications for Sustainable Industrial Fermentation

Muhammad Abdullah

Corresponding Email: abdullah08790@gmail.com

Xanthan gum, a widely used food biopolymer with unique rheological properties, is synthesized by Xanthomonas campestris through pathways regulated by quorum sensing (QS). However, how environmental and metabolic cues influence QS to simultaneously modulate virulence and xanthan biosynthesis remains poorly understood. Recent studies have demonstrated that rpfF helps bacteria sense the environmental cues. This type of regulation suggests that external cues which enhance virulence and help bacteria survive oxidative stress may also drive xanthan production. Constraint-based modelling further supports this link, predicting that rpfF activation stimulates metabolism of branched chain amino acids and related metabolic pathways. Building on these insights, this work aims to investigate how diverse stimulants including physical, plant-derived, diffusible factor, and amino acid inputs influence the QS activity, virulence expression, and EPS secretion. To test this, cultures were grown under physical, plant-derived, and metabolic stimulants, and QS activation, virulence enzyme activities, and xanthan production were quantified at the exponential–stationary transition. Protease and cellulase activities (skimmed milk and CMC agar assays) were used as virulence readouts, and xanthan was quantified by precipitation with ethanol. By identifying stimulants that accelerate xanthan biosynthesis, this work supports strategies to reduce fermentation time and resource consumption, offering clear benefits for the water–energy–food (WEF) nexus.

ICWEES-31

Identifying Challenges and Solutions to the Implementation of Sindh Climate Change Policy

Zuhaib Ahmed Bhatti [a], Muhammad Aslam Uqaili [b], Zulfiqar Ali Umrani [c], Sheeraz Ahmed Memon [d], Waheed Ali Khokhar [e]*

[a] US-Pakistan Center for Advanced Studies in Water, Mehran UET Jamshoro

[b] Electrical Engineering Department, Mehran UET Jamshoro

[c] Ziauddin University, Karachi

[d] Institute of Environmental Engineering and Management, Mehran UET Jamshoro

[e] Institute of Environmental Engineering and Management, Mehran UET Jamshoro

Sindh is a province in Pakistan that is facing increasing environmental issues as a result of climate change, even though the nation only contributes 0.8% of global greenhouse gas emissions. Nonetheless, the effects are profound. Climate-related calamities cost Pakistan approximately $3.8 billion every year. Catastrophic floods, which destroyed millions of homes, drowned over 9 million acres of crops, and affected 33 million people, generated damages of $30 billion in 2022 alone. Sindh was particularly heavily struck, experiencing social displacement, food insecurity, and economic harm. A catastrophic heatwave that killed over 1,200 people in Karachi earlier in 2015 brought attention to the region's increasing vulnerability. The Sindh government established the Sindh Climate Change Policy 2022 to address these growing challenges, focusing on seven important climate-impacted sectors. Although the policy is a step in the right direction, the actual situation nevertheless shows increasing dangers and poor adaptation. Finding the primary obstacles preventing the policy's implementation in various areas is the major goal of this study. In order to close the gap between policy and action, it also looks at workable, situation-specific solutions. The objective is to help Sindh and Pakistan in general move towards a more sustainable and climate-resilient future by tackling these issues.

ICWEES-32

Enhancing soil carbon sequestration using biochar and vermicompost during an intercropping system"

Albab Iqbal, Muhammad Arshad, Iram Gul, Tayyaba Asim

Institute of Environmental Sciences and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology, Islamabad, Pakistan

Corresponding Email: albabiqbal126@gmail.com; marshad@iese.nust.edu.pk

Intercropping is an eco-friendly practice that improves the sustainability of farming systems whilst being considered a low-input approach. Maize (*Zea mays L.*) and mungbean (*Vigna radiata L.*) intercropping is a proven strategy to enhance land productivity, improve soil fertility, and promote environmental sustainability. Organic amendments such as vermicompost (VC) and biochar (BC) improve soil health, nutrient availability, and water-holding capacity, which can enhance plant physiological performance and stress tolerance. However, the comparative effects of VC and BC under single and double cropping systems remain underexplored. The present study was conducted to evaluate the physiological and biochemical responses, quality performance, and CO_2 sequestration potential of maize (*Zea mays L.*) and mungbean (*Vigna radiata L.*) under single and double cropping systems with biochar (1% per pot) and vermicompost (1% per pot) amendments. A pot experiment was conducted in greenhouse conditions with 36 pots arranged in a completely randomized block design with four replicates. Measurements included growth traits (shoot length, root length, leaf count, shoot and root biomass), physiological parameters (relative water content, membrane stability index, total chlorophyll content), and biochemical markers (hydrogen peroxide (H_2O_2), lipid peroxidation (MDA), and antioxidant enzymes — catalase (CAT), peroxidase (POD), and superoxide dismutase (SOD)). Vermicompost under double cropping produced the highest values for shoot length (89.9 cm), shoot fresh weight (9.14 g), relative water content (88.6–89.9%), and membrane stability index (86.92%). It also recorded the lowest H_2O_2 and MDA levels, along with the highest antioxidant activities (CAT 2.179 U/mg protein; POD > 2.3 U/g FW) in both crops. Biochar treatments significantly improved all measured parameters compared to the control but were generally less effective than VC. Control treatments showed the lowest growth, chlorophyll content, and physiological stability, coupled with the highest oxidative stress

indicators. The results demonstrate that vermicompost is more effective than biochar in enhancing biomass production, physiological stability, and oxidative stress tolerance in maize–mungbean systems, particularly under double cropping. Vermicompost application can therefore be recommended as a sustainable strategy to improve crop productivity and promote soil carbon sequestration.

ICWEES-33

Integrated Application of Vermicompost and Titanium Dioxide nanoparticles for Sustainable Crop Growth under Drought Stress Conditions

Aatika Murtaza, Muhammad Arshad

Institute of Environmental Science and Engineering (IESE), National University of Science and Technology (NUST) H-12, Islamabad

Corresponding Email: maatika231999@gamil.com, marshad@iese.nust.edu.pk

One of the most pervasive and destructive threats to global agriculture is drought, which threatens food security, reduces crop productivity, and makes it difficult for farming communities around the world to survive. Vermicompost (VC) and other organic amendments enhance soil health, nutrient availability, and water-holding capacity, while titanium dioxide nanoparticles (TiO_2 NPs) have demonstrated promise in improving plant physiological responses and drought stress tolerance. The combined effects of these factors under different drought intensities, however, are unexplored. The objective of this research was to investigate the independent and synergistic effects of vermicompost (1%) and titanium dioxide (20mg per kg of soil) on various physiological, biochemical and morphological parameters in maize plant under two different drought stress levels. A pot experiment was conducted in greenhouse conditions with 32 pots in a completely randomized design, including drought treatments at 60% and 30% field capacity. Growth parameters, chlorophyll content and relative water content improved more when vermicompost and titanium dioxide nanoparticles were applied together as compared to individual application in both drought conditions. Similarly, as compared to drought stress controls without any amendment, oxidative stress parameters like H_2O_2, MDA and Proline content were significantly reduced and membrane stability index improves under VC+TiO_2 treatment. Furthermore, catalyze, peroxidase and superoxide dismutase activities, which significantly increased with drought stress, were reduced to lower levels in each treatment under both stress conditions. These findings indicate that applying vermicompost and titanium dioxide nanoparticles together is a more efficient way to improve plant performance and lessen oxidative damage caused by drought. It may also be suggested as a sustainable way to increase crop resilience in water-limited environments.

ICWEES-34

Economic impacts of Nano-Technology, Artificial Intelligence and Environmental Pollution and Resilient Agricultural system on Human Health of Belt & Road Initiatives (BRI) Countries

Dr. Sana Fayyaz

Corresponding Email: sanafayyaz@bzu.edu.pk

The Belt and Road Initiative (BRI) represents a transformative global development strategy, integrating infrastructure, trade, and technological collaboration across participating nations. While emerging technologies such as Nano-Technology (NT) and Artificial Intelligence (AI) drive economic growth, their intersection with environmental pollution and agricultural resilience has profound implications for human health in BRI countries. This study investigates the dual-edged impact of NT and AI, which enhance agricultural productivity, precision medicine, and pollution control but also introduce risks such as job displacement, ethical dilemmas, and environmental degradation from nano-waste and energy-intensive AI infrastructure. Concurrently, rapid industrialization under BRI exacerbates air and water pollution, increasing the burden of respiratory and cardiovascular diseases, particularly among marginalized populations. Resilient agricultural systems, bolstered by AI-driven precision farming and nano-fertilizers, offer a pathway to sustainable food security and reduced ecological harm. However, unequal access to these technologies may widen socio-economic disparities, undermining health equity. Employing a mixed-methods approach, this paper synthesizes macroeconomic trends, public health data, and regional case studies to evaluate the trade-offs between technological advancement, environmental sustainability, and health outcomes. The findings underscore that the economic benefits of NT and AI are contingent upon stringent regulatory frameworks, inclusive policy design, and transnational environmental governance. The study concludes with actionable recommendations to align BRI's economic objectives with sustainable development goals (SDGs), ensuring that technological progress does not compromise long-term health and ecological resilience.

ICWEES-35

"Interactive Effects of Lead, Cadmium and Zinc on The Metal's Accumulation and Growth of Ornamental Plants in Multi-Metals Spiked Soils"

Iram Gul[1], Ghulam Mujtaba Shah[2], Imran Ahmad[3], Waqar Azeem Jadoon[4], Syeda Irsa Mazhar[5], Muhammad Arshad[1]*

[1]Institute of Environmental Sciences and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology, Islamabad, Pakistan

[2]Department of Botany, Hazara University, Mansehra, Pakistan

[3]Department of Geology, University of Malakand, Chakdara, Lower Dir, Pakistan

[4]Department of Earth and Environmental Sciences, Hazara University, Mansehra, Pakistan

[5]School of Interdisciplinary Engineering and Science, National University of Sciences and Technology, Islamabad, Pakistan

Corresponding Email: igul@iese.nust.edu.pk

Soil is the heterogenous mixture and contains various heavy metals. One plant may be affective in the remediation of specific metal but may not efficiently remove that metal in the presence of other heavy metals. Therefore, the present study was conducted to evaluate the interactive effects of heavy metals on each other's uptake and plant growth. For this purpose, soil was spiked with cadmium (Cd @ 150 mg kg-1), lead (Pb @ 1500 mg kg-1) and zinc (Zn @ 1500 mg kg-1) alone and in combinations. Two ornamental plants namely marigold and vinca were grown in spiked and control soil (No heavy metal added). Plants were exposed for 30 days, kept in greenhouse, watered daily, and illuminated with natural light. Both plant species were able to survive in soil spiked with single heavy metal. However, soil spiked with mixture of heavy metals reduced the plant dry biomass. The plants showed lower biomass in soil spiked with Pb+Cd and Pb+Cd+Zn. Among both studied ornamental plant species, marigold was able to survive in all treatments. The maximum toxicity was found in Pb+Cd treatment and Pb+Cd+Zn treatment as compared to the other treatments. Heavy metals have toxic impacts on the plant growth and metals accumulation. Ornamental plants have ability to accumulate and grow in multi-metals contaminated soil. But the mixture of heavy metals causes the phytotoxicity. Marigold has ability to survive in multi-metal contaminated soil and accumulated higher concentration of heavy metals in shoots.

ICWEES-36

Optimizing lettuce (Lactuca sativa) growth through sustainable coated fertilizers

*Saira Zafar[1], Iram Gul[1], Fouzia Perveen Malik[2], Muhammad Arshad[1], **

[1]Institute of Environmental Science and Engineering (IESE), National University of Science and Technology (NUST), H-12, Islamabad, 44000, Pakistan

[2]School of Interdisciplinary Engineering and Science (SINES), National University of Science and Technology (NUST), H-12, Islamabad 44000, Pakistan

Corresponding Email: marshad@iese.nust.edu.pk

Lettuce growth and production is highly influenced by environmental factors, quality and the functionality of the fertilizers. This comparative study assesses the effect of nano-biofertilizer coated diammonium phosphate fertilizer on the physical development of the lettuce under controlled greenhouse conditions. DAP granules were coated with three different amendments, containing plant growth promoting microbial consortia, titanium dioxide (TiO_2) nanoparticles and green synthesized graphene oxide (GO) nanoparticles to improve plant growth. Each coating was designed to promote plant growth via microbial activity, photocatalytic enhancements and surface functionalized nutrient delivery. Growth parameters were finally evaluated after 30 days of experiment and results demonstrated that all coated versions considerably increase the lettuce growth when compared to uncoated DAP. Chlorophyll content increased 56.6% in titanium dioxide coated DAP, 15.8% in biofertilizer coated DAP and 44.6% in graphene oxide coated DAP respectively. Similarly, overall plant height was improved by 16% in titanium dioxide 18% in graphene oxide meanwhile biofertilizer treatment resulted in 31% decrease in plant height. The findings highlight the ability of the functional fertilizers coatings to improve crop production, synthesis of innovative fertilizers, improving nutrient use efficiency, soil remediation and sustainable agriculture.

ICWEES-37

Estimating Ground-Level PM2.5 In South Asia Using Satellite AOD and Meteorological Data

Zainab Azam[1], Muhammad Zeeshan Ali Khan[1], Salman Atif[2]

[1]Institute of Environmental Sciences & Engineering, NUST, Islamabad, Pakistan

[2] Institute of Geographical Information Systems, NUST, Islamabad, Pakistan

Corresponding Email: azamzainab050@gmail.com; mzalikhan@iese.nust.edu.pk; salman@igis.nust.edu.pk

Air pollution remains one of the most pressing environmental and health issues in South Asia, where fine particulate matter (PM2.5) poses serious risks. However, monitoring PM2.5 is challenging due to the limited number of ground-based air quality stations. To address this gap, this study combines satellite observations with meteorological information to estimate ground-level PM2.5 concentrations. Specifically, MODIS Terra and Aqua Aerosol Optical Depth (AOD) products were used along with key meteorological variables such as temperature, dew point temperature, and wind speed. A set of eight regression models was tested using different combinations of predictors. For each monitoring site, the most suitable model was identified based on statistical strength and overall performance. These models were further validated using independent testing datasets. The results show that including meteorological variables with AOD data improves PM2.5 estimates compared to using AOD alone. Model performance varied across locations and satellite platforms. The correlation between observed and estimated PM2.5 ranged from 0.42 in Chennai (Terra) to 0.78 in Colombo (Terra). Error values (RMSE) ranged from 7.75 µg/m3 in Colombo (Aqua) to 48.57 µg/m3 in Lahore (Terra). Urban sites generally produced better results than heavily polluted inland regions, reflecting spatial differences in air quality dynamics. Overall, this study highlights the usefulness of a multi-source approach for PM2.5 estimation. The integration of satellite and meteorological data offers a practical way to monitor air pollution in regions with limited ground monitoring, which can help inform air quality management and policy planning.

ICWEES-38

A Deep Learning Framework for Real-Time Speed Violation Detection and Automated E-Challan Generation using YOLOv8, DeepSORT, and EasyOCR"

Javed Hussain, Muhammad Arbab Iqbal

Department of Computer Science, Sindh Madressatul Islam University, Karachi, Pakistan

Corresponding Email: javedshar2000@gmail.com, 2 arbabiqbal076@gmail.com

As urbanization accelerates, sustainable and intelligent traffic management systems are essential for building resilient and smart cities. Traditional enforcement methods relying on manual monitoring or radar are often inefficient, error-prone, and lack scalability. This study presents a real-time, AI-powered framework for speed violation detection and automated e-challan generation. The proposed system integrates YOLOv8 for vehicle detection, DeepSORT for multi-object tracking, and EasyOCR for license plate recognition in a fully automated pipeline. This com- bination enables the identification of over speeding vehicles, license plate recognition, and instant generation of challans without human intervention. The model was tested using real- world traffic videos and synthetic datasets. It achieved approximately 90% detection accuracy, 85% tracking accuracy, and 80% OCR accuracy, outperforming previous systems built with YOLOv5 and OpenALPR. The results highlight the framework's potential for real-world deployment in urban environments. Future improvements will focus on multilingual OCR, robustness in night time or adverse weather conditions, and seamless integration with smart city infrastructure like GPS and blockchain. Overall, this framework contributes a scalable, cost- effective, and intelligent solution to next-generation traffic enforcement systems.

ICWEES-39

Traffic Congestion Prediction Using Ai and Machine Learning

Muhammad Umer Waleed, Muhammad Bilal Awan, Muhammad Mehsum Khan

Corresponding Email: Mumerwaleed7@gmail.com, awa9bi1a1@gmail.com, mahsumkhan11@gmail.com

Urban traffic congestion is a growing challenge, exacerbated by rapid urbanization, increasing vehicular usage, and variable environmental conditions. Traditional traffic management approaches are often reactive and costly, with limited adaptability under adverse weather or atypical traffic patterns. This study develops and evaluates multiple machine learning (ML) models to predict traffic congestion in terms of *Level of Service* (LOS) per lane, incorporating both weather parameters and a binary holiday indicator to capture temporal variability. Using a six-month dataset from the Safe City Project, encompassing traffic counts, meteorological variables, and holiday information, we preprocess, normalize, and encode features before training models including Support Vector Machines, K-Nearest Neighbours, Linear Regression, Naïve Bayes, and Decision Trees. Model performance was assessed using classification accuracy, precision, recall, F1-score, and confusion matrices. Results indicate that integrating environmental and temporal variables significantly improves LOS prediction accuracy, with tree-based ensemble models outperforming others in both robustness and interpretability. By translating predictions into standardized LOS categories (A–F), the framework offers actionable insights for intelligent transportation systems, enabling adaptive traffic control, informed urban planning, and data-driven congestion mitigation strategies.

ICWEES-40

Water Quality Assessment and Nature-Based Restoration of University Lakes

Arooj Fatima[1]; Imran Hashmi[1]; Hira Amjad[1]; Hamza Farooq Gabriel[2]*

[1]School of Civil and Environmental Engineering (SCEE), Institute of Environmental Sciences and Engineering (IESE), National University of Sciences and Technology (NUST), Islamabad 44000, Pakistan

[2] School of Civil and Environmental Engineering (SCEE), NUST Institute of Civil Engineering (NICE), National University of Sciences and Technology (NUST), Islamabad 44000, Pakistan

Corresponding Email: farooj01@gmail.com, imranhashmi@iese.nust.edu.pk

Water is a critical resource that supports both environmental health and sustainable development. In countries like Pakistan, where water scarcity is becoming acute, the Integrated Water Resources Management (IWRM) framework is essential for ensuring water security. At the National University of Sciences and Technology (NUST), three artificial lakes and 11 wells were initially developed to support on-campus water storage, supply, and reuse. However, increasing pollution from university residential facilities, cafes, workshop, sports complex, saddle club, and adjacent sectors G-13 and H-13 has led to significant water quality degradation. This study evaluated the lakes' physicochemical, biological, and ecological conditions to determine their suitability for localized water management. Water, sediment, and aquatic vegetation were analyzed at six sampling points (inlets and outlets of each lake). Temperature (13.4–34.7 °C), electrical conductivity (EC) (570–1686 µS/cm), turbidity (24.6–90.2 NTU), total Kjeldahl nitrogen (TKN) (26.5–97.6 mg/L), phosphate (PO4-P) (0.47–0.75 mg/L), and dissolved oxygen (DO) (1.9–3.2 mg/L) exceeded the WHO thresholds. Chlorophyll a, b, and c levels (0.00007–0.0006 mg/L) were low, indicating oligotrophic conditions, while the chlorophyll content index (CCI) ranged from 3.7 to 165.3, peaking in *Stellaria graminea*. Microscopic analysis identified dominant algae, including *Nitzschia*, *Navicula*, and *Euglena* species, while atomic absorption spectrophotometry (AAS) quantified four heavy metals (Pb, Cr, Cd, and Zn), with Zn showing the highest concentrations in water (3.974 mg/L), sediment (4.021 mg/kg), and plant samples (5.302 mg/kg), likely exceeding WHO limits. ArcGIS Pro was used to generate spatial maps representing the quantitative distribution of physicochemical parameters. Pearson correlation analysis revealed

significant interactions between variables, emphasizing the need for integrated monitoring. Nature-based solutions (NBS) such as bioremediation and phytoremediation, were explored as restoration strategies. The study recommends enhanced wastewater control, ecological monitoring, and awareness initiatives to promote sustainable water practices under the IWRM framework.

ICWEES-41

An insight into the Role of Fibers and Issues in Advancing Sustainable Infrastructure with Engineered Cementitious Composites

M. Waqas Malik, M. Usman Farooqi*

Capital University of Science and Technology, CUST, Islamabad.

Corresponding Email: waqas.malik@cust.edu.pk, m.usman@cust.edu.pk

Engineered Cementitious Composites (ECC) are a class of high-performance fiber-reinforced cementitious materials characterized by their high ductility and crack control of less than 100 microns. The incorporation of fibers plays a pivotal role in imparting strain-hardening behavior and multiple micro-cracking in ECC, which distinguishes ECC from conventional concrete. This paper explores the role of fibers in the development of ECC, focusing on PVA, PE, PP, and Steel fibers, their mechanisms in enhancing mechanical performance and durability, and the comparative performance of these synthetic and natural fibers when used in hybrid form. Furthermore, the paper highlights recent advances in hybrid fiber systems and addresses the challenges associated with fiber dispersion, interfacial bonding, and long-term durability. Applications enhanced by fiber reinforced ECC in seismic structures, offshore structures, thin structures, and in the repair and rehabilitation of infrastructure are also discussed in the paper. It has been observed that high material costs and a lack of standardized codes are the main hindrances to the acceptance of ECC in the field. Addressing these challenges will be critical to transitioning ECC from a specialized material to a mainstream, sustainable solution for resilient and durable infrastructure.

ICWEES-42

Using machine learning models to predict the removal efficiency of an integrated constructed wetland (ICW) and assessing its water quality

Shaiza Siddique[1], Hassan Farooq[2*], Dr. Tayyaba Asim[1*], Prof. Dr. Imran Hashmi[1*], Dr. Humayoun Akram[1*], Muhammad Fahad Akram[1*], Prof. Dr. Iftikhar Hussain Adil[3*]*

[1,3,4] Institute of Environmental Sciences and Engineering, NUST-H12, Islamabad, Pakistan.

[2] School of Electrical Engineering and Computer Sciences, NUST-H12, Islamabad, Pakistan.

[3]School of Social Sciences and Humanities, NUST-H12, Islamabad, Pakistan.

Corresponding Email: shaizasiddique98@gmail.com

Water scarcity is becoming prevalent around the world due to increasing population and industrialization which is depleting the water resources as well. Conserving water is the prime goal of several nations, including recycling wastewater. Constructed wetland is one of the conventional and sustainable wastewater treatment technology; a man-made system that uses vegetation to recycle wastewater. The aim of the present study is to determine the performance efficiency of the ICW through various physicochemical and meteorological parameters. SPSS was used to find the correlation of various parameters and how they impact each other. Data-driven machine learning models are recently being used to predict the concentration of pollutants in the effluent of wetlands, improving their performance efficiency. Decision Tree model was used to predict the removal efficiency based on the past data of water quality parameters. The variables were COD, TSS, and Phosphates and features were temperature, pH, turbidity, electrical conductivity, and dissolved oxygen. RMSE (Root Mean Square Error) was calculated to find out the accuracy of predicted and actual values. The lower the RMSE value, the more accurate are the predictions. Also, the model described the correlation of COD, TSS, and Phosphates with other parameters that how change in different parameters affect the removal efficiency. STATA MP 17 was used to analyze the data collected from a survey conducted among the residents living nearby the ICW to address concerns regarding odor, health and aesthetics.

ICWEES-43

Forecasting Groundwater Consumption for an Urban Environment Using Machine Learning Techniques

Muhammad Usama[1], Muhammad Luqman[1,2], Muhammad Sajid[3,]*

[1] School of Mechanical and Manufacturing Engineering (SMME), National University of Science and Technology, H-12, Islamabad, 48000, Pakistan.

[2] KSB Pumps Company Limited, Rawalpindi, 46000, Pakistan

[3] School of Mechanical & Materials Engineering, Engineering & Materials Science Building, University College Dublin, Dublin D04 V1W8, Ireland.

Corresponding Email: muhammad.sajid@ucd.ie

Poor water management systems in major cities can be addressed by water consumption forecasting using multiple factors e.g., climatic data, population count, and water requirement. In this study, a primary dataset is obtained including water consumption of a 3 sq. kilometres urban site in Pakistan over the course of 7 years along with environmental variables like temperature, precipitation, humidity, wind speed, and population. The results indicate that time-series modelling is the best approach for forecasting problems that include environmental variables like temperature, precipitation, humidity, wind speed, population, and water consumption. Three distinct machine learning models, namely artificial neural network, Long Short-Term Memory (LSTM) models, and transformers, were rigorously evaluated. In terms of accurately forecasting urban water demand and supply, the proposed architectural framework of transformer models outperformed the other models, according to the evaluation results. The LSTM model has an R2 score of 0.31 for predicting monthly water consumption, whereas the transformer performed exceptionally well with an R2 score of 0.98. For further substantiation, annual water consumption forecasts are made for the transformer whose R2 score was 0.917. The proposed model has been successfully employed to forecast water consumption in all four seasons indicating that it is impactful for sustainable water resource management in an urban environment.

ICWEES-44

Eco-Engineered Green Walls and Roofs: Low-Tech Plant-Based Solutions for Sustainable Urban Resilience in Semi-Arid Climates

Abid Hussain, Muhammad Kabir*

[1]*Department of Biological Sciences Thal Univeristy Bhakkar, Bhakkar, 30000, Punjab, Pakistan*

Corresponding Email: abidhussain5malik@gmail.com

Urban centers in Pakistan face mounting environmental challenges—rising temperatures, air pollution, and inefficient water management—exacerbated by rapid urbanization and climate variability. This study explores eco-engineered green walls and roofs as sustainable, plant-based innovations to enhance urban resilience, with a focus on Bhakkar, a semi-arid and underrepresented region in Punjab, Pakistan. Modular green infrastructure systems, incorporating locally adapted drought-tolerant plants with phytoremediation potential, were installed on rooftops and building facades in Bhakkar's densely populated areas to assess their environmental performance. The systems utilized biodegradable coir-based substrates, compost-enriched soil, and advanced sensor-controlled drip irrigation employing real-time monitoring of soil moisture, ambient temperature, and humidity. Precision valves were automatically regulated by threshold-based algorithms using the sensor data. Over a 12-month period, key performance indicators—including thermal regulation, stormwater retention, particulate matter ($PM_{2.5}$) absorption, and carbon sequestration—were systematically evaluated. Results demonstrated a 35–45% reduction in surface temperatures, a 52% increase in stormwater retention, and up to 40% improvement in local air quality. Biomass analysis revealed enhanced carbon capture, while the sensor-regulated irrigation system reduced water consumption by 35% compared to conventional systems. These findings highlight the viability of eco-engineered green infrastructure in semi-arid cities like Bhakkar as a scalable solution for carbon-neutral, water-efficient, and climate-resilient urban development. This nature-based, technology-assisted approach aligns with Sustainable Development Goals (SDGs) and presents a practical, replicable model for sustainable urban planning in Pakistan and other climate-vulnerable regions with limited technological infrastructure.

ICWEES-45

Study on Water Foot Prints for Sustainable Water Resource Management in Agricultural Crop Production System

Waqar Ahmed Pahore[*1], *Abdul Hameed Memon*[2], *Saeed Ahmed Buriro*[3], *Nisar Ahmed Pahore*[4]

[1] *Lecturer, Department of Soil Science The University of Larkano*

[2] *Assistant Professor, Department of Soil Science The University of Larkano*

[3] *Assistant Professor, Department of Horticulture The University of Larkano*

[4] *Assistant Professor, Department of Social Sciences The University of Larkano*

Corresponding Email: Waqar.szabac@gmail.com

The water footprint refers to the total volume of water utilized in the production of agricultural or industrial goods. It encompasses both the direct and indirect water usage associated with the creation of any industrial or agricultural product. Analyzing the water footprint aids in the strategic planning for the efficient use of water across various sectors, ultimately contributing to the sustainable management of water resources. This review examines the methodology for estimating the Water Footprint, discussing its advantages and limitations, as well as the practical challenges associated with the available data and resources in both the Pakistani context and globally. As the population grows and industrialization expands, the challenge of ensuring adequate water availability and its effective distribution is increasingly confronting policymakers at government level as well as farmers using irrigation water for crop production in Pakistan. Existing statistics on water consumption, along with policies and awareness initiatives, primarily aim to minimize water waste and enhance efficiency in water usage. Research on water footprints across different regions of Pakistan indicates that climate change and agricultural practices have notably decreased water consumption. However, critical analyses of different crops based on the amount of water consumption per production level has not been studies so closely, hence this critical review presents the Water footprints of major crops grown in Pakistan along with helping policy makers and farming community to adopt sustainable water use management in crop production system.

ICWEES-46

GIS-Based Mapping and Analysis of Water-Stressed Communities Near Glacial Regions: A Case Study of Hunza Valley

*[1]Hassan Ali[*], [2]Syed Abbas Gillani,[3] M. Waqas Malik**

[1]Department of Civil Engineering, Capital University of Science and Technology, CUST, Islamabad. email: hassanali06488@gmail.com

[2]Department of Civil Engineering, Capital University of Science and Technology, CUST, Islamabad. email: Syedabbasgillani5@gmail.com

[3]Department of Civil Engineering, Capital University of Science and Technology, CUST, Islamabad. email: waqas.malik@cust.edu.pk

Glacial regions are among the most vulnerable to climate change, with cascading impacts on downstream water availability and community resilience. The glacier and snow-fed river basins of the Hindu Kush Himalaya (HKH) mountains provide water to 1.9 billion people in Asia. This study employs a Geographic Information System (GIS)-based approach to identify and analyze water-stressed communities in the Hunza Valley, a glacially influenced region in northern Pakistan. In the present study, temporal Landsat satellite images, acquired in the years of 1990 to 2025, were used to evaluate the temporal dynamics of the glaciers in the Hunza Valley**.** By integrating satellite imagery, hydrological data, and socio-economic indicators, spatial patterns of water scarcity were mapped and analyzed. Water-stressed zones were assessed through integrated spatial analysis, incorporating hydrological data, land use patterns, and socio-economic factors. Remote sensing and buffer analysis reveal significant reductions in glacier coverage and identify settlements within 5–10 km of major glaciers that face heightened water vulnerability. A series of thematic maps were developed to visually highlight vulnerable zones, offering insights into the geographic extent and severity of water stress. Thematic maps highlight the zones of water stress, with lower-altitude and densely populated areas emerging as the most affected. Findings underscore the critical need for sustainable water management, including rainwater harvesting and alternative water sourcing. This GIS-based approach offers a replicable framework for identifying and mitigating water stress in other glacial regions impacted by climate variability.

ICWEES-47

Removal Of Nickel from Synthetic Wastewater Using Acid-Treated Corncob Biochar

Namra Saleem[*], Kiran Hina[1], Zainab Haider , Maham Nawaz

Department of Environmental Sciences, University of Gujrat, Gujrat

Corresponding Email: namrasaleem122494@gmail.com

Water contamination is mostly caused by heavy metals from industrialization, waste disposal and human activities. Water contamination is a worldwide problem that has an impact on economic stability, sustainable development and human health. The heavy metals are persistence and have ability to affects local flora and animals along with human being. The development of effective, economical and environmentally friendly remediation techniques has become necessary due to the increasing levels of nickel contamination in wastewater. This study explores the possibility of using corncob biochar treated with nitric acid to remove nickel from synthetic effluent. A comprehensive analysis was conducted to determine how several operational parameters such as pH, contact time, initial nickel concentration and dose of biochar affected nickel adsorption. Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM) were used to evaluate the treated biochar in order to clarify the adsorption and surface modification mechanisms. The results show that the nitric acid treatment greatly increased the ability of corncob biochar to adsorb nickel with a maximum adsorption capacity of q_{max} 24.45 mg/g at ideal conditions. Freundlich constant K_f 4986.54 and Langmuir constant K_L 10.76 that counts the adsorption ability. The pseudo first and second order shows equilibrium adsorption capacity 5.24 mg/g and 40.03 mg/g respectively. Both the pseudo second order and Langmuir models provided acceptable fits to the adsorption kinetics and isotherms respectively. After three cycles in a row the treated biochar showed reduced adsorption capacity and outstanding stability and reusability. This comprehensive study indicates that nitric acid treated corncob biochar is a cost effective, environmentally friendly and efficient adsorbent for removing nickel from synthetic effluent.

ICWEES-48

"Effect of Tank Material on Biofilms and Residual Chlorine Dynamics in an Institutional Water Distribution System"

Aiza Javed[1]; Imran Hashmi[*1]; Hira Amjad[2]*

[1]Institute of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad 44000, Pakistan

[2]Pakistan Navy Engineering College (PNEC), Karachi, Pakistan

Corresponding Email: imranhashmi@iese.nust.edu.pk

Biofilm formation in drinking water storage tanks poses a significant public health risk due to its potential to harbor pathogenic microorganisms. This study investigated the influence of tank material and residual chlorine levels on biofilm-associated microbial communities within a university drinking water system. The research focused on physico-chemical and microbial analysis of water, monitoring the effects of residual chlorine, effect of tank materials including Reinforced Cement Concrete (RCC) and Polyvinyl Chloride (PVC) and temporal variations (15 and 30 days) on biofilm growth. Predominant microbial species were isolated and characterized using Scanning Electron Microscopy (SEM), while heavy metals in biofilms were analysed using an Atomic Absorption Spectrophotometer (AAS). Results showed that RCC tanks promoted denser biofilm growth and greater bacterial abundance and diversity than PVC tanks, likely due to their surface roughness and material properties. Significant bacterial growth was observed after 30 days. Water quality analysis revealed turbidity values (<5 NTU) within World Health Organization (WHO) and Pakistan Standards for Drinking Water Quality (PSDWQ) permissible limits, but dissolved oxygen (>8 mg/L), total suspended solids (>5 mg/L), and Most Probable Number (>23 MPN index) exceeded WHO/PSDWQ limits. Residual chlorine levels (0-0.18 mg/L at source) were found to be below WHO guidelines, increasing microbial contamination risk. Heavy metal analysis showed elevated iron (0.09–0.73 mg/L) and manganese (0.25–0.81 mg/L) concentrations after 15 and 30 days, exceeding WHO guidelines and posing health risks. The overhead storage tank in Zone-II was identified as a bacterial diversity hotspot, illustrated through heat maps generated using ArcGIS version 10.8. Overall, RCC tanks and low residual chlorine were critical

factors promoting microbial contamination and dense biofilm formation. It is recommended to monitor environmental factors influencing biofilm formation, maintain adequate chlorine levels, raise community awareness on safe water practices, and implement advanced molecular methods for specific bacterial identification.

ICWEES-49

Assessment of Micro plastics in Wetlands, with Physical and Chemical Analysis of Water Quality Parameters

Iqra Younis

Corresponding Email: mughalikra@gmail.com

Worldwide, micro plastics are entering in aquatic bodies due to increase in their production, usage and poor management techniques for plastics. In addition the rain water and wastewater are also the major source of micro plastics in aquatic environment. The artificial wetlands facilities serves both as research laboratories for environmental study while handling waste water treatment. The wetlands function as both biodiversity generator for diverse plant and animal species and also provide natural research area for pollution prevention studies. There is a few information in the literature about the possible effect of integrated constructed wetland. In previous studies there's no such detail information about physicochemical parameters but this study mainly focus on those parameters. This work is performed to assess the micro plastics in integrated constructed wetlands located in National University of sciences and technology (NUST) H12 campus, Islamabad Pakistan. The studies main objective are to assess the micro plastics by using physical analysis, water testing parameters and different characterization techniques. The samples were collected from inlet and outlet pond of wetlands. Sampling is followed by experimental analysis (wet peroxidation, density separation, and filtration). The characterization i-e Fourier Transform Infrared Spectroscopy (FTIR) done for the chemical composition of plastics and SEM (scanning electron microscope) for the identification of shapes and surface texture of polymers. The most common shapes of micro plastics in wetlands ecosystem is fiber, fragments and filaments. The water quality parameters of both ponds were also checked in this study. The polymer like polypropylene (PP), low density polyethylene (LDPE), high density poly ethylene (HDPE) and polystyrene (PS) were found.

ICWEES-50

Cost-Effective Phosphorous Recovery from Distillery Wastewater using Inherent Magnesium: An Economic Assessment"

*Raffia Siddique[1], Muhammad Ansar Farooq[1,2]**

[1]Institute of Environmental Sciences and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology, 44000, Islamabad, Pakistan

[2]CFAES Rattan Lal Center for Carbon Management and Sequestration, School of Environment and Natural Resources, The Ohio State University, Columbus, Ohio, 43210, USA

Recovering phosphorous from wastewater as struvite offers a win-win solution towards mitigating environmental challenges as well as organic production and sustainable agriculture. P recovery as Struvite is feasible but faces economic challenges due to required magnesium additives. This study analyzes distillery wastewater's inherent magnesium for cost effective resource recovery as struvite ($MgNH_4PO_4$) by optimizing N/P ratios using Visual MINTEQ. Results showed higher Mg/P molar ratios increased P removal, while increase in N/P ratio had minimal impact on P removal efficiency. Inherent nutrients yielded ~20% PO_4^{3-} removal with 2.3-2.5 g/L recovery as struvite and hydroxyapatite. Visual MINTEQ optimization of the N/P molar ratio revealed that a balanced N/P ratio (1:1) in excess of inherent Mg achieved ~65% PO_4^{3-} removal while Mg/N/P (1:1:1) using wastewater's inherent Mg increased the removal efficiency up to ~73%. Economic analysis for 90m^3/d wastewater indicate a financial return of ≥ $70/d. This study's limitations include wastewater's varying organic load and recalcitrant compounds, which presented challenges towards struvite crystallization and opportunities for future research. Future research should also include evaluating the agronomic potential precipitates in pot tests.

ICWEES-51

"A Systematic Review of the Use of Ambient Vibration Analysis for Masonry Structures"

Muhammad Hamza[1*], Muhammad Moazzam Ali[1], Muhammad Abdul Ahad[2], Muhammad Ali Makki[2]

[1*]*School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad 44000, Pakistan*

mhamza.ms23nice@student.nust.edu.pk

[2]*Department of Civil and Infrastructure Engineering, School of Engineering and Technology, Asian Institute of Technology, Pathum Thani 12120, Thailand*

St125499@ait.asia

Ambient Vibration Analysis (AVA) has proven to be one of the most effective non-destructive methods of evaluating the dynamic characteristics of masonry buildings, especially in the realm of historic preservation, seismic risk evaluation and for updating finite element models. This systematic review critically appraises the use of AVA on masonry structures through reviewing peer-reviewed articles that have been published in the past 20 years. It pays attention to methodologies, frameworks, deployment solution of sensors, modal identification techniques such as Frequency Domain Decomposition (FDD), Stochastic Subspace Identification (SSI) and Enhanced Frequency Domain Decomposition (EFDD). It points out the use of AVA to precisely identify modal parameters, including natural frequencies, damping ratios, and mode shapes, in ambient excitation without any forced inputs and operational pauses. Another major challenge outlined in the paper is the effect of environmental noise, low amplitude excitation of massive structures, and complications involved in the interpretation of signals because of heterogeneity of materials and geometric irregularities of masonry. New directions include AVA methods combined with AI-based damage detection and real-time monitoring systems. This review will help to further develop the knowledge about the possibilities and constraints of the AVA and can provide suggestions as to how it can be better used in structural health monitoring (SHM) and seismic evaluation of the masonry heritage structures.

ICWEES-52

Identification of Key Barriers to Construction 4.0 in Smart Cities: A case study from the construction industry of Pakistan

Saad Fawad Azim[a] , Maria Zulfiqar Awan[b] , Muhammad Faisal Noor[c], Rashid Bin Nazir[d], Syed Usama Farooq[e]

[a] National University of Technology I-12, Islamabad 4400, Pakistan – saadfawad05@gmail.com

[b]National University of Technology I-12, Islamabad 4400, Pakistan - mariazulfiqarawan1@gmail.com

[c]National University of Technology I-12, Islamabad 4400, Pakistan muhammadfaisalf19@nutech.edu.pk

[d]National University of Technology I-12, Islamabad 4400, Pakistan - rashidnazirf19@nutech.edu.pk

[e]National University of Technology I-12, Islamabad 4400, Pakistan- usamafarooqf19@nutech.edu.pk

Urbanization in the developing world, especially in Pakistan, has remained a rapid phenomenon, and undoubtedly it has increased its impact on the environment. To address this issue, a solution has been provided in the form of smart cities that will encourage sustainability by incorporating digital technologies. Nevertheless, construction, being the key to smart city development, remains stuck with traditional methods, constraining the achievement of sustainable initiatives. The Construction 4.0, comprising BIM, AI, robotics, and digital twins, has the potential to transform the construction industry, but the actual implementation level is low due to diverse impediments. This paper examines the major factors hindering the implementation of Construction 4.0 in the scope of smart city development by analyzing a case study of Smart City Islamabad. These barriers are identified, analyzed, and prioritized using Pareto analysis and machine learning-based optimization. The methodology is bringing out the most important barriers and interdependencies among them. The findings will assist policymakers, urban planners, and industry stakeholders in facilitating the digitalization of the construction sector, which has not been widely adopted yet, thus narrowing the gap between the smart city rhetoric and reality.

ICWEES-

ICWEES-53

Development and Performance Evaluation of Recycled Plastic Composite Drains for Sustainable Urban Stormwater Management

Muhammad Ameer Hamza [1], Muhammad Usama [2], Saad Ud Din [3], Fawad Ullah [1], Muhammad Suleman [3]*

[1]COMSATS University Islamabad, Abbottabad Campus, Department of Civil Engineering, Abbottabad 22060, KPK, Pakistan

[2] HafenCity University, Department of Geodesy and Geoinformatics, Hamburg 20457, Germany

[3] National University Of Science And Technology, NUST Institute Of Civil Engineering, Islamabad 44000, Pakistan

Corresponding Email: hamza.zeb940@gmail.com Tel.: +92-3151436874

Rapid urbanization and climate change are exacerbating urban flooding, overwhelming conventional concrete drainage systems. Simultaneously, plastic waste poses a severe environmental threat. This study presents an innovative, sustainable solution by developing open-channel drainage elements from recycled plastics—specifically Polyethylene Terephthalate (PET) and High-Density Polyethylene (HDPE)—and Waste Foundry Sand (WFS). A comprehensive methodology encompassing material processing, composite fabrication, and rigorous testing was employed. Over 150 composite mixes were evaluated for compressive strength and hydraulic efficiency (Manning's roughness coefficient). Results indicate that composite composition directly dictates performance: high-WFS composites (60-75%) achieved superior compressive strength (up to 5.59 MPa), while high-plastic composites (>70%) yielded minimal flow resistance (Manning's n as low as 0.0069). A balanced mix (40-60% WFS, 20-30% PET/HDPE) offered an optimal compromise (~5.4 MPa strength, n ≈ 0.010). A predictive machine learning model was developed to optimize mix designs based on target strength and hydraulic properties. The study concludes that recycled plastic composites are a viable, tunable, and sustainable alternative to traditional concrete drains, addressing both waste management and resilient infrastructure challenges.

ICWEES-54

Sensitivity, Seasonality, And Flood Hazard in The Kabul River Basin: Insights From 1963–2023 At Nowshera

Muhammad Ameer Hamza [1], Fawad Ullah [1], Muhammad Usama [2], Saad Ud Din [3], Ubaid Ullah [4]*

[1] COMSATS University Islamabad, Abbottabad Campus, Department of Civil Engineering, Abbottabad 22060, KPK, Pakistan

[2] HafenCity University, Department of Geodesy and Geoinformatics, Hamburg 20457, Germany

[3] National University Of Science And Technology, NUST Institute Of Civil Engineering, Islamabad 44000, Pakistan.

[4] Department of Civil Engineering, University of Wah, Pakistan

Corresponding Email: hamza.zeb940@gmail.com Tel.: +92-3151436874

The Kabul River is prone to frequent severe flood events, resulting in substantial damage to property, significant economic losses, and the displacement of residents in its vicinity. This research is centered on the Hydrology Irrigation Division Gauge Station located at the Kabul River Bridge in Nowshera, Khyber Pakhtunkhwa (KPK), Pakistan. It aims to analyze historical discharge data spanning from 1963 to 2023 by employing Gumbel and Log-Pearson Type III distributions. The primary goal is to detect patterns and annual trends in river discharge to enhance flood forecasting capabilities and formulate effective flood management strategies. Through sensitivity analysis, it was revealed that the curve number (CN2) is the most influential variable, with a 10% increase leading to a 20% surge in flow. Despite some underestimation, the model's calibration and validation demonstrate accurate peak timing. Both observed and simulated flows exhibit peak levels from June to September, showcasing annual variations. However, the precision of flood frequency analysis is contingent upon the accuracy of historical data. Future studies should incorporate climate change predictions to evaluate their impact on flood frequency. The study concludes that the Log-Pearson Type III distribution is the most appropriate for predicting future flood events, underscoring the substantial risk posed by 100-year return period floods. This information is crucial for informing infrastructure projects, disaster preparedness, and policy development to safeguard Nowshera.

ICWEES-55

RSM-Guided Synthesis and Optimization of GQD/ZnO Nanoadsorbents for Efficient Removal of Textile Dye from Aqueous Solution"

Ayesha Arshad[1], Samia Khan[1], Nadia Riaz[1], Muhammad Saqib Khan[1], Muhammad Asif, Muhammad Younas Afzal[2], Ahsan Jabbar Shaikh[2], Muhammad Bilal[1]

[1]Department of Environmental Sciences, COMSATS University Islamabad Abbottabad Campus

[2]Department of Environmental Sciences, COMSATS University Islamabad Abbottabad Campus

Corresponding Email: mbilal@cuiatd.edu.pk

Environmental sustainability has become a pressing global priority, necessitating innovative strategies to conserve natural resources and mitigate ecological degradation. Among various pollutants, synthetic industrial dyes pose a significant threat to aquatic ecosystems, adversely affecting water quality and the survival of aquatic organisms. This study addresses the removal of Reactive Blue 15 (RB15) dye using a Response Surface Methodology (RSM)-guided synthesis of graphene quantum dot (GQD)-modified zinc oxide (ZnO) nanoadsorbents (GQD/ZnO). Nanoadsorbents were synthesized under both RSM-optimized and manually optimized conditions, enabling a comparative evaluation of resource utilization, adsorption efficiency, and optimal operating parameters. Experimental design was based on the Central Composite Design (CCD) of RSM, in which ZnO nanoparticles were synthesized at calcination temperatures of 300, 400, and 500 °C, while GQD/ZnO composites were prepared by incorporating 1%, 2%, and 3% GQDs into a constant ZnO dosage. RSM analysis determined that pH 9 and a calcination temperature of 550 °C yielded optimal ZnO properties, whereas 1% GQD loading and 300 °C calcination produced the most effective nanohybrid (1%GQD/ZnO-300). Optimized adsorption parameters for RB15 removal were identified as an initial dye concentration of 30 mg L^{-1}, adsorbent dosage of 1 mg L^{-1}, pH 4, and an equilibrium time of 30 minutes. Under these conditions, the RSM-guided synthesis and application strategy outperformed manual optimization in both efficiency and resource conservation. Density Functional Theory (DFT) simulations revealed higher interaction energy between RB15 and 1%GQD/ZnO-300 compared to pristine ZnO, indicating enhanced adsorption affinity at the atomic scale. Characterization confirmed a nanorod-like morphology and the presence of surface functional groups, including carboxylic, hydroxyl, nitrate, and carbonyl

moieties, in the 1%GQD/ZnO-300 nanohybrid. Reusability studies indicated a 65% loss of adsorption efficiency after five regeneration cycles, accompanied by notable shifts in major peaks, suggesting partial structural and surface modification. Overall, the findings establish RSM-driven synthesis and adsorption optimization as a superior approach for efficient RB15 dye removal, balancing high adsorption capacity with sustainable resource usage.

ICWEES-56

Feasibility Investigation of Frictional Base Isolation Material for Masonry Buildings

Imran Ullah[a,b], Muhammad Usman*[a]

[a]*School of Civil and Environmental Engineering, National University of Sciences and Technology (NUST), Sector H-12, Islamabad, Pakistan.*

[b]*Department of Civil Engineering Technology, University of Technology, Nowshera, Pakistan.*

Corresponding Email: imranullahdallan@gmail.com; m.usman@nice.nust.edu.pk

Unreinforced masonry buildings are residential units of middle class that can not effort conventional base isolators like elastomeric bearings, lead-rubber bearings, etc. Frictional base isolation is a low cost technique that decouple the super structure from sub structure to dissipate seismic energy. Although different materials have been investigated for frictional base isolation but still there is a need of environmental friendly materials to be investigated. Material with low coefficient of friction, enough compressive strength to with stand against sliding and compact elastic microstrucrture are considered suitable for frictional base isolation materials. This research investigates control mortar, resin mortar, rubberized resin mortar (fine), and rubberized resin mortar (coarse). Moreover, microstructural study is carried out for analysis. Based upon the results, rubberized resin mortar (fine) is considered to be suitable as frictional base isolation material.

ICWEES-57

Accident Analysis on Construction Sites in Pakistan: Causes and Prevention Strategies

Muhammad Mursaleen,Awais Bashir, Chaudhry Muhammad Shahram Akbar

NUST School of Civil and Environmental Engineering, National University of Sciences and Technology NUST H-12, Islamabad, Pakistan

Corresponding Email: muhammadmursaleen2002@gmail.com, awaiskalyar78@gmail.com, shahramkhan056@gmail.com

The construction industry of Pakistan has its significance in the growth and development of the country as it helps in providing employment to millions and erects infrastructural facilities in the country. Nevertheless, it remains one of the deadliest industries with high risks of fatal and non fatal calamities and mishaps. This study aims at identifying the causes of construction-site accidents, their impacts and preventive measures in Pakistan. The causes of accidents found from the study are lack of skilled workforce, occupational hazards, substandard equipment, culture of prioritizing time over adherence to safety measures, and feeble observational check and balances. These accidents lead to massive loss of lives, money and also bring reputational losses. To deal with these risks, the study suggests increased training schedules, higher standards in workplace safety, better systems of reporting work-related mishaps, and expenditure in protective gear. Aspects such as commitment to safety culture and the application of effective systems in the management of safety are likely to reduce the frequency of accidents in the construction industry in Pakistan hence protecting the lives of the personnel and increasing operational productivity

ICWEES-58

Optimization of a Moving Bed Sequencing Batch Reactor for Treating Oil Refinery Wastewater

Momina Maheen, Kamran Manzoor, Sher Jamal Khan, Kanwal Anwar*

Institute of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad, Pakistan.

Corresponding Email: mominamaheen99@gmail.com; kamranmunzoor@hotmail.com; s.jamal@iese.nust.edu.pk;

The oil refinery wastewater, distinguished by a high organic load and oil content, was effectively treated using a moving bed sequencing batch reactor (MBSBR). MBSBR integrates the benefits of both sequencing batch reactor (SBR) and moving bed biofilm reactor (MBBR) techniques, operated in sequencing batch mode, resulting in improved treatment performance. The performance of lab-scale aerobic MBSBR was investigated for oil refinery wastewater with a chemical oxygen demand (COD) concentration of 810 ± 30 mg/L. The study intent to analyze the performance of carrier media filing ratios (FR) and hydraulic retention time (HRT) on treating oil refinery wastewater as well as to determine the optimal value for both parameters. The experimental investigation included optimization of parameters by varying filling ratio ranging from 10 to 40% and hydraulic retention time from 6 to 24 h. The COD, BOD, oil and Ammonium-N (NH_4-N) removal efficiencies were determined to be 88.43, 88.50, 86.21 and 88.72%, respectively at the optimum filling ratio of 30% and hydraulic retention time of 18 h. The morphology of biofilm shows that the biofilm thickness was larger at lower HRT as compared to higher HRT. Overall, this study provides a better understanding of oil refinery wastewater treatment by identifying the optimal values of media FR and HRT in the MBSBR.

ICWEES-59

Water Quality Analysis and Characterization of Antibiotic-Resistant Bacterial Strains in the Nilan Kas, Khanpur Dam

Muhammad Fahad Akram, Imran Hashmi, Nazish Iftikhar

Institute Of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad 44000, Pakistan

*Corresponding author: imranhashmi@iese.nust.edu.pk. *

Water reservoirs are the main source of water-borne infections in humans. A surge in bacterial infections increases the use of antibiotics. Excessive reliance on antibiotics results in prevalence of antibiotic-resistant bacteria which pose a serious threat to public health. This study investigates water quality and accesses the bacterial resistance of Nilan Kas, Khanpur Dam. Environmental samples were collected from three sites (Up, Mid and Downstream) for physicochemical parameters, in addition, bacterial strains including *Salmonella spp, Escherichia coli, Shigella flexneri and Klebsiella pneumoniae* were isolated. Kirby disc diffusion assay was used to determine the susceptibility of bacterial isolates against 7 different antibiotics (ampicillin, levofloxacin, ofloxacin, ciprofloxacin, trimethoprim, tetracycline and metronidazole). The results showed increase in alkalinity (310 mg/L), COD (160–192 mg/L), and phosphates (3.94–4.79 mg/L), all above PSDWQ and WHO limits, indicating significant water pollution. Microbial analysis revealed that sediments samples had considerably greater bacterial loads ranging from 3.0E+00 to 4.50E+00 Log10 CFU/ml than water samples fluctuated from 2.40E+00 to 3.68E+00 Log10 CFU/ml across all three-culture media namely Coliform select agar (CS), Brilliant green agar (BGA) and Salmonella Shigella agar (SSA). This depicts that in the aquatic environment, sediments act as vital reservoirs for enteric bacteria. Sediment samples often displayed rising bacterial concentrations from upstream to downstream stations, especially for pathogens on BGA and SS Agar. This indicates a possible downstream accumulation of microbial pollution, although water samples consistently displayed low counts. The antibiotic susceptibility test showed 7 bacterial isolates (from water and sediment) were highly resistant to six tested antibiotics. Tetracycline and levofloxacin exhibited limited efficacy among the antibiotics, with several

isolates demonstrating intermediate or sensitive reactions in comparison to resistant isolates. The existence of highly resistant bacteria, specifically *E. coli*, *Shigella*, and *Salmonella*, in environmental samples emphasizes a significant public health issue and reinforces the immediate necessity for monitoring antibiotic resistance in aquatic ecosystems.

ICWEES-60

Performance Evaluation of Acetone-Treated Expanded Polystyrene Angular Light Weight Aggregates for Rigid Pavements

Azan Hassan Khan[*]*, Arshad Hussain*

NUST Institute of Civil Engineering (NICE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad, Pakistan

Corresponding Email: azanhassankhan@gmail.com

Expanded polystyrene (EPS) waste has raised environmental concerns due to its abundant use in disposable items. Although EPS provides advantages in construction by decreasing structural loads, its integration into concrete compromises mechanical performance, restricting wider application. This work mitigates this constraint by investigating an innovative method: producing angular lightweight coarse aggregates (ALCA) from EPS waste utilizing acetone as a solvent, with the intent of using it in structural concrete for rigid pavements and evaluating their performance as aggregates and in the concrete mix versus normal aggregates while adhering to circular economy principles and conserving natural aggregate sources. The methodology involved fabricating ALCA by dissolving EPS waste in acetone and letting it dry, followed by breaking it into ALCA. By dissolving EPS in acetone, its volume reduces, significantly increasing EPS diversion per concrete batch, and drying it results in an ALCA, which is apparently harder than the usual EPS beads used in concrete. The replacement ALCA composition used in concrete is 0%, 15%, 50%, and 100%. The results indicated that ALCA are 3.8 times lighter and have 14.3 times more absorption capacity, while being 3.9 times more impact resistant and 1.7 times more abrasion resistant relative to normal aggregates but lack crushing resistance. Additionally, increasing LWA content from 15% to 100% leads to compressive strength reduction from 14.77% to 63.46% and dry density reduction from 4.01% to 24.52% compared to conventional concrete. Thus, ALCA can be used for rigid pavements, but for high load demands, lower ALCA proportions should be used.

ICWEES-61

Thermal-Hydraulic Performance Enhancement of Finned Plates Through the Placement of Geometrical Protrusions on Fin Edges: A Computational Study

Zargham Ahmad[a,b,*], *Syed Maaz Hasan*[a,b,]

[a] *School of Mechanical and Manufacturing Engineering, National University of Sciences and Technology, H-12, Islamabad, Pakistan*

[b] *Artificial Intelligence for Mechanical Systems (AIMS) Lab, School of Interdisciplinary Engineering and Sciences, National University of Sciences and Technology, H-12, Islamabad, Pakistan*

Corresponding Email: zahmad.me20bsmme@student.nust.edu.pk

This study presents a numerical investigation, using Finite Element Analysis (FEA), of the thermal–hydraulic performance of finned plates commonly employed in heat exchanger applications. The primary objective is to evaluate the influence of protrusions of various geometries attached to the lateral surfaces of the fins on heat transfer enhancement and flow characteristics. Five distinct protrusion geometries are considered: (a) semicircular, (b) spherical, (c) triangular, (d) pyramidal, and (e) complex tooth-shaped forms. Three-dimensional models are developed in SolidWorks and simulated in ANSYS/COMSOL under steady-state conditions to assess their impact on fluid flow patterns, turbulence intensity, and heat transfer rates. The proposed protrusions are designed to interrupt boundary layers, induce localized turbulence, and increase surface area, thus improving convective heat transfer alongwith potentially affecting pressure drop. Presented analysis includes velocity distribution, temperature fields, and Nusselt number evaluation for each geometry, with the aim of identifying the most effective design for enhanced performance. The presented work aims to provide design guidelines for optimizing fin surface modifications in compact heat exchangers, balancing thermal gains against hydraulic issues.

ICWEES-62

Parametric Study of Die-Sinking EDM for Titanium Diboride with Varied Electrodes

*Muhammad Tayyab[a,b], *, Syed Maaz Hasan[a,b]*

[a] *School of Mechanical and Manufacturing Engineering, National University of Sciences and Technology, H-12, Islamabad, Pakistan*

[b] *Artificial Intelligence for Mechanical Systems (AIMS) Lab, School of Interdisciplinary Engineering and Sciences, National University of Sciences and Technology, H-12, Islamabad, Pakistan*

Corresponding Email: mtayyab.me22smme@student.nust.edu.pk; maaz.hasan@smme.nust.edu.pk

Titanium diboride (TiB_2) is a type of ultra-high temperature ceramic (UHTC) known for its exceptional hardness, high melting point, and excellent oxidation resistance. It is ideal for demanding industrial applications like cutting tools, wear-resistant components, and thermal protection in high-temperature manufacturing environments. TiB_2's exceptional hardness and brittleness pose problems for traditional machining processes, resulting in excessive tool wear and potential workpiece damage. Electrical Discharge Machining (EDM) die sinking is a potential option for precise shape of electrically conductive ceramics without producing mechanical stress. This study analyzes die-sinking EDM of TiB_2 using copper, graphite, and copper-tungsten electrodes. A Taguchi orthogonal array design was used to assess the effect of major process parameters—pulse on time, pulse off time, discharge current, gap voltage, and auxiliary jet flushing height—on material removal rate (MRR), surface roughness (Ra), tool wear rate (TWR), and dimensional overcut. Experiments were conducted on sintered TiB_2 specimens with IONOPLUS 3000 dielectric oil to maintain steady discharge conditions and minimize fume formation.

The findings offer statistical insight into the relationship between electrode material qualities and machining responses, as well as optimal parameter sets for roughing, semi-finishing, and finishing processes. This work provides practical suggestions for efficient EDM processing of TiB_2, making it more suitable for high-performance industrial applications that need precision, surface integrity, and productivity.

ICWEES-63

Vibration Control through Nonlinear Vibration Absorbers

Aaqib Najeeb [a], Zili Zhang [a], Muhammad Usman [b].*

[a]Department of Structural Engineering, College of Civil Engineering, Tongji University, Shanghai,200092, China. Email: aaqib_najeeb@tongji.edu.cn & zili_zhang@tongji.edu.cn

[b]NUST Institute of Civil Engineering (NICE), National University of Sciences and Technology (NUST), Islamabad, Pakistan. Email: m.usman@nice.nust.edu.pk

Structural safety and durability are often compromised by vibrations induced by wind and earthquakes. Linear dynamic vibration absorbers (DVAs), particularly tuned mass dampers (TMDs), are widely used but suffer from detuning. In contrast, nonlinear DVAs such as nonlinear energy sinks (NES) offer improved performance by exploiting Resonant Capture Cascade (RCC), whereby the damper sequentially targets dominant energy modes. The transition time between modes, known as pumping time, serves as a key indicator of NES efficiency. Unlike TMDs with linear restoring forces, NES devices employ nonlinear restoring forces that allow both softening and hardening behaviors. This study investigates the performance of different NES configurations, including Purely Cubic NES, Cubic NES, and Track NES with Bi-stable and Asymmetric types. Each configuration was modeled as a three degree-of-freedom (DOF) system, with the first two DOFs representing the primary structure and the last DOF corresponding to the auxiliary system. The governing equations of motion were numerically solved in MATLAB using the adaptive Runge–Kutta 4(5) (RK45) method, and the responses of the NES-equipped systems were compared against those of the uncontrolled structure. Results demonstrate that NES can achieve significant vibration reduction over a wider frequency bandwidth, although their efficiency remains dependent on the input energy level. The configuration with the lowest square root of the sum of squares (SRSS) value and the highest vibration reduction was identified as optimal.

ICWEES-64

Greening Campuses: Carbon Footprint Analysis for an Educational Institution in Islamabad

Sanober Sahar[1], Rabeea Zafar[1], Seema Andleeb[2], Muhammad Farooq Mustafa[1] & Nazia Iftakhar[1]*
[1]Department of Nutritional Sciences and Environmental Design, Faculty of Sciences, Allama Iqbal Open University, Sector H-8, Islamabad, 44000, Pakistan
[2]SADA, National University of Sciences and Technology (NUST), Sector H-12, Islamabad, 44000, Pakistan
Corresponding Email: aini.chf@gmail.com

Carbon Footprint (CF) analysis in educational facilities is an indispensable step towards achieving sustainable campus procedures and aligning with national climate goals. The rapid increase of greenhouse gas (GHG) emissions from academic operations necessitates targeted assessment for emission reduction. This study represents the first inclusive carbon footprint analysis of selected building at Allama Iqbal Open University, Islamabad. The objective was to quantify the emissions from heating and cooling, waste, and transportation to identify intrusion points. A mixed approach was employed, including primary data from site surveys, operational records, by the side secondary data from available literature. To calculate Scope 1, 2, and 3, the IPCC Greenhouse Gas Protocol was used. Statistical analysis reveals that natural gas consumption is the primary source for heating in winters, contributing 205,719.9 tCO_2e/ year, followed by transportation, which is 85.6 tCO_2e/year. According to the results, electricity consumption totaled 3,760 kWh annually, resulting in 2.5764639 tCO_2e/year, with a notable decline after the solar panel installation. Waste generation was estimated at 532.9 kg annually, resulting in 0.270212 tCO_2e / year. Transportation analysis revealed that 81% of respondents acquire multiple transport modes, with 52% relying on public transport and 33% on private vehicles, predominantly diesel and gasoline cars. Private vehicles are the main source of generating 51.8t CO_2e/year. This study provides actionable recommendations and proposed measures, including full digitalization to eliminate paper use, installation of renewable energy infrastructure, and promotion of sustainable transport, along with structured waste segregation. Beyond assessing the environmental impact, this evaluation presents a scalable framework for other educational institutions in developing countries aiming for carbon neutrality.

ICWEES-65

Sustainable Smart Car Parking Multistory Building

Rizwan Ullah, Muhammad Zeshan Jamil

Department of Mechanical Engineering, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan

Department of Electrical Engineering, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan

Corresponding Email: rizwanullah.me@gmail.com

Urban centers face increasing challenges due to population growth, limited parking space, and inefficient vehicle management. The rise in car ownership has led to severe traffic jams, fuel waste, time delays, and environmental stress, creating an urgent need for innovative parking solutions. This project addresses the urban parking crisis by proposing a sustainable, multi-story smart car parking system integrated with mechanical innovation and energy-saving features. The proposed design introduces a mechanical lifting mechanism capable of parking and retrieving up to three vehicles simultaneously, utilizing advanced automation and sensor integration for seamless operation. The system focuses on minimizing space consumption, reducing parking time, and enhancing operational efficiency while maintaining cost-effectiveness and reliability. An energy harvesting mechanism is also incorporated, which stores gravitational potential energy during vehicle descent, contributing to the system's overall energy sustainability and reducing operational costs. The methodology involves a phased approach: initial concept development and comprehensive problem analysis, followed by detailed digital 3D modeling using SolidWorks, including comprehensive motion studies to analyze the mechanical performance and safety parameters. The system's feasibility will be demonstrated through a fully developed digital concept model, motion analysis, and performance evaluation metrics. This innovative project highlights a practical and efficient solution for urban infrastructure challenges, with significant potential to support sustainable transportation networks and smart city initiatives. The design's mechanical simplicity, combined with its energy efficiency and operational functionality, offers a highly scalable and economically viable model for modern urban environments facing increasing urbanization pressures.

ICWEES-66

Optimised Energy Dissipation in Buildings Using Efficient Base Isolation Systems A Literature Based Analysis

a Syed Abbas Gillani, b Majid Ali

a: Department of Civil Engineering, CUST, Islamabad. syedabbasgillani5@gmail.com

b: Department of Civil Engineering, CUST, Islamabad. majid.ali@cust.edu.pk

Corresponding Email: syedabbasgillani5@gmail.com

Each year, earthquakes result in significant loss of life, homes, and communities. Earthquake occur due to the sudden release of energy caused by the movement or collision of tectonic plates. This energy generates a shearing force at the foundation of structures, known as base shear, which can have a damaging impact on the entire building. This paper provides an extensive review of research papers from the last one decade, focusing on their working and performance during seismic activity. The base isolators are categorized into Elastomeric Isolators and Sliding Isolators. All the types of these base isolators were reviewed from highly reputable journals for their energy dissipation mechanism, recentering capability, and applications. The experimental data and performance in real-world scenarios show that base isolation reduces base shear, structural acceleration, and inter-story drifts up to a great extent, protecting both the structure and its occupants. The study concludes that by using appropriate BIs for structures can reduce the seismic effect and enhance the serviceability and structural resilience. Future studies should investigate the response of base isolators in detail through experimentation, typically on HDRBs, LRBs and DCPBs in order to move towards safe and resilient structural system.

ICWEES-67

Ergonomics in Construction Industry: Evaluating Quick Postural Training Effectiveness for Bricklayers in Pakistan

[a] Abdullah Adnan, [b] Muhammad Atta Mustafa, [c] Muhammad Uzair Iqbal Malik, [d] Khola Riaz, [e] Hasnain Ali, [f] Dr.Khursheed Ahmed

a: Department of Construction Engineering & Management, National University of Science and Technology, Islamabad, Pakistan, abdullahadnan45@gmail.com.

b: Department of Construction Engineering & Management, National University of Science and Technology, Islamabad, Pakistan, attamustafa280443@gmail.com.

c: Department of Construction Engineering & Management, National University of Science and Technology, Islamabad, Pakistan, malikuzair205@gmail.com.

d: Department of Construction Engineering & Management, National University of Science and Technology, Islamabad, Pakistan, engr.kholariaz@gmail.com.

e: Department of Construction Engineering & Management, National University of Science and Technology, Islamabad, Pakistan, hasnainali1749@gmail.com.

f: Department of Construction Engineering & Management, National University of Science and Technology, Islamabad, Pakistan, khursheed@nice.nust.edu.pk

The brick kiln works in Pakistan are a major industry, but the workers are subjected to numerous risks due to the nature of manual repetitive work with a bad practice of postural practice. Despite international studies indicating that there are musculoskeletal disorders (MSDs) among bricklayers, there is a research gap on the particular conditions in Pakistan. The purpose of this study is to evaluate the effectiveness of a brick kiln Quick Ergonomics Training to mitigate these risks. An initial assessment, using the Manual Handling Assessment Charts (MAC) tool, identified that there were significant ergonomic hazards regarding the lifting, carrying and team handling activities. Considering the workers' low literacy level, a series of Quick Ergonomic Trainings, providing working instructions on safe body mechanics, micro-breaks, and environmental improvements, were developed and delivered through visual aids and on-site demonstrations. Following the trainings, workers' feedback was collected and documented via. post training evaluations using verbal questionnaires and observational audits. The workers' reported significant improvements in ergonomic practices at work and MSDs symptoms, especially in the lower back and knees. The study highlights that short, practical ergonomics training can significantly increase workplace safety and health outcomes in Pakistan's brick kiln sector.

ICWEES-68

Bioaccumulation of Heavy Metals in Native Plant Species: Implications for Environmental Sustainability

Ayesha[1], Zaki ul Zaman Asam[1*],Muhammad Naeem[1], Mujahid Farid[1], Mohsin Abbas[2], Ghulam Mustafa[3]*

[1]Department of Environmental Sciences, University of Gujrat, Gujrat, Pakistan

[2]College of Health Sciences, University of Buraimi, Oman

[3]Department of Chemistry, University of Gujrat, Gujrat, Pakistan

For the assessment of the soil contamination and bioaccumulation of the heavy metals in different parts of plants, soil and plant samples (*Cannabis sativa and Ricinus dentratus*) were collected around 10 different dumpsites located in Dinga, Punjab, Pakistan. The soil samples were evaluated for the various physicochemical properties including pH, electrical conductivity (EC), organic matter (OM) and heavy metals such as cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni), and copper (Cu). The different parts of plants like roots, stems and leaves were cut down into small pieces for the assessment of the effect of heavy metals on various plants tissues. The results obtained were compared with various established regulatory standards and evaluated for the statistically significant difference in concentration across various parts of plant by using t-test. In soil samples, the measured concentration of Cd (up to 42.6 mg/kg), Cr (up to 347.1 mg/kg), Ni (up to 238.4 mg/kg), Pb (up to 876.4 mg/kg) and Cu (up to 856.2 mg/kg) was found well over the tolerable range of concentration prescribed by World Health Organization (WHO) for agricultural soil (table 1). Significant bioaccumulation of the of heavy metals in different parts of both Cannabis sativa and *Rumex dentatus* observed, compared to the control sites. For Cannabis sativa, the accumulation Cd, Cr, Pb, Ni, and Cu in roots, stems, and leaves with concentration reaching up to 10.25 mg/kg for Cd, 40.64 mg/kg for Pb, and 35.17 mg/kg for Cr. In the same way, *Ricinus dentatus* also exhibited heightened concentration with Cd reaching up 8.24 mg/kg, Cr up to 37.41, Pb up to 182 mg/kg, Ni up to 72.32 mg/kg and Cu up to 189.7 mg/kg in roots and markedly exceeded the levels observed at the control sites. These elevated concentrations highlight the potential risk of heavy metal contamination through plant uptake in the studied areas.

ICWEES-69

Development of limestone calcined clay cement (LC3) in Pakistan

[a] *Anis Ul Hasnain,* [b] *Sahbanullah,* [c] *Waqas Haroon,* [d] *Muhammad Noman*

a: Department of Civil Engineering, International Islamic University, Islamabad, Pakistan. anis.bsce245@iiu.edu.pk

b: Department of Civil Engineering, International Islamic University, Islamabad, Pakistan. sahban.bsce280@iiu.edu.pk

c: Department of Civil Engineering, International Islamic University, Islamabad, Pakistan. waqas.haroon@iiu.edu.pk

d: Department of Civil Engineering, International Islamic University, Islamabad, Pakistan. muhammad.noman@iiu.edu.pk

The growing environmental impact of cement production has created an urgent need for low-carbon, sustainable alternatives. In Pakistan, traditional construction practices lead to excessive energy consumption, resource depletion, and harmful emissions, contributing significantly to ecological degradation. This study aims to develop and assess limestone calcined clay cement (LC^3) using locally available materials to reduce environmental harm while maintaining structural performance. LC^3 has been produced by partially replacing clinker with calcined clay and limestone. Standard mortar cubes were prepared and tested for compressive strength at 7 and 28 days. FTIR and XRD analyses were conducted to identify the main reaction products, and SEM imaging was used to observe the internal microstructural development. These techniques provided valuable insight into material behavior and confirmed the formation of stable binding phases. Even with a lower clinker content, the developed LC^3 blend demonstrated consistent strength development, achieving compressive strengths of 19.1 MPa at 7 days and 26.8 MPa at 28 days. The results demonstrated acceptable mechanical strength, and reliability for long-term use along with its environmental benefits. This study provides a scalable, environmentally friendly solution to encourage sustainable building practices throughout the region, supporting the practical adoption of LC^3 cement in Pakistan.

ICWEES-70

Tools and Techniques for Identifying Barriers to Construction Waste Minimization for Sustainable Developments

Muhammad Usman Shahid[1,], Majid Ali[2]*

[1,2]Department of Civil Engineering, Capital University of Science and Technology, Islamabad, 45750, Pakistan.

Corresponding Email: usman.shahid@iefr.edu.pk; majid.ali@cust.edu.pk

Sustainable development in the construction sector necessitates the effective implementation of waste minimization (WM) strategies. However, the presence of multiple, often subjective, barriers has hindered the widespread adoption of such strategies. This study evaluates key analytical tools employed in previous research to identify and analyze these barriers within building projects. A critical review of four major multi-criteria decision making (MCDM) techniques, Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Structural Equation Modeling (SEM), and fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL), was conducted to assess their suitability in dealing with qualitative, complex, and interdependent variables based on articles from one last decade. While AHP and ANP support hierarchical decision-making, and SEM facilitates validation of theoretical constructs through large samples, these methods face limitations in capturing the subjective and causal nature of WM barriers. Fuzzy DEMATEL, a hybrid fuzzy-based approach, is identified as a robust tool for modeling expert judgments, quantifying ambiguity, and uncovering the cause-effect relationships among interrelated WM obstacles. Its ability to address subjectivity makes it particularly effective in analyzing barriers that cannot be represented through precise numerical data. The findings justify the application of fuzzy DEMATEL in studies to examine root causes of construction waste, thus enabling the formulation of WM policies. This contributes to the advancement of sustainable construction practices.

ICWEES-71

Sulfate Resistance of Mortar Containing Nano Silica as Partial Replacement of Mortar

Imran Ullah[a,b], Muhammad Faisal Khan[b], Muhammad Usman[a], Zili Zhang[c]*

[a]*School of Civil and Environmental Engineering, National University of Sciences and Technology (NUST), Sector H-12, Islamabad, Pakistan.*

[b] *Department of Civil Engineering Technology, University of Technology, Nowshera, Pakistan.*

[c]*Department of Structural Engineering, College of Civil Engineering, Tongji University, Shanghai,200092, China. Email: aaqib_najeeb@tongji.edu.cn & zili_zhang@tongji.edu.cn*

Corresponding Email: imranullahdallan@gmail.com

Sulfate attack degrades cement mortar because of presence of SO_4^{-2} ions. Sulfate attack can be decreased with filling effects by enclusion of particles smaller than cement particles in mortar. Nano size particles have better filling effects as compared to micro size supplemantry substances like fly ash, granulated ballast furnace slag, metakoline etc. Nano-silica is a nino sized supplementary material that can results better as compared to the micro size particles. This study investigates the effects of Nano-silica on the strength and microstructural characteristics of mortar regarding sulfate attack. The samples were studied for compressive strength at 30, 56, 90, and 120 days. Scanning electron microscopic (SEM) images were analysed for hydration products after curing in normal and sulfate solution. Results indicates that nano-silica in cement mortar decreases sulfate attack by developing the calcium silicate hydrate (C-S-H) gel, and produces calcium hydroxide (CH) and ettringites. The study shows that nano silica improves the long-term performance of mortar.

ICWEES-72

Improving Compressive Performance of Concrete using Steel Fiber Reinforcement: An Experimental Study

Abu Bakar, Majid Ali

Site Engineer, NESPAK, Islamabad, Pakistan.

Department of Civil Engineering, CUST, Islamabad

Corresponding Email: *chabubakar2003@gmail.com*

The overall objective of this study is to determine the ideal steel fiber ratio that yields the greatest results, as well as to assess the extent to which fiber affects the strength of concrete. Fine and coarse particles, cement, steel fibers, and water were all properly mixed by hand. The concrete mixture underwent a slump test. The concrete mixture was poured into a cylinder that measured 4" in diameter and 8" in height after its workability was assessed, and it was left for a full day. The samples were taken out of the mold after 24 hours and allowed to cure for 28 days in a water tank. After the 28 days curing of samples, the compressive strength of the cylinder was measured using a universal testing machine. The purpose of this research is to create high-strength concrete by adding steel fiber to the standard mix ratio. Concrete's mechanical capabilities are improved and its ability to withstand fracture is increased when steel fibers are used as reinforcement. This article describes an experimental investigation that shows how steel fiber affects the compressive strength of concrete and establishes the ideal steel fiber ratio for best outcomes. Steel fiber reinforcing was used to boost the compressive strength of concrete.

ICWEES-73

Screening of Ornamental Plants for Hydrocarbon Degradation through Rhizoremediation"

Alqama Nawaz1,2, Aroona Sohail

Institute of Environmental Science and Engineering, School of Civil and Environmental Engineering, National University of Science and Technology, H-12, Islamabad.

COMSATS University Islamabad, Abbottabad campus.

Corresponding Email: anawaz.mses24iese@student.nust.edu.pk; aroonasohail349@yahoo.com

As global population is growing extensively, there is rapid utilization of resources. The industrial boom in past decades introduced dangerous environmental toxins, which not only affect people, animals, and plants but also disrupt the natural food chain. Environmental pollution has been a major concern in modern world and in developing countries. Different types of pollutants from various sources and of varying toxicity are present in environment, contaminating our food, water, air and soil. Hydrocarbons of different kinds contaminate the environment, i.e., soil and air, contributing to environmental pollution. Polycyclic aromatic hydrocarbons (PAH), Total petroleum hydrocarbons (TPH) and n-alkanes, coming from various sources has a direct impact on plant growth and has a deteriorative effect on food crops. In this experiment, we employ the rhizoremediation method, in which the plant's roots interact with rhizosphere microorganisms to help in the breakdown of hydrocarbon pollutants in the soil. We investigated five ornamental plant species to analyze their rhizoremediation efficiency in diesel and cooking oil spiked soil. Results demonstrated that certain plant species such as Schefflera arboricola and Strobilanthes crispa exhibited exceptional ability to thrive and degrade hydrocarbons, indicating their potential as possible candidates for rhizoremediation applications. The implementation of these plants in contaminated areas can accelerate the degradation process. Additionally, the aesthetic appeal of ornamental plants makes them a favorable choice for integrating remediation efforts into urban and landscaped areas.

ICWEES-74

Spatiotemporal Trends in Precipitation and Their Implications for Water Security in Pakistan (1984–2024)

Maria Bibi[1], Erum Aamir[1], Noor Haleem[1] and Humayoun Akram[1]*

Institute of Environmental Sciences and Engineering (IESE), SCEE, NUST, Pakistan

Corresponding Email: maria.bses1423@iiu.edu.pk

Climate change, caused by anthropogenic activities and greenhouse gas (GHG) emissions, is significantly altering the precipitation pattern, resulting in more intense and frequent torrential rain, cloud burst, deluge and downpour events. Pakistan, though a low-emitting GHG country, is disproportionately vulnerable to risks because of its sensitive geography and socio-economic vulnerabilities. This study investigates long-term precipitation pattern (1984-2024), using monthly and annual data from 57 Meteorological stations managed by Pakistan Meteorological Department (PMD). The stations represent all major regions including Punjab, Sindh, Baluchistan, Khyber Pakhtunkhwa, Gilgit Baltistan and Azad Jammu and Kashmir (AJK). Thirteen precipitation variables (twelve monthly and one annual) were analyzed employing non-parametric Mann-Kendall tests to investigate the trend significance and Sen's Slope estimator to quantify the magnitude and direction of the changes. Results indicate a statistically significant decrease in December precipitation, indicating a decrease in precipitation during winter, and an increase in rainfall during June, suggesting a temporal shift in the monsoon patterns. Changes in precipitation are severely impacting Pakistan's water availability, agricultural productivity, and hydropower generation, thereby threatening crop production, food, water, and energy security. The present scenario demands rapidly building up resilience to climate-related hazards, incorporating climate initiatives into national policy, and raising awareness and capacity to effectively address climate change impacts. Our study is aligned with SDG 13, which emphasizes the necessity for rapid and effective measures to address climate change and its consequences.

ICWEES-75

Microbiome-Guided Functional Foods: From Faecalibacterium duncaniae to Prevotella copri: A Platform for Sustainable Gut Health and Early Cancer Prevention

Aamna Dilshad[a], Shehzad Abid khan[a]

a. Department of Microbiology and Biotechnology, Atta-ur-Rehman School of Applied Biosciences, National University of Science and Technology

Corresponding Email: aamnadilshad8@gmail.com

Colorectal cancer (CRC) is rising worldwide, and current screening tools are invasive, costly, and underutilized. Increasing evidence shows that microbial changes in the gut precede visible disease — particularly the depletion of protective commensals. *Faecalibacterium duncaniae*, a major butyrate producer, is consistently reduced in CRC patients, supporting its role as an early biomarker and potential preventive target. In parallel, genome-level analysis of *Prevotella copri* using KEGG pathway mapping and BLAST verification against its pangenome reveals a metabolic repertoire for synthesizing amino acids, short-chain fatty acids, and sphingolipids, all critical for gut barrier integrity and immune regulation. Together, these findings illustrate a systematic approach to microbiome-guided intervention: (1) identify health-associated species depleted in disease, (2) map their functional capabilities in silico, and (3) design precision prebiotics, probiotics, or postbiotics to selectively enrich them. By using sustainable feedstocks and industrial fermentation, such functional foods can restore microbial balance at a population level, offering a non-invasive strategy to reduce CRC risk and promote gut homeostasis. This work demonstrates how clinical microbiome profiling and metabolic modeling can converge into scalable food biotechnology platforms, moving beyond single-species studies toward sustainable, preventive healthcare.

ICWEES-76

Environmental and Metabolic Stimulants Enhance Quorum Sensing, Virulence, and Xanthan Gum Production in *Xanthomonas campestris*: Implications for Sustainable Industrial Fermentation

Muhammad Abdullah

Corresponding Email: abdullah08790@gmail.com

Xanthan gum, a widely used food biopolymer with unique rheological properties, is synthesized by Xanthomonas campestris through pathways regulated by quorum sensing (QS). However, how environmental and metabolic cues influence QS to simultaneously modulate virulence and xanthan biosynthesis remains poorly understood. Recent studies have demonstrated that rpfF helps bacteria sense the environmental cues. This type of regulation suggests that external cues which enhance virulence and help bacteria survive oxidative stress may also drive xanthan production. Constraint-based modelling further supports this link, predicting that rpfF activation stimulates metabolism of branched chain amino acids and related metabolic pathways. Building on these insights, this work aims to investigate how diverse stimulants including physical, plant-derived, diffusible factor, and amino acid inputs influence the QS activity, virulence expression, and EPS secretion. To test this, cultures were grown under physical, plant-derived, and metabolic stimulants, and QS activation, virulence enzyme activities, and xanthan production were quantified at the exponential–stationary transition. Protease and cellulase activities (skimmed milk and CMC agar assays) were used as virulence readouts, and xanthan was quantified by precipitation with ethanol. By identifying stimulants that accelerate xanthan biosynthesis, this work supports strategies to reduce fermentation time and resource consumption, offering clear benefits for the water–energy–food (WEF) nexus.

ICWEES-77

Exploring the Interactive Toxicity of Microplastics and Pathogenic Bacteria in Aquatic Organisms

*Mahnoor Akbar Mohsin Bhatti, Rashid Iftikhar, Nazish Iftikhar, Tayyaba Asim, Imran Hashmi**
Institute of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Science and Technology (NUST), Sector H-12, Islamabad 44000, Pakistan.
Corresponding Email: imranhashmi@iese.nust.edu.pk

Freshwater ecosystems are increasingly polluted by microplastics; tiny fragments from plastic waste, introduced through sewage, runoff, and improper disposal. Rawal Lake in Pakistan, a key freshwater source, has exhibited contamination by microplastics and pathogenic bacteria, raising concerns for aquatic life and food safety. This study examines the toxic effects of polyethylene (PE) and polypropylene (PP) microplastics, along with *E. coli* and *Salmonella*, on grass carp (*Ctenopharyngodon idella*) over 28 days exposure. Environmentally relevant low (2µg/L) and high doses (200µg/L) were used, reflecting current pollution levels and projected future scenarios. Six assessments were performed: biochemical biomarkers: alanine aminotransferase (ALT), glucose (GLU), and total protein (TP); oxidative stress: reactive oxygen species (ROS); immune response: nitro blue tetrazolium (NBT); along with histopathology, behaviour, and bioaccumulation. ALT levels increased from 66 to 104 U/L (PP 200 µg/L) and from 84 to 108.5 U/L (PE 200 µg/L), indicating liver stress. GLU levels elevated from 119.2 to 131.4 mg/dL (PP 200 µg/L) and from 84.8 to 108.2 mg/dL (PE 200 µg/L), reflecting metabolic disruption. TP declined from 97.6 to 83.9 g/dL (PP 2 µg/L), suggesting reduced protein synthesis. ROS in gills fluctuated from 98 to 113 units (PP 2 µg/L), while brain ROS ranged from 457 to 522 units (PP 200 µg/L), indicating oxidative stress. NBT slightly declined from 0.5804 to 0.5586 (PP 2 µg/L), pointing to immune suppression. Gill and liver histology showed epithelial lifting, inflammation, and vacuolation, especially in PP-bacteria groups. Behaviourally, fish showed reduced feeding and disrupted schooling. Microplastics accumulated mainly in the gut, followed by gills and skin. Overall, PP especially in combination with bacteria caused enhanced biomarker response than PE, underscoring the need for immediate microplastic pollution control to protect freshwater ecosystems like Rawal Lake.

ICWEES-78

Assessing the Removal Efficiency of High-density Polyethylene Microplastics from Water Using Electrocoagulation

Hira Amjad[1], Nida Maqbool[2], Sehrish Sarwar[3], Ahmed Sohail[4], Mohtashim Noor[5]*

*[1]*Pakistan Navy Engineering College (PNEC), National University of Sciences & Technology (NUST), Karachi, Pakistan;*

[2,3,4 & 5] School of Civil & Environmental Engineering (SCEE), Institute of Environmental Sciences & Engineering (IESE), National University of Sciences & Technology (NUST), Islamabad, Pakistan

Corresponding Email: *hamjad@iese.nust.edu.pk*

Microplastic contamination is a severe environmental problem that must be addressed, especially in developing countries like Pakistan, where there is a dearth of research on its effects on ecosystems and public health. This study suggests an economical and environmentally friendly method for removing microplastic from aquatic habitats, which helps to achieve Sustainable Development Goals (SDGs) 6 (Clean Water and Sanitation) and 12 (Responsible Consumption and Production). For this particular study, the electrocoagulation (EC), an electrolytic method conventionally used for water and wastewater treatment. EC is well-known for producing coagulants in situ that destabilize and agglomerate microplastics. The intrinsic electrochemical reactions of EC further improve particle removal, providing a low-chemical, size-inclusive, and adaptable technique. The current study utilized high-density polyethylene (HDPE) microplastics with a particular size range. Using aluminum electrodes, system optimization was accomplished at 12 volts and 100 rpm. The effectiveness of the EC procedure was evaluated in a pilot trial that removed microplastics up to 94%.

ICWEES-79

Strategies for Water Savings and Agricultural Enhancements in support of the UAE Water Security Strategy 2036 and National Food Security Strategy 2051

Khalil Ur Rahman1and Mohamed Khalifa Bin Thaleth1

1 Al Nakhli Sector, The Private Office of Ruler of Dubai. UAE

Corresponding Email: *khalil.rahman@alnakhli.ae; Tel: +971- 506623001*

Arid and semiarid regions account for almost 40-45% of the Earth's total land surface, and these areas are highly prone to salinization due to low rainfall and improper water management practices. Salinity and drought, two very closely associated abiotic stressors, negatively affect crop productivity (Gamalero et al.2020). Almost 20% of the total irrigated land has been degraded due to excess soil salinity (FAO, 2020). The world population is to reach 9.3 billion in 2050, the population explosion will affect mainly the world food demand, researchers predict that the demand for food will rise by 60%. Demand for food, directly affects the necessity of increasing agricultural output, as agriculture is the main food producer and the driving force of most countries' economy. But to produce food, one requires water, and our region (MENA) and the world are already today facing water scarcity, in the coming years the increase in demographics will boost the demand for water even more. Governments need to ensure water sustainability rapidly, ground water is depleting, desalination is a costly and non-ecological process and treated sewage water availability is limited. MENA is one of the most water scarce regions of the world and despite that, its average daily water consumption per capita is one of the highest in the world, due mainly to its agricultural irrigation needs (60-70% of its daily water usage). The Private Office of HH Ruler of Dubai – Al Nakhli in on a mission to help UAE agriculture become more sustainable by saving trillions of litres of water per year, supporting the UAE Water Security Strategy 2036. The used systems not only saves water, saves money, improves food security, and increases crop productivity but also reduces methane gas emission, evaporation and percolation losses by up to 90 percent. It is easy to implement– existing farm management teams do not require any specialist training, Through artificial intelligence including sensors and solenoid valves, we only irrigate when necessary. The process is entirely organic, using shredded date palm fronds and cattle manure as the topsoil mix, with no added chemicals. This had the added benefit of increasing the water

holding capacity of the soil. If the system was installed across the millions of date palms in the UAE, it could save up to a trillion litres of water per year – that's the same consumption as 5 million people or half the population of the UAE. The overall impact has demonstrated that sustainable production is possible in the UAE, with huge water savings. This helps support the conclusion that domestic production in the UAE can be both sustainable and economically feasible.

ICWEES-80

Bioavailable Fraction of Selected Antibiotics in Agricultural Soil and its Implication for Microbial Nitrogen Cycling"

Marium Fiaz[1], Muhammad Arshad[2]*

[1]School of Interdisciplinary Sciences and Engineering, National University of Sciences and Technology, Sector H-12, Islamabad, 44000, Pakistan.

[2]Institute of Environmental Sciences and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology, Sector H-12, Islamabad, 44000, Pakistan.

Corresponding Email: marium.fiaz@sines.nust.edu.pk

The persistence of antibiotic residues in agricultural soils is an emerging environmental concern due to their potential to disrupt microbial functioning and biogeochemical cycling. A major limitation in current risk assessments is the frequent use of total concentration values, which do not accurately reflect the fraction available for microbial exposure. The present study quantified the bioavailable percentage of two selected antibiotics (oxytetracycline and levofloxacin) in soil irrigated with contaminated water and assessed the impact of soil physicochemical properties on antibiotic mobility. The initial extraction of antibiotic residues from the soil was achieved through solid phase extraction (SPE) using Oasis HLB cartridges, followed by quantification using high-performance liquid chromatography (HPLC). Soil organic matter, pH, cation exchange capacity and texture were also analysed to determine their roles in antibiotic sorption and desorption. Although total antibiotic concentrations in the bulk soil remained relatively low, 30–45 % were present in bioavailable form. Notably, this high bioavailable fraction coincided with a significant reduction in microbial biomass carbon. This suggests that the bioavailable fraction of selected antibiotics possibly interacted with and altered the soil microbial community. Such microbial decline could subsequently influence total nitrogen content and nitrogen transformation processes in agricultural soils. These findings emphasize the importance of adopting bioavailability-based approaches in the environmental risk assessment of antibiotic contamination in agroecosystems.

ICWEES-81

"Waste-to-Energy Approach for Desalination Plant in Karachi: A Step Towards Sustainable Development"

Israr Ahmed Memon [a], Sheeraz Ahmed Memon [b], Zulfiqar Ali Umrani [c], Waheed Ali Khokhar[b]*

[a] US-Pakistan Center for Advanced Studies in Water, Mehran UET Jamshoro

[b] Institute of Environmental Engineering and Management, Mehran UET Jamshoro

[c] Ziauddin University, Karachi

Corresponding Email: memonisrarahmed99@gmail.com

Pakistan's largest city, Karachi, is currently struggling with two major challenges: an increasing lack of drinking water and the growing burden of municipal solid waste (MSW). The current population of the city is about 18.1 million, with a growth rate of 2.43% and the city has water supplies of about 2.7 MCM per day, which is fulfilling 60 to 84% of the total water demand (3.09-4.5 MCM per day). Karachi is already facing a water deficit of 1.8 MCM per day; a further increase in population will put the city in an alarming situation. Another challenge is the MSW generation, which is about 16,000 tons per day. Rapid urbanization will put more burden on the environment as well as on the economy of the city. Therefore, the circular economy concept has to be considered for this case to resolve both challenges simultaneously. This study demonstrates a sustainable, integrated solution by assessing the potential of waste-to-energy (WtE) systems to power desalination plants. The power plant with a capacity of 30 MW is required to run a desalination plant with an output of 0.18 MCM per day (fulfilling 10% of the current deficit), which will serve the population of 0.72 million. Approximately 400-500 tons per day of MSW is required to run a 30 MW power plant. In this study, two coastline sites for a desalination plant are identified, i.e., Mubarak Village and Hocks Bay. However, Hocks Bay is the most feasible site in terms of water uptake, MSW availability, and disposal of brine. Other factors, such as tipping fees and operating costs, are also key components for the selection of a suitable site. This study provides a framework for new cross-sectoral strategies to improve urban recovery and sustainability for cities like Karachi.

ICWEES-82

Improving Compressive Performance of Concrete using Steel Fiber Reinforcement: An Experimental Study

Abu Bakar

Site Engineer, NESPAK, Islamabad, Pakistan.

Majid Ali

Department of Civil Engineering, CUST, Islamabad.

majid.ali@cust.edu.pk

Corresponding Email: *chabubakar2003@gmail.com*

The overall objective of this study is to determine the ideal steel fiber ratio that yields the greatest results, as well as to assess the extent to which fiber affects the strength of concrete. Fine and coarse particles, cement, steel fibers, and water were all properly mixed by hand. The concrete mixture underwent a slump test. The concrete mixture was poured into a cylinder that measured 4" in diameter and 8" in height after its workability was assessed, and it was left for a full day. The samples were taken out of the mold after 24 hours and allowed to cure for 28 days in a water tank. After the 28 days curing of samples, the compressive strength of the cylinder was measured using a universal testing machine. The purpose of this research is to create high-strength concrete by adding steel fiber to the standard mix ratio. Concrete's mechanical capabilities are improved and its ability to withstand fracture is increased when steel fibers are used as reinforcement. This article describes an experimental investigation that shows how steel fiber affects the compressive strength of concrete and establishes the ideal steel fiber ratio for best outcomes. Steel fiber reinforcing was used to boost the compressive strength of concrete.

ICWEES-83

Bio-electrochemical system: evaluating the performance of Dictyosphaerium nanoparticle-coated nickel electrodes

Ayesha Aslam [a], Rabia Liaquat [a,], Mohammed Zwawi [b], Ali Bahadar [c]*

aUS Pakistan Center for Advanced Studies in Energy (USPCAS-E), National University of Sciences and Technology (NUST), Islamabad 44000, Pakistan

bDepartment of Mechanical Engineering, King Abdulaziz University, Rabigh 21911, Saudi Arabia

cDepartment of Chemical and Materials Engineering, King Abdulaziz University, Rabigh 21911, Saudi Arabia

Advancing MEC technology requires the development of low cost, applicable anode catalysts to treat wastewater efficiently. This study reported the fabrication of green nanoparticles (cobalt (Co), iron (Fe), and silver (Ag)) via microalgal strain *Dictyosphaerium* DHM_I. These synthesized nanoparticles were used to engineer the anode of a microbial electrolysis cell (MEC) and evaluated their performance in kitchen wastewater treatment and biohydrogen production. The characterization results of UV–Vis. analysis revealed cobalt nanoparticles (CoNPs), iron nanoparticles (FeNPs) and silver nanoparticles (AgNPs), express surface plasmon resonance at around 286 nm, 300 nm, and 450 nm, respectively. FT-IR analysis showed microalgal biomolecules facilitated the reduction of Co, Fe, and Ag ions. The SEM analysis revealed that AgNPs were triangular while CoNPs and FeNPs exhibited circular shapes. The GC results indicated Co-coated electrode produced highest biohydrogen (2379.25 ± 713.19 mm^3/mL/d) on the 4th day, followed by Fe-coated electrode (1886.93 ± 754.48 mm^3/mL/d) on the 5th day of experiment. In contrast Ag-coated electrode showed lowest (1402.32 ± 771.39 mm^3/mL/d) production. SEM analysis of the modified anode revealed diverse microbial colonies, including Shewanella oneidensis, Geobacter, and Enterobacter, greater microbial diversity and dense biofilm growth were observed on the CoNPs and then on FeNPs-anodes compared to the AgNPs anodes. The CV and EIS results showed that the CoNPs-coated anode have the highest current density 2.796 mA/cm^2 and the lowest charge transfer resistance of 1.684 Ω. The result suggests that eco-friendly synthesized green nanoparticles function as redox mediator on the engineered anode electrode, enhancing both biocompatibility and conductivity.

ICWEES-84

Assessment of Self-Cleaning Performance and Photocatalytic activity of Photocatalytic Concrete

Maaz Khan[1], Dr. Muhammad Faisal Javed[1], Dr. Nadia Riaz[2]*

[1]Ghulam Ishaq Khan Institute of Engineering Sciences and Technology

[2]COMSATS University Islamabad - Abbottabad Campus

Corresponding Email: arbabfaisal@giki.edu.pk , gcv2463@giki.edu.pk

This study assesses self-cleaning and photocatalytic activities of photocatalytic concrete with 8% TiO_2 by cement weight in a 1:3 cement-to-sand mixture. Specimens were immersed in an initial 20 mg/L methylene blue (MB) solution and exposed to natural sunlight for 15 days. Following exposure, the MB concentration was reduced to an assumed 14 mg/L, which has a degradation efficiency of 30%. The UV-Vis spectrophotometer was utilized at 664 nm to determine the concentrations in dyes degradation and thus the progress of degradation inside the aquatic ecosystem and soil. Findings show that organo-dye pollutants can be removed by TiO 2 -modified photocatalytic concrete under outdoor conditions with potential self-cleaning surface and environmental remediation use.

ICWEES-85

Integrating Driver Behavior into Intelligent Transportation Systems: A GIS-Based Analysis of U-Turn Patterns on Signal-Free Highways

Rana Muhammad Usman [1,3], Ali Javaid [2,3], Mussadiq Abdul Raheem [2,4], Muhammad Rashid [2], Muhammad Sajid [3,5,]*

[1]School of Information Science and Technology, University of Science and Technology of China (USTC), Hefei 230026, China

[2]NUTECH School of Engineering & Technology (NUSET), National University of Technology, Islamabad 44000, Pakistan

[3]School of Mechanical and Manufacturing Engineering (SMME), National University of Sciences and Technology (NUST), Islamabad 44000, Pakistan

[4]King Fahd University of Petroleum and Minerals (KFUPM), Street, City, 610101, State, Saudi Arabia.

[5]School of Mechanical and Materials Engineering, University College Dublin, Dublin, Ireland

Corresponding E-mail: muhammad.sajid@ucd.ie

The implementation of designated U-turns at signalized junctions to create signal- free corridors presents a viable way to enhance traffic flow and reduce the number of delays. It does, however, provide additional difficulties for traffic control and safety, especially in mixed traffic situations when both intelligent connected vehicles (ICVs) and human-driven cars are present. This study assesses the effects of replacing traffic signals with designated U-turns on the Srinagar Highway, concentrating on changes in driver behavior, congestion patterns, and safety outcomes. We examine traffic circumstances both before and after the conversion using Geographic Information Systems (GIS) and organic driving data in order to pinpoint important variables affecting traffic dynamics. According to our research, dedicated U-turns shorten intersection delays, but they also impact traffic stability and introduce new sources of contention. To overcome these obstacles, we suggest incorporating driver behavior models into Intelligent Transportation Systems (ITS) to optimize traffic flow on signal-free highways, increase human-vehicle- road coordination, and improve real-time traffic forecast. This study emphasizes how crucial it is to include human behavior in ITS frameworks to guarantee safer and more effective urban mobility.

ICWEES-86

Solar and Hydro-Piezoelectric Integration for Enhanced Energy Harvesting: Design and Experimental Analysis

Ali Javaid [1,2], Syed Maaz Hassan [1], Muhammad Sajid [3,]*
[1]School of Mechanical and Manufacturing Engineering (SMME), National University of Sciences and
Technology (NUST), Islamabad 44000, Pakistan
[2]National University of Science and Technology, Islamabad 44000, Pakistan
[3]School of Mechanical and Materials Engineering, University College Dublin, Dublin, Ireland
Corresponding E-mail: *muhammad.sajid@ucd.ie*

One of the major concerns for the world today is the rapid depletion of hydrocarbon reserves and the subsequent increase in global warming due to the excess usage of said resources. Governments and power generation companies are exploring avenues for sustainable alternative energy sources. Conventional Hydro and Wind power energy systems have a lot of potential to meet energy demand as alternate energy resources but require a massive investment in infrastructure. Solar and vibrational energies are also available in abundance in our environment and have the potential to provide green energy. Solar PV standalone systems are easy to install, but they require a large area for deployment. Also, the decrease in efficacy when experiencing an increase in surface temperature and thermal degradation of PV panels are significant concerns to the system. The area utilized by the standalone systems cannot be used for any other purpose hence hybrid systems are favored instead of standalone systems. Hybrid systems are in a developing stage for harvesting energy to ensure constant output availability, these systems are complex and complicated. The need for a hybrid system is to increase the energy density, and the system has a positive impact on the outputs of both systems. This paper presents a novel hybrid design based on Solar and hydro-vibrational energies to be a cost-effective alternative energy solution. An experimental study is performed on a water tunnel, electric eel is used to harvest energy from vortex-induced vibrations and is coupled with the solar panel to enhance the heat transfer from the surface of the PV panel resulting in an increase in efficiency. The system can be implemented on solar panels placed on water bodies like canals and rivers for amplified efficiency of solar panels and energy production with the help of electric eel. The result indicates that the proposed system has three advantages stacked together, i.e., PV panel coupled with the electric eel generates more energy due to the

increase in efficiency of solar panel, evaporation rate of water is reduced with this approach, copper rod attached to hold the eel serves as the heat sink for passive cooling and simultaneous generation of energy by the eel. Results showed that the energy density was increased up to 5% over 97.75cm2 or 0.01m2 approximately. Reduction in a voltage drop of solar PV was also observed up to 7%.

ICWEES-87

An IoT-Based Automated Air Cooling System for Safer Marine Engine Rooms

Dr. Syed Waqar Hasan, Eesha Akhtar Iqbal Zainab Jibran Haris Shabbir Zain Ul Abideen

National University of Sciences & Technology (NUST-PNEC)

Emails: **(eeshashaikh25@gmail.com)**, **(zainabjibran5@gmail.com)**, **(harisshabbir2010@gmail.com)**, **(zainulabideen7877@gmail.com)**

In marine engineering, heat build-up in engine rooms has always posed a great safety risk to the ship's structure and the crew members. To mitigate this challenge, proper monitoring and engineers are required to maintain safe conditions. Minimizing with less cost and labor, we have proposed an automated air cooling system designed for marine applications and safety.

We used an ESP-32 mini controller to collect the data from the temperature sensor – to cross check the values, we have a designated thermal camera as additional equipment. Using wired connection with Ethernet module, effective data transfer and monitoring are ensured in the harsh marine environment.

According to the range given to define the safe engine room's temperature, the ESP-32 will keep monitoring when the recorded temperature exceeds the range. If the engine's temperature increases more than the defined threshold, the ESP-32 will send an alert to activate the relay, thus switching on the blowers or fans until the temperature comes within the limit. This would reduce labor cost, automatically keep the engine room operational without any physical input, and ensure safety of the members in the vessel.

Temperature and fan operation data are logged and transmitted to a centralized database using the Ethernet connection. This can be visualized and analyzed using Looker Studio or Google Sheets. Using RTC (Real-Time Clock) along with the temperature sensor, we can easily plot the graph for a particular time frame. This helps the engineers to check for any defects in the data, and to effectively check if the system is operating. This easy combination of IoT and marine engineering can replace traditional practices – long term benefits include safer cruising and vessel production.

ICWEES-88

Quantifying Precipitation Probability and Drought Risk Across Spatiotemporal Scales

*Yasir Ali[1], Muhammad Waseem [1], Mudassar Iqbal[1,] *, Muhammad Masood[1]*

[1] Centre of Excellence in Water Resources Engineering, University of Engineering and Technology Lahore 54890, Pakistan

Corresponding Email: mudassar@cewre.edu.pk (M.I);

Reliable data on precipitation probability, volume, frequency, and variability is critical for effective water resource planning and management in regions prone to seasonal water scarcity. Hence, in this study, the probability analysis of precipitation was conducted at various time scales, including months, standard seasons, agricultural seasons, and annual precipitation, for the period 2001-2020 at six meteorological stations in South Punjab, Pakistan. The results of the study revealed that South Punjab experiences an average annual precipitation of 212.2 mm, of which 46% of the total wet days experienced precipitation below 10 mm, which is considered lower than heavy precipitation. Furthermore, the probability of experiencing very heavy to severe precipitation in a year was only 7%. The monthly probability of July among all months presented 56% of normal events, while October and November presented 78% probability of drought. Autumn, with a 52% probability, faces a high risk of drought conditions. On the other hand, Summer, with a 71% probability of receiving abundant precipitation, offers an opportunity to accumulate water reserves that can be effectively utilized during the drier Autumn season. Overall, the findings support managers or departments in mitigating the dry conditions and developing a plan for water harvesting, thereby improving vegetation.

ICWEES-89

Non-Stationary Flood Modeling under Hydro-Climatic Variability

Ali Hassan Jaffry[1,2], Mudassar Iqbal[1], Muhammad Waseem[1,]*

[1] Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore 54890, Pakistan

[2] School of Remote Sensing and Geomatics Engineering, Nanjing University of Information Science and Technology, Nanjing 210044, PR China

Corresponding Email: dr.waseem@uet.edu.pk

The increasing variability in hydroclimate and anthropogenic influences challenges the assumption of constant flood frequencies, potentially resulting in inaccurate design predictions. This study analyzes the flood using a Bayesian Generalized Extreme Value framework that explicitly accounts for non-stationarity behavior. The annual maximum floods from five gauging stations were assessed for monotonic trends using the Mann–Kendall statistic. Additionally, stationery and non-stationary Bayesian flood-frequency curves with 95% credible intervals were compared across two datasets: one that included known outliers and another that excluded them. Four stations exhibit statistically significant declining trends (Mann–Kendall $Z = -1.94$ to -2.46, $p < 0.05$), while one station shows no trend. At the 100-year return period, discrepancies between stationary and non-stationary estimates differ by site: excluding outliers, the stationary model overestimates the 100-year flood at Palote by 981 m^3/s (58%), whereas differences at other locations generally remain below 10%. Bayes factors below one across all sites consistently indicate support for the non-stationary formulation. The data collectively suggest that reliance on stationarity may either overstate or understate risk, leading to important implications for spillway dimensions, reservoir management, and floodplain administration. Recognizing non-stationarity enhances risk evaluation and facilitates more resilient hydraulic design. Future research must integrate key climate factors, including monsoon rainfall indices, and adopt regionalized Bayesian pooling to reduce uncertainty and improve decision support.

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