BOOK OF ABSTRACTS

ICPCCE 2025

International Conference on Pollution Control for Clean Environment (2025)

22-23 December 2025

School of Infrastructure
Department of Electrical Engineering
Indian Institute of Technology Bhubaneswar

2nd International Conference on Pollution Control for Clean Environment (ICPCCE-2025)

22-23 December 2025

Indian Institute of Technology Bhubaneswar

"The earth, the air, the land, and the water are not an inheritance from our forefathers but on loan from our children. So, we have to handover to them at least as it was handed over to us."

Mahatma Gandhi

PREFACE

Dear Colleagues,

It is our great pleasure to present the *Book of Abstracts of the International Conference on Pollution Control for Clean Environment (ICPCCE-2025)*. We are delighted to share this compilation with the authors, delegates, researchers, and professionals participating in this year's event. We hope that this volume will serve as an engaging, informative, and thought-provoking resource for all readers.

ICPCCE-2025 is being organized at the Indian Institute of Technology Bhubaneswar during 22-23 December, 2025. Building upon the success of the inaugural edition held in 2023, the present conference has received a commendable response from across India and abroad. Researchers, academicians, industry professionals, and policy experts have come together once again to exchange ideas and advance knowledge in the domain of pollution control and environmental sustainability.

The conference continues its mission of providing a dynamic platform for discussing emerging challenges, opportunities, and technological advances in pollution mitigation. As environmental concerns intensify globally, the need for integrated, anticipatory, and sustainable solutions has never been more urgent. While significant efforts have been made toward environmental protection, many regions—especially in developing countries—still face rapid and complex pollution-related issues. These challenges underscore the necessity of effective monitoring tools, innovative treatment technologies, policy support frameworks, and collaborative research endeavours.

The abstracts featured in this volume highlight cutting-edge research addressing pollutant occurrence across environmental media, pathways of contamination, and comprehensive risk and impact assessments. Contributions span a wide range of topics, including advanced sensing and monitoring approaches, sustainable and cleaner technologies, emerging treatment processes, energy-efficient and energy-positive systems, circular economy strategies, life cycle assessment, and resource recovery innovations.

For the convenience of readers and to facilitate focused discussions, the contents of this publication are organized into the following thematic tracks:

Track 1: Wastewater Treatment and Reuse

- Sustainable wastewater treatment, reuse, and product recovery
- Microplastics and contaminants of emerging concern removal
- Wastewater treatment using non-thermal plasma
- Innovative technologies for achieving zero liquid discharge
- Decentralized wastewater treatment systems
- Case studies on effective wastewater treatment and reuse.

Track 2: Water Quality Monitoring and Treatment

- Surface water, groundwater pollution and prevention
- Advanced technologies for water quality monitoring

- Managing and interpreting water quality data
- Advancements in water treatment processes
- Case studies on successful water quality monitoring and treatment
- Effects of climate change on water quality

Track 3: Air Pollution Control

- Big data and artificial intelligence for air quality monitoring, analysis, and prediction
- Sources and characterization of air pollutants
- Climate change and air pollution
- Advancements in air quality monitoring technologies
- Air pollution control technologies
- Integrated pollution control strategies for addressing multiple pollutants
- Indoor air pollution and prevention
- Air pollution control using non-thermal plasma
- Interactions between climate change and air pollution

Track 4: Solid Waste Management and Resource Utilization

- Waste audits and assessments
- Generation, collection, storage, and transportation of solid waste
- Smart waste management systems
- Recycling and upcycling
- Biological treatment of solid waste and energy production
- Thermal treatment technologies
- Plastic waste, E-waste, and hazardous waste management
- Landfill Management and Remediation

Track 5: Environmental Management & Policies

- Effective governance structures and policy frameworks
- Environmental law and regulation
- Climate change mitigation and adaptation
- Methods and procedures for pollution risk assessment
- Best practices in environmental auditing
- Life cycle assessment of pollution control technologies
- Circular economy in environmental management

We hope that this compilation provides a valuable overview of the most recent advances and innovative directions in pollution prevention and clean-environment technologies. It is our belief that researchers and practitioners will find this publication useful for further study, collaboration, and future research pursuits.

We express our heartfelt appreciation to all authors for their contributions, to the Keynote and invited speakers for graciously sharing their time and expertise, and to the organizing committee for their tireless efforts in ensuring the successful organization of ICPCCE-2025. We look forward to continued collaboration and to welcoming you in future editions of the conference at the Indian Institute of Technology Bhubaneswar.

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MESSAGE FROM CHIEF PATRON, ICPCCE 2025

Prof. Shreepad Karmalkar

Director
Indian Institute of Technology Bhubaneswar

यत् ते भूमे विश्वनामी क्षिप्रं तदापि रोहतु
मा ते मर्म विमरुगवरी मा ते हृदयमर्पिपम्

A profound verse from the Atharva Veda implores: “Oh! Mother Earth, when I dig out substances from your body, let your wounds heal quickly. Let me never hurt the essence of your vitality and turn you barren.”

It brings me great joy to observe that the Indian Institute of Technology (IIT) Bhubaneswar is deeply committed to upholding this ancient wisdom. Even as we develop infrastructure to transform this campus into a hub of education and intellect, we remain dedicated to protecting our natural environment. Significant research on environmental pollution control is currently being carried out by the members of our Institute. Taking this commitment, a step further, it is heartening to learn that the School of Infrastructure and the Department of Electrical Engineering are jointly organizing the Second International Conference on Pollution Control for Clean Environment (ICPCCE 2025).

I am confident that this conference will effectively address critical issues regarding environmental pollution. It will serve as a vital platform for scientists, engineers, and professionals to deliberate on advanced technologies, new management practices, and innovative strategies for a cleaner, greener future.

I convey my sincere appreciation to the conveners and organizers for their initiative and hard work. On behalf of IIT Bhubaneswar, I extend a warm welcome to all keynote speakers and participants. I wish ICPCCE 2025 every success.

MESSAGE FROM PATRON, ICPCCE 2025

Prof. V. Pandu Ranga

Dean (Continuing Education)
Indian Institute of Technology Bhubaneswar

I am delighted to learn that the School of Infrastructure and School of Electrical Sciences of the Indian Institute of Technology Bhubaneswar are jointly organizing the second edition of the International Conference on Pollution Control for Clean Environment (ICPCCE-2025) during 22-23 December, 2025.

Following the successful debut of this platform in 2023, I must once again congratulate the Conveners and the organizing team for their commitment to sustaining this vital dialogue. As environmental pollution remains a critical global challenge, the need for persistent innovation and tangible solutions is more urgent than ever.

I am pleased to note that building on the momentum of the first edition, this year's conference has continued to receive an overwhelming response from the global academic and research community. I am confident that the deliberations over these two days will further evolve the strategies required to benefit both local and global environments.

The Office of Continuing Education remains committed to supporting such impactful events. I wish to record my sincere appreciation for the faculty, staff, and students working tirelessly behind the scenes, as well as the keynote speakers and participants for their continued trust in this forum. I wish ICPCCE-2025 a grand success.

MESSAGE FROM PATRON, ICPCCE 2025

Prof. Sumanta Haldar

Head of the School of Infrastructure
Indian Institute of Technology Bhubaneswar

It gives me immense pleasure to extend this message on behalf of the School of Infrastructure, Indian Institute of Technology Bhubaneswar, for the second International Conference on Pollution Control for Clean Environment (ICPCCE-2025). Following the success of the inaugural edition, this year's conference marks another significant step in our collective effort to foster innovative solutions and deeper understanding in the field of pollution control. We are proud to continue this initiative in collaboration with the School of Electrical Sciences, IIT Bhubaneswar.

The environmental challenges we face today have only grown more complex, reminding us of the urgency to strengthen our research, knowledge-sharing, and collaborative action. Pollution continues to impact the air, water, and soil that sustain life, and addressing these concerns remains a global priority. This second edition of ICPCCE aims not only to revisit the pressing issues discussed previously but also to explore emerging technologies, new scientific insights, and practical strategies for achieving a cleaner and more sustainable environment.

We are honoured to welcome an even broader group of distinguished experts, researchers, and practitioners from around the world. Their contributions—through keynote lectures, technical sessions, and discussions—will enrich this conference and inspire innovative approaches to pollution mitigation.

I extend my heartfelt welcome to all keynote and invited speakers and participants who have joined us to make this event meaningful and impactful. I am confident that the deliberations over the next two days will serve as an excellent platform for learning, collaboration, and future research endeavours.

I wish all participants a productive and rewarding experience at ICPCCE-2025.

MESSAGE FROM CONVENERS ICPCCE 2025

Prof. Rajesh Roshan Dash
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It is our great pleasure to welcome you to IIT Bhubaneswar for the second edition of the International Conference on Pollution Control for Clean Environment (ICPCCE-2025). Building upon the success of ICPCCE-2023, this edition continues our mission of bringing together researchers, academicians, industry professionals, and practitioners working in the field of Environmental Science and Engineering. The conference provides an enriching platform to present recent research outcomes, share practical experiences, and exchange innovative ideas aimed at addressing the pressing environmental challenges.

ICPCCE-2025 is planned to host eight keynote addresses, nine invited talks and more than 170 technical presentations (oral and poster) in 2 days with multiple parallel sessions, in both offline and online modes. The presentations will span across major thematic tracks, including Environmental Monitoring and Management, Water Pollution Control, Air Pollution Control, and Solid Waste Management and Resource Utilization. The sub-themes under each track emphasize emerging research, advancements in technology, and progressive strategies to combat contemporary environmental issues that are of global significance.

We take this opportunity to extend our heartfelt thanks to all authors for their valuable contributions and to the keynote and invited speakers for graciously sharing their time and expertise. We express our sincere appreciation to members of the technical and advisory committees, the organising committee, and the student volunteers who have generously given their time for organising the Conference, and the concerned Institute functionaries, officers and staffs for their support. We gratefully acknowledge the constant encouragement and guidance from the Director, IIT Bhubaneswar, Dean Continuing Education, Head of the School of Infrastructure, and Head of the School of Electrical Sciences. We extend our sincere thanks to Springer for publishing the conference book. We are grateful to all our sponsors; Anusandhan National Research Foundation (ANRF), Department of Science and technology, Govt. of India, Mahanadi Coalfield Limited (MCL), Sambalpur, Odisha, and M/S Internation Trade Links (ITL) Instrumentation Pvt. Ltd., Maa Gouri Scientific Bhubaneswar, Biolab India Bhubaneswar, Krishrad India Bioscience, Rashmita Traders and Science House Bhubaneswar for sponsoring the event.

We believe that ICPCCE-2025 will inspire meaningful discussions, foster collaborative research, and guide the development of advanced systems, processes, and solutions for pollution mitigation across environmental media. We are confident that the participants will gain significant technical insights and benefit from the diverse knowledge shared throughout the conference. We look forward to your active participation and hope that your experience at ICPCCE-2025 is enriching, productive, and memorable. We wish you a pleasant and fulfilling stay at IIT Bhubaneswar.

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CONTENT

Track 1: Wastewater Treatment and Reuse

Track – 2 (Water Quality Monitoring & Treatment)

Track – 4 Solid Waste Management & Resource Utilization

Track – 5 Environmental Management & Policies

Keynote: 1

Perovskite-based cathode catalyst for sustainable wastewater treatment and seawater desalination through microbial desalination cell

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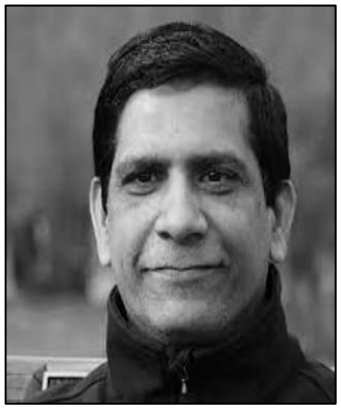
ABSTRACT

The growing water demand supports the innovation of desalination technologies. Microbial desalination cell (MDC), a form of bio-electrochemical system, provides a green solution for saltwater desalination with its bio-energy harvesting property while treating wastewater through *exo*-electrogens. The use of suitable catalysts further enhances the power production and desalination efficiency of MDC by overcoming the sluggish kinetics of the oxygen reduction reaction (ORR). A bimetallic oxide of Sr-Mn was thus prepared by a facile method and coated on the cathode surface to improve the performance of MDC. This bimetallic oxide obtained had a significant amount of perovskite ($SrMnO_3$) synthesized in the process, contributing to the enhanced catalytic activity. The physicochemical properties of the catalyst were characterized through scanning electron microscopy, X-ray photoelectron spectroscopy, X-ray diffraction, and Fourier transform infrared spectroscopy analysis. The electrochemical characterization was done through cyclic voltammetry and electrochemical impedance spectroscopy analyses, showcasing the superior performance of the synthesized catalyst. The MDC having a bimetallic oxide-coated cathode performed better than the MDC having a bare carbon felt cathode due to improved ORR within the MDC. The addition of catalyst resulted in COD removal of 81.1 ± 0.5%, which was 35.5% higher than that recorded in the scenario without a catalyst. Similarly, in terms of desalination, the MDC with a catalyzed cathode exhibited an 83.3 ± 1.2% desalination efficiency compared to the control MDC (45.76 ± 1.4%). The improved electrocatalytic performance of the system due to the catalyst was explained through the electrochemical analysis of the synthesized perovskite. The non-reliance of the MDC system on any external power source makes it a self-sustained and green technology for performing wastewater treatment and saltwater desalination, contributing to Sustainable Development Goal 6 of clean water and sanitation.

Keywords: Microbial desalination cell; Bioelectrochemical system; Perovskite, oxygen reduction reaction

Keynote: 2



Mapping plastic pathways: How urban waste streams impact surface waters and SDG 6 goals

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ABSTRACT

Plastic pollution in rivers is a growing threat to both the environment and human health, and the Ganga River is one of the regions most affected. This study introduces a new town-level model that estimates how much plastic leaks into the river. The model uses information on population, plastic waste generation, and the performance of waste collection, treatment, and recycling. It was validated with field data, showing good agreement within ±10%, and also matched well with earlier research.

Our results show that if current practices continue, mismanaged plastic waste in the Ganga basin could reach 550–750 kt per year by 2061. However, with improved waste management, this could be reduced by about 81%, bringing it down to 40–140 kt per year. Plastic entering the river would also drop by around 75%. The study highlights that plastic pollution is initially driven by rising waste generation, but over time it is more influenced by how well waste systems function. These insights can support better policies and more sustainable waste management planning.

Keywords: Plastic pollution; Ganga River basin; Waste management systems

Keynote: 3

Evaluating suspended particulate matter induced stress and tolerance in selected native plant species and urban green belt strategies

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ABSTRACT

Urban air quality has deteriorated rapidly due to accelerated urbanization and heightened anthropogenic emissions, with suspended particulate matter (SPM) laden with metals emerging as a primary pollutant. Prolonged exposure to SPM-bound particulate matter in particular Inhalation of these fine particles poses severe human health risk, as they penetrate deep into the lungs and bloodstream. Trees play a pivotal role in mitigation through multiple biophysical mechanisms. By intercepting airborne particles on their leaf surfaces via dry and wet deposition, urban trees effectively capture SPM, including fine particulates like PM2.5 and PM10, preventing their resuspension and reducing ambient concentrations; for instance, studies indicate that urban forests can remove substantial amounts of pollution annually, with leaf stomata absorbing gaseous pollutants while bark and foliage trap heavier metals and dust. On vegetation, SPM-bound metals deposit via dry and wet processes, influenced by factors like metal type, leaf pH, surface microstructure, and co-occurring pollutants. Once accumulated, these metals induce oxidative stress through reactive oxygen species, causing lipid peroxidation, pigment loss, metabolic disruption, and cause ecological threats. Plants play a crucial role in mitigating air pollution. Furthermore, certain species exhibit tolerance to pollution stress, and prevent their atmospheric release, thereby supporting sustainable green belt designs that integrate biodiversity with air quality management in megacities.

This study is an attempt to comprehensive understand seasonal variations and quantitative assessments of SPM-bound metal concentrations on and within leaf surfaces in highly polluted megacities. This aim is to develop targeted urban greening and abatement strategies. The present study examines variations in metal and metalloid accumulation among six common urban tree species namely, *Ficus benghalensis* L., *Ficus religiosa* L., *Polyalthia longifolia Thwaites*, *Azadirachta indica* A. Juss., *Ficus benjamina* L., and *Bougainvillea glabra*, during pre- and post-monsoon seasons. It was observed that the accumulation is affected by plant height, leaf area, seasonal rainfall, and proximity to traffic, commercial, residential, educational, and industrial zones, reflecting anthropogenic influences on deposition and retention. Evaluation of species-specific metal retention potential has been done and accordingly, a predictive metal accumulation index based on foliar uptake has been developed. By establishing these species as effective bioindicators and pollution sinks for air pollutants, this work provides insights for optimizing urban forestry and creating pollution control greenbelts in megacities.

Keywords: Air quality; Suspended particulate Matter; Plant tolerance to pollution stress; Urban green belt design

Keynote: 4

Analysis of waste-to-energy through incineration

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ABSTRACT

Incineration of Municipal Solid Waste (MSW) was not recommended in India until recently as the thermal properties of Indian MSW were not conducive for incineration. Over years, the thermal properties of Indian MSW improved and a 2000 tons/day plant came up in Okhla, New Delhi in 2012. Like the previous plants, this plant was also was supposed to burn raw mixed MSW. A few more incineration plants came up soon in Delhi and elsewhere in India. Later, in 2016, the Solid Waste Management Rules were implemented and that rules out the incineration of biodegradable (wet) waste. 2016 Rules emphasizes on source segregation so that only burnable components, but not compostable components, go for incineration. The compostable, biodegradable portion of MSW should go for any biological process like composting or bio-methanation. Since segregation was not strictly implemented, like many other cities, Delhi also generates raw mixed waste. Hence the incineration plants needed to be modified with separation techniques so that no wet waste goes for incineration.

There has been a shift from the conventional belief that prime objective of incineration is waste destruction without causing any damage to the environment. Power generation was supposed to be secondary. Incineration plants in India are all now Waste-to-Energy plants giving equal importance to power generation and waste treatment. Modern incineration plants have efficient grates for burning MSW components and excellent air pollution control equipment to ensure complete compliance with the stringent emission standards. However, the real time continuous monitoring of Dioxins and Furans is still an issue. This is due to the non-availability of reliable sensors.

It is expected that more Waste-to-Energy plants based on incineration technology will come up in India as it is now considered to be complimentary to the biological treatment techniques. Further, incineration plants may be operated for dealing with certain waste fractions like used sanitary pads & napkins, combustible fraction from the mined legacy waste, etc. Co-combustion or co-incineration is going to be adopted in a big way to use the Refuse Derived Fuel (RDF) from MSW and to deal with the different new types of waste generated.

Keywords: Solid waste management; Waste to energy; Incineration

Keynote: 5

Risk or resource? Balancing safety and circularity in biowaste management

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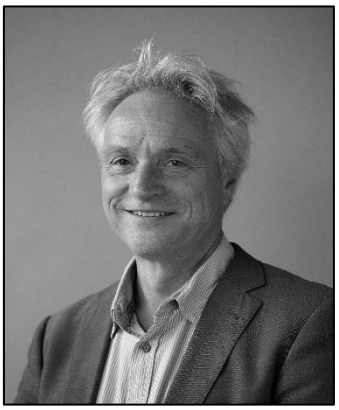
ABSTRACT

Bioconversion using larvae of the Black Soldier Fly (BSFL, *Hermetia illucens*) can contribute to more sustainable animal feed production, as the larval biomass provides proteins and lipids while also supporting resource-efficient and circular waste management strategies. For true sustainability and circularity, the use of post-consumer biowaste as a substrate would be ideal; however, such use is currently prohibited in the European Union due to concerns about disease transmission. While regulations are less defined or absent in other parts of the world, some countries in Asia and Africa do permit the use of post-consumer food waste for insect rearing. This EU ban limits the circular potential of insect production in Europe. This presentation will discuss the rationale behind current EU legislation, describe its environmental consequences, and outline potential risks associated with rearing BSFL on post-consumer food waste.

Keywords: Bioconversion; Black soldier fly; Circular waste management;

Keynote: 6



The role and potentials of anaerobic treatment in the circular economy

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ABSTRACT

In anaerobic conversion processes, organic compounds present in liquid waste streams, slurries, manure and solid wastes are converted to its mineral end products. The biochemical energy, stored in these compounds, is accumulated in the most reduced form of carbon, the gaseous, almost non-soluble, CH_4. The latter is commonly recovered as energy source replacing fossil fuels. In addition to carbon, many other elements, such as nitrogen, phosphorus, and (heavy) metals, are mineralized and can be recovered using biochemical and physicochemical recovery techniques. Alternative to methane, fermentation products can be harvested serving as platform bulk chemicals. In the past decades, different resource recovery techniques have been developed of which several are already implemented at full scale in both municipal and industrial wastewater treatment plants. The keynote lecture will present our current insights and recent developments in resource recovery techniques coupled to anaerobic processes. In addition, advances in sludge digestion will be discussed treating excess sewage sludge coming from activated sludge municipal wastewater treatment plants. Are we indeed able to operate sewage treatment plants without fossil fuels?

Keywords: Anaerobic treatment; Resource recovery; Sludge digestion; Municipal and industrial; Energy neutrality

Keynote: 7

Towards a sustainable urban water use system for the future

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ABSTRACT

Climate change and rapid urbanization are causing water shortages in major Asian cities. Even in Japan, where annual rainfall is roughly twice the global average, urban areas lack abundant water resources. Japan's water resources have primarily been used for irrigation for rice cultivation, and this supply has been prioritized. Since the rapid economic growth and urban population increase that began in the 1960s, Japan has periodically experienced severe water shortages. To address water shortages and ensure a stable water supply throughout the year, Japan has actively developed water resources, primarily through the construction of dams and other reservoirs. Furthermore, Japan is transitioning to Integrated Water Resources Management (IWRM), which includes the efficient use of water resources, comprehensive management of water quality and quantity, and risk management.

To achieve a sustainable water supply in the future, it is essential to ensure a sound water cycle while adapting to climate change and conducting social activities. Concerns about sustainable urban water use and increasing demand have led to growing interest in the use of rainwater and reclaimed water. It is necessary to reconsider the current urban water use system, which relies on surface water and groundwater, and propose a new system that can adapt to future climate change. However, from the perspective of urban water sustainability, it is necessary to evaluate the potential of rainwater and reclaimed water use under climate change. These valuable urban water resources should be utilized under appropriate water quality management.

In this presentation, I will first outline past and current practices of rainwater and reclaimed water use in Japan. Next, I will discuss the need to ensure urban water supply and demand balance and appropriately allocate rainwater and reclaimed water to water uses with different water quality requirements. I will then present the results of a research project evaluating the quality of rainwater and reclaimed water. Regarding rainwater, we conducted a water quality monitoring survey at road runoff infiltration facilities to promote rainwater infiltration and direct use for groundwater recharge. Furthermore, regarding reclaimed water use, we evaluated the biodegradable organic matter content in various reclaimed water distribution systems, as microbial proliferation can cause health hazards, aesthetic degradation, and biofouling. Finally, I developed a new evaluation method for assessing water quality risk and stability, taking into account environmental costs and diverse user preferences, and attempted to build a sustainable urban water use system.

Keywords: Climate change; Rainwater; Reclaimed water; Urban water use, Water Resource

Keynote: 8

Finding something or missing something: A twelve-month search operation for emerging contaminants in Mexico

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ABSTRACT

The aquatic environment is increasingly threatened by a wide spectrum of chemicals originating from consumer and industrial activities, including emerging contaminants (ECs) such as volatile organic carbon (VOCs), per- and polyfluoroalkyl substances (PFAS), pharmaceuticals, and pesticides. These persistent compounds jeopardize the integrity of aquatic ecosystems and human health through their pervasive presence and accumulation in water matrices. Addressing this growing challenge requires a comprehensive monitoring framework that extends beyond traditional contaminant assessments. In this context, A Twelve-Month Search Operation for Emerging Contaminants in Mexico seeks to generate a holistic understanding of the country's water systems through extensive, multi-parameter chemical analyses. Water samples are being collected from diverse aquatic sources, including the wastewater treatment plants (WWTPs), groundwater system, rivers, and lakes from Monterrey, Queretaro, Mexico city, Texcoco and Toluca. These sites represent distinct hydrological and anthropogenic influences, allowing a comprehensive evaluation of pollution dynamics across urban, industrial, and natural water systems. For each sample, a suite of analytical approaches is being employed -encompassing target and non-target analysis, pesticide and pharmaceutical profiling, PFAS determination, and the quantification of major ions and heavy metals. Together, these analyses aim to capture the complexity of chemical pollution, identify both known and previously unreported contaminants, and link chemical fingerprints to potential sources and environmental pathways. Environmental water surveillance serves as a central component, as wastewater functions both as an indicator of community-level chemical exposure and a conduit for resistant bacteria and persistent pollutants, whereas rivers and lakes helps in systematic monitoring for contaminants, pathogens, and other indicators of public health or environmental risk. To overcome the limitations of conventional targeted methods, Non-Target Analysis (NTA) is integrated to reveal unregulated micropollutants and transformation products of PFAS and pesticides, enabling more accurate risk evaluation and early warning. This initiative envisions a collaborative, data-driven platform that advances chemical surveillance under the One Health framework, strengthens regional monitoring capacity, and promotes sustainable, evidence-based water quality management across Mexico.

Keywords: Emerging contaminants; one health; pesticide; PFAS; Pharmaceuticals

Invited Speaker: 1

My Aerobic-Anaerobic Journey in waste and wastewater management: Harnessing Microbial for Sustainable Solutions

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ABSTRACT

This work focused on the application of aerobic and anaerobic pathways in advancing sustainable waste and wastewater management, with a focus on harnessing microbial interactions for energy recovery, water reuse, and resource recovery. Beginning with the development of integrated anaerobic aerobic systems, the research demonstrates field-scale validation of low-energy sewage treatment technologies, with robust pollutant removal and resilience under high-loading conditions. Extension of anaerobic-aerobic principles to the industrial sector, particularly beverage effluent treatment, highlights the performance of advanced sequencing batch reactors (APBF-SBR) coupled with reclamation units, achieving >95% removal of organics and nutrients, alongside water savings of 35%. At the national scale, sludge management emerges as a critical challenge, with over 5 million tonnes of dry sludge generated annually in India, much of it inadequately treated or disposed. Innovative pathways, including thermal hydrolysis process (THP) integrated with anaerobic digestion, show promise for improving volatile solids reduction, methane yield, pathogen inactivation, and micropollutant removal. Parallel studies on municipal solid waste and agro-residues reveal the potential of thermal-chemical pretreatments, carbon-based additives, and ferric dosing to enhance biomethanation and mitigate recalcitrant toxicity. Pilot and full-scale case studies, including the 100 TPD Goa MBT plant, demonstrate operational feasibility of circular waste management. Collectively, these innovations underline microbial synergy as a cornerstone for energy-positive, low-carbon wastewater and solid waste treatment, aligning with sustainable development goals and pathways toward a circular economy.

Keywords: Wastewater Treatment, Anaerobic Digestion, Biomass waste, Thermal Hydrolysis Process (THP), Energy and Resources Recovery, Water Reclamation & Reuse

Invited Speaker: 2

Diversity and resistome shifts in combined clinical-domestic effluent following submerged aerated filter treatment: Insights from culture-dependent and independent methods

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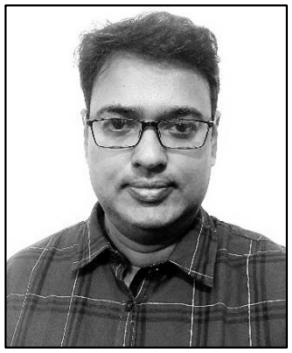
ABSTRACT

The performance of submerged aerated filtration systems such as BioKube® in treating clinical wastewater—characteristically low in organic load but enriched with pathogens and antibiotic-resistant bacteria—remains insufficiently studied. This work assessed long-term efficiency of a BioKube® unit using an integrated strategy that combined culture-based bacterial identification and antibiotic susceptibility testing (AST) with metagenomic analysis. Effluent biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were moderately reduced to 40 mg/L and 129 mg/L, corresponding to removal efficiencies of 25 and 20%, likely influenced by high influent COD:BOD ratio (~3). The Gram-positive to Gram-negative ratio decreased from 0.86 to 0.5, suggesting selective shifts in microbial community. Culture-based results showed enrichment of *Pseudomonas* and *Escherichia* and depletion of *Bacillus* and *Aeromonas*, while metagenomic data indicated a distinctly different community structure. Antibiotic resistance profiles also varied by method: culture-based AST predominantly detected resistance to colistin, quinolones, and macrolides, whereas metagenomics revealed resistance to cephalosporins/penems, aminoglycosides, and quinolones. Both approaches identified resistance to last-resort antibiotics such as carbapenems and colistin. Overall, findings highlight importance of integrating culture-based and metagenomic tools to thoroughly evaluate antimicrobial resistance (AMR) in clinical effluents and illustrate limitations of relying on conventional indicators like coliforms to assess AMR dissemination risks.

Invited Speaker: 3



Performance of Riverbank Filtration for Pollution Control under Varying Hydrogeological Conditions

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ABSTRACT

Ensuring reliable access to clean and safe drinking water remains a critical environmental challenge under conditions of rapid population growth, urbanization, industrial expansion, and increasing climate variability. Surface water sources, which serve as the primary drinking water supply in many regions, are progressively degraded due to the presence of suspended solids, pathogenic microorganisms, nutrients, and emerging organic pollutants. Although conventional water treatment plants are capable of producing potable water, their high capital cost, energy demand, and operational complexity often limit their applicability in small towns and resource-constrained settings. Under these circumstances, Riverbank Filtration (RBF) has gained prominence as a sustainable and low-cost, nature-based treatment alternative that utilizes the natural filtration and attenuation processes within river-connected aquifers.

The present study comprehensively evaluates the performance of RBF in controlling surface water pollution and improving drinking water quality under varying hydrogeological conditions. Laboratory-scale batch and column experiments were conducted to investigate the removal of turbidity, microbial contaminants (total coliform and E. coli), and an anionic surfactant, linear alkylbenzene sulfonate (LAS). The effects of key hydrogeological parameters—including aquifer soil type, grain size distribution, fine content, hydraulic gradient, detention period (travel time), and groundwater flow velocity—on pollutant removal efficiency were systematically examined. To complement the laboratory investigations, field studies supported by tracer techniques were carried out at selected RBF sites in Odisha, India, to evaluate river–aquifer interactions and to validate laboratory observations under field conditions. The results demonstrate substantial attenuation of turbidity, microbial indicators, and LAS in RBF-treated water compared to the corresponding source river water, confirming the strong pollution control capability of the RBF process. Improved removal efficiencies were observed under conditions of increased travel time, higher fine content, greater aquifer thickness, and lower hydraulic gradients.

Overall, the study establishes Riverbank Filtration as an effective, resilient, and environmentally sustainable pollution control measure for the production of safe drinking water. The findings underscore the importance of site-specific hydrogeological characterization and predictive modeling for optimizing RBF system design, thereby contributing to clean environment initiatives and long-term water resource sustainability.

Keywords: Riverbank Filtration; Pollution Control; Drinking Water Treatment; Hydrogeological Conditions; Microbial Contamination; Sustainable Water Management

Invited Speaker: 4

Mainstream anammox nitrogen removal and switching of flows with sidestream, key microorganisms capable of resource recovery

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ABSTRACT

Loss of anammox bacterial activity at lower temperatures and higher organic contents needs to be avoided to perform mainstream anammox and recover valuable organic substances. We performed a novel switching method between sidestream (reject water at >22 °C) and mainstream wastewater (municipal wastewater at 16.5 °C). Real sidestream wastewater (biogas plant effluent) (≈1000 mg NH_4^+-N L^{-1}) and synthetic mainstream (municipal wastewater-like source) (≈100 mg NH_4^+ -N) wastewater were used for reactor feeding. The highest total nitrogen removal rate (TNRR) of 527 g N m^{-3} d^{-1} (average TNRR 180 (±140) g N m^{-3} d^{-1}) was achieved in the 20 L deammonification biofilm reactor operation with sidestream at a low chemical oxygen demand (COD)/TN ratio of 1.1/1. COD/N ratio of 3.2/1.

The highest TNRR in a batch test was achieved at the COD concentration of 480 mg L^{-1}, reflecting a TNRR of ≈ 5 mg N g^{-1} TSS h^{-1}. With a high COD concentration of 2600 mg L^{-1} (TOC/TN=8/1), TNRR decreased similarly in both feeds to 1.6 mg N g^{-1} TSS h^{-1}. The anammox microorganism's genus *Candidatus Brocadia* enrichment in deammonification biofilm reactor was higher in mainstream feed (7.6 % of all bacteria) than in sidestream feed (<0.7 % out of all species). *Pseudomonas* bacteria (~10 %) represented as resource recovery key players.

Keywords: Specific anammox activity; biofilm; reject water

Invited Speaker: 5

Integration of biochar and microbial sludge in constructed wetlands for enhanced nitrogen removal from wastewater

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ABSTRACT

Excess nitrogen (N) from agricultural runoff, domestic sewage, industrial effluents and other anthropogenic sources threatens aquatic ecosystems, causing eutrophication, oxygen depletion, and long-term water quality degradation. Constructed wetlands (CWs) have emerged as efficient, low-cost systems for N removal through synergistic interactions among plants, microorganisms and substrates. However, the efficiency of CWs treating low C/N wastewater is often limited by poor microbial activity and carbon availability. Integrating biochar and sludge offers a promising approach to overcome these constraints and enhance N removal performance. Biochar, a porous carbonaceous material, enhances N adsorption, improves aeration and provides a favorable surface for biofilm development and microbial colonization. Also, sludge (activated or anaerobic) introduces diverse functional consortia accelerating N transformations. Biochar-amended CWs have achieved >85% total nitrogen (TN) and >87% chemical oxygen demand (COD) removal, with 30-40% of N retained within the sand-biochar matrix, indicating dual roles of adsorption and microbial assimilation. Sludge-augmented CWs exhibited urea and NH_4^+-N removal efficiencies of >70% and 99% respectively, accompanied by elevated enzyme activities (urease and dehydrogenase) highlighting enhanced organic N mineralization. Additionally, under low C/N conditions (3.6-2), sludge-biochar integration enhanced microbial activity and shifted N removal from adsorption to biologically driven pathways. This integration achieved up to 94.9% TN removal, supported by the coexistence of nitrifiers (*Nitrosospira*, *Nitrospira*), denitrifiers (*Pseudomonas*, *Thauera*), and anammox bacteria (*Candidatus Kuenenia*). Overall, biochar-sludge integration strengthens microbial diversity, enzymatic activity and N conversion efficiency establishing CWs as robust nature-based systems for sustainable N management across diverse wastewater stream.

Keywords: Nature based solutions; Microbial activity; Enzyme activity; Anammox; Sustainable wastewater treatment

Invited Speaker: 6

Entomoremediation and other directions of alternative use of insects

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ABSTRACT

The utilization of insects in various biotechnological, agricultural, and environmental applications has gained growing scientific and industrial interest, especially in the European Union in recent years. Traditionally, insects have played an important role in human societies as sources of food, feed, medicine, textiles, as well as in ecological services such as pollination and biological pest control. In the context of the global population growth and the forecasted increase in demand for animal protein, edible insects offer a sustainable and efficient alternative to conventional livestock production. Their cultivation requires significantly fewer resources and generates a lower environmental footprint. The European Union has progressively developed a regulatory framework enabling the farming of insect species for food and feed purposes, including mealworm beetles, crickets, and locusts, reflecting a broader transition toward novel and circular bioeconomy solutions. With growing insect breeding sector there will be growing waste production in the form of insect frass and biomass of naturally dead insects and their puparia. The question is whether it is possible to create something new from this type of waste in the spirit of upcycling and circularity?
Beyond traditional uses, there are other, several possible applications of insects and insect-derived materials. These include waste bioconversion, biochar and biogas production, and extraction of bioactive compounds such as antimicrobial peptides and chitin. The concept of entomoremediation is emphasized as a novel environmental remediation strategy. Insects can accumulate pollutants within their tissues or exoskeletons, enabling their subsequent removal or transformation from the environment. Experimental results demonstrate that larvae of species such as *Tenebrio molitor* are capable of biodegrading synthetic polymers, including polystyrene and polyurethane. Moreover, the conversion of insect biomass residues (puparia of *Hermetia illucens*) through pyrolysis yields biochar with favorable physicochemical properties for soil improvement and carbon sequestration, showing no ecotoxicity in laboratory tests. Similarly, insect frass serves as a high-potential substrate for anaerobic digestion, producing biogas yields comparable to traditional agricultural wastes.
In conclusion, insects represent a versatile biological tool that bridges food security, waste management, and environmental protection.

Keywords: Insects; Biomas valorization, Entomoremediation, *Hermetia illucens*; Upcycling

Invited Speaker: 7

From pollution to restoration: A case study on phytoremediation of chromium

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ABSTRACT

Environmental pollution through mining activity has emerged as one of the most important global challenges due to its persistence, toxicity and bio-accumulative nature. Among these pollutants, chromium (Cr) is particularly concerning because of its extensive use in electroplating, textile dyeing, leather tanning and pigment production industries. Chromium contamination, especially in the hexavalent form (Cr^{6+}), poses severe risks to soil quality, fertility, groundwater resources, plant growth/development and human health. Conventional physicochemical remediation methods such as ion exchange, precipitation and electrochemical treatment are often expensive, energy-intensive and generate large amount of secondary waste. As a sustainable alternative, phytoremediation uses green plants to remove, stabilize, or remediate contaminants from soil and water has gained significant attention in recent years. The present phytoremediation study of chromium-contaminated soil focuses on the mechanisms, efficiency and ecological benefits of selected hyperaccumulator plant species.

In connection with sponsored project funded by OMC, we got an opportunity to study the impact of Chromium on mining sites at South Kaliapani chromite mines of OMC. The overburden dump within mine lease area was selected for plantation after primary survey of the area and detailed discussion with OMC officials of South Kaliapani mines. The major factors of site selection were availability of large patch overburden area (more than 10 hectare) to undertaken the work, execution plantation and post plantation activities (land preparation, plantation, irrigation, specific time interval growth measurement etc.). The hyperaccumulating/ high biomass producing species like ***Cymbopogon martini (palmarosa), Cymbopogon flexuosus (lemongrass)*** and ***Chrysopogon zizanioides (Vetiver)*** were planted.

Moreover, the case study highlighted the importance of optimizing growth conditions, such as soil pH, organic matter content and biochemical chelating agent application to enhance metal uptake efficiency. From an ecological prospective, phytoremediation offers multiple co-benefits: promotes vegetation cover, prevents erosion, improves soil microbial activity, and provides a cost-effective, environmentally friendly solution. Although more research is necessary for conclusive results, our study is pivotal in that it would help in assessing plant species as potential phytoremediation species in heavily contaminated soils.

Invited Speaker: 8

Upcycling agro-residues into functional agro-mycelial composite for Circular and Sustainable Applications

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ABSTRACT

Annually, the global agri-food sector generates substantial quantities of lignocellulosic agro-residues as an inevitable secondary product from crop cultivation, harvesting, and post-harvest processing. However, due to a lack of efficient valorization strategies, a significant portion of these residues remains unexploited and is often subjected to open-field incineration, thereby leading to greenhouse emissions, solid waste generation, and environmental degradation. Consequently, the global sustainable development strategies emphasize the need to transform these low-value agro-residues into value-added materials instead of leaving them as unmanaged waste in order to foster a circular bioeconomy. Towards the same, agro-mycelial composites have recently garnered worldwide attention as an emerging composite material that can be produced from agro-residues. These harness the natural intrinsic binding ability of fungal mycelia as an effective bio-fabrication method to upcycle the agro-residues into functional composite material that can be used across wide industries. Despite prior efforts to convert agro-residues into an agro-mycelial composite, the production process is often constrained by the physico-chemical characteristics of a single substrate, which often result in nutrient deficiencies and suboptimal mycelial proliferation. Therefore, the present research employs a defined blend of agro-residues and indigenous fungal isolates for efficient colonization and composite development. The resulting composite undergoes morphological, chemical, thermochemical, and mechanical analysis for evaluation of its structural integrity and compressive strength. Furthermore, various production parameters such as the different ratios of fungal mycelia and substrate, growth conditions, and post-processing were optimized for a suitable composite in prospect of packaging applications. Overall, the study demonstrates that agro-mycelial composites present a step toward building a future beyond the waste era by transforming agro-residues into high-value, sustainable packaging inserts.

Keywords: Lignocellulosic biomass; Waste management; Upcycling agro-residues, Agro-mycelial composites; Sustainable packaging

Invited Speaker: 9

Advancing Sustainable Groundwater Remediation: Pilot Scale Ion Exchange Membrane Bioreactor for High Nitrate Removal

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ABSTRACT

Nitrate contamination in surface and groundwater, primarily arising from agricultural runoff, domestic sewage and industrial discharges has become a significant environmental and public health concern. Elevated nitrate levels cause severe health effects such as methemoglobeinemia (blue baby syndrome), necessitating efficient and sustainable removal technologies. This study presents the development and pilot scale evaluation of an Ion Exchange Membrane Bioreactor (IEMB) integrating Donnan dialysis and biological denitrification for nitrate removal from contaminated water. The IEMB utilizes an anion exchange membrane to selectively transport nitrate ions from feed to biocompartment, where denitrification occurs under anoxic conditions using glycerol as an electron donor. The system efficiently treated feed nitrate concentrations of 150±10 mg/L at flow rates of 40-60 L/h, achieving a treatment capacity of 1.5 m3/day and nitrate loading rate of 6.5 kg/m3/day. Membrane screening revealed the FAS-PET-75 anion exchange membrane as the most effective in minimizing sulphate co-transport while maintaining high nitrate selectivity. MATLAB-based modeling of Donnan dialysis accurately predicted nitrate and chloride fluxes, validating experimental outcomes and supporting scale-up potential. Metagenomic analysis of bioreactor confirmed a stable denitrifying community dominated by *Proteobacteria*. The treated water met the quality standards prescribed by WHO, IS:10500 (2012), and EU guidelines. Overall, the developed IEMB system demonstrates a sustainable, high throughput and predictive approach for nitrate remediation in contaminated ground water, with strong potential for large scale application in decentralized water treatment systems.

Keywords: Biological denitrification; Water treatment; Ion Exchange Membrane Bioreactor; Microbial community

Invited Speaker: 10

Tire-Derived Aggregates for Urban Runoff

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ABSTRACT

Stormwater runoff management is a critical environmental challenge due to the transport of nutrients such as phosphates and metals that can degrade water quality. Recent studies investigated the use of tire-derived aggregates (TDA) as a sustainable and cost-effective medium in stormwater treatment and infiltration systems. One study explored how biofilm formation within TDA chambers influences metal leaching and the long-term performance of TDA-based treatment systems, finding that biofilm development can significantly reduce metal leaching from TDA and enhance system longevity under stormwater conditions. Complementing this, another study examined the leachability of multiple metals and the phosphate removal capacity of TDA under controlled runoff storage conditions. Results showed that TDA can effectively reduce phosphate concentrations in synthetic stormwater, indicating its potential to mitigate eutrophication risk. However, TDA was also found to leach metals such as zinc, copper, and iron, with concentrations sometimes exceeding freshwater chronic toxicity criteria, suggesting that integrating metal-adsorbing materials may be necessary to minimize environmental risks. Together, these studies highlight both the promise and challenges of using TDA in stormwater systems-demonstrating mechanisms for nutrient removal while also identifying important considerations for managing metal release. The combined insights support the development of improved sustainable stormwater treatment practices that leverage waste tire materials in engineered environmental systems.

Keywords: Stormwater management; Biofilm development; Metal leaching; Phosphate removal; Nutrient attenuation; Waste tire reuse

Track -1
Wastewater Treatment and Reuse

Paper ID: 013

Electro-peroxone process as a promising approach for PFAS degradation in aqueous systems

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ABSTRACT

PFAS, or per- and poly-fluoroalkyl substances, are a group of more than 10,000 man-made chemicals. They are often called 'forever chemicals' because they don't break down easily and are persistent in the environment. PFAS exhibit unique properties such as resistance to heat, water, and oil, making them versatile for usage in industries and everyday products like non-stick cookware, food packaging, firefighting foams, stain-resistant fabrics, and personal care products. India's rapid industrialization and urbanization raise concerns about the potential widespread use of PFAS. They have been ubiquitously detected in air, water/wastewater/effluents, soil, human blood, hair and breastmilk, biota, and found bioaccumulating into the food chain/environment. Human exposure occurs through skin contact, inhalation, and ingestion of contaminated food and water, leading to severe health issues like infertility, weakened immunity, birth defects, and even cancer.

A major concern is PFAS contamination of drinking water, affecting millions globally. These compounds infiltrate groundwater and persist indefinitely, because most water treatment plants aren't equipped to remove them. Current methods fail to address the entire spectrum of PFAS compounds, posing regulatory and remediation challenges. This research focuses on an electrochemical ozone oxidation technique, 'Electro-peroxone' (E-peroxone) process. It is a novel electrochemically driven advanced oxidation process that integrates conventional ozonation with an electrolysis process using a carbon-based cathode. It offers extremely high removal for long-chain PFAS and is also the one of the very few methods with substantial efficiency for short-chains. The process was optimized by evaluating the effects of electrolyte type/dose, pH, applied current, and anode material. The E-peroxone process operates without the need for external chemical addition and generates no sludge, resulting in minimal by-products requiring further treatment. E-peroxone process is thereby the most effective and environmentally-friendly advanced oxidation technology for PFAS degradation.

Keywords: Degradation; Electrochemical; Ozone; Peroxone; PFAS

Paper ID: 021

Development of sustainable porous adsorbent for cationic dye adsorption: a fresh start for waste valorization

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ABSTRACT

Industrial wastewater treatment has been a serious global issue in recent decades, and waste management necessitates the invention of new, cost-effective, sustainable technologies. There is a massive demand for potential wastewater purification methods using eco-friendly, low-cost material. Adsorption is the most affordable, reliable, and operationally quick wastewater treatment method. In the 21st century, there is a rising demand for environmentally friendly porous geopolymer adsorbents that may be produced from industrial waste via the circular economy concept. In this work, a cost-effective, porous, shaped, fly-ash-based adsorbent is prepared to efficiently remove cationic dyes from wastewater. Various percentages of GGBS and clay are combined with fly ash to improve the removal efficiency of the synthesized adsorbent. Parent batches are activated using an activator solution of sodium silicate and sodium hydroxide to prepare the geopolymer slurry. To create a foamed slurry with surface tension, sodium dodecyl sulfate was added at 0.5%, 1%, and 1.5% as a foaming agent. Using the injection solidification process, the slurry was injected drop by drop into the PEG-6000 medium using a syringe. The bead-shaped adsorbents are then cleaned and dried at 60°C for 48 hours. Standard techniques (FTIR, XRF, XRD, and SEM-EDX) were used to characterize the adsorbents. Methylene blue (MB), a hazardous dye, was removed from water using batch mode to assess the adsorbents' adsorption capabilities. With a maximum adsorption capacity of 37 mg/g and a removal efficiency of 90%, the ideal geopolymer-shaped adsorbent demonstrated a high adsorption efficiency for 10 mg/L of MB dye solution (pH = 9) at room temperature. The porous beads recycle up to 8 times for multiple cycle uses. The adsorption kinetics, which follow a pseudo-second-order model, emphasize how the geopolymer's unique ion exchange capabilities generally enabled it to absorb MB by chemisorption. The study examines the adsorbent's features in detail, including the regeneration and desorption processes.

Keywords: Geopolymer; Methylene blue; Porosity; Fly-ash; Dye removal.

Paper ID: 022

Optimizing graphite-based electrode configurations for high-cod domestic wastewater: A comparative RSM study

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ABSTRACT

Electrooxidation (EO) is an advanced treatment technology for degrading refractory organic pollutants in domestic wastewater, offering advantages such as high efficiency, minimal sludge production, and adaptability to variable effluent compositions. However, its efficiency is dependent upon the various input operational parameters, necessitating robust optimization techniques. The integration of Response Surface Methodology (RSM) in this field is crucial, as it allows for systematic optimization of process parameters to maximize treatment efficiency while minimizing operational costs. This study presents a systematic evaluation of cost-effective electrode configurations, investigating graphite as base material in combination with stainless steel and dimensionally stable anode (Ti-RuO_2). In this study, the key operational parameters were optimized using RSM to maximize treatment efficiency in electrochemical wastewater treatment. Experiments were conducted using a batch reactor (400 ml) with three electrode configurations: standalone graphite, graphite-stainless steel, and graphite-Ti/RuO_2 systems. Box-Behnken Design under RSM framework optimized three variables: current intensity (1 – 2.5 A), initial pH (4-10), and electrolysis time (15-70 min). Real domestic wastewater samples were collected, treated, and analysed for COD removal efficiency. RSM optimization revealed optimal conditions for graphite-Ti/RuO_2: current intensity of 2.5 A, pH 10, and treatment time of 70 min, achieving 95% COD removal efficiency. Statistical validation confirmed high model adequacy (R^2 = 0.9831) with significant parameter interactions. The optimized process also achieved 99% turbidity removal from the wastewater. The superior performance of graphite-Ti/RuO_2 is attributed to Ti/RuO_2's high hydroxyl radical generation and graphite high conductivity facilitating efficient electron transfer enabling synergistic processes that maximize oxidative degradation under the optimized alkaline conditions. This research successfully demonstrates the effectiveness of graphite-based electrode systems with graphite-Ti/RuO_2 configuration, offering enhanced pollutant removal efficiency and better oxidant generation compared to conventional electrodes such as graphite alone.

Keywords: COD removal, Domestic wastewater, Graphite-Ti/RuO_2, Response Surface Methodology

Paper ID: 025

Putative role of carboxylesterases in *Enterobacter mori* BI1245 in the biodegradation of modified phthalates

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ABSTRACT

Plasticizers make polyvinyl chloride flexible that is used in making plastic materials. After using these materials, they end up in the environment where these plasticizers leach out and accumulate. The most used plasticizers are phthalates, and therefore, they are found in considerable amounts in the aquatic systems. In our previous studies, we found that bacterium *Enterobacter mori* BI1245 could grow well in the media containing diethyl (DEP), dibutyl (DBP), and dioctyl (DOP) phthalate, indicating that it could use these phthalates as a carbon source for its growth. Thus, in the present studies, we focused on the enzymes involved in helping the bacterium use these phthalates. Crude extract obtained by inoculating the bacterium in minimal salt media with the phthalates had elevated activity when using p-nitrophenyl acetate as a substrate. Extract was found to be stable under broad temperature, wide pH range, and organic solvents. Degradation constant (k) for DBP, DEP, and DOP was found to be 0.073/ h, 0.084/ h, and 0.052/ h, while the half-life ($t_{1/2}$) of it was found to be 1.36 h, 1.58 h, and 2.1 h. No accumulation of intermediates or end products or metabolites was found at any time point by GCMS analyses. Biodegradation percentage (B %) for DEP, DBP and DOP was found to be 68.2 %, 63.77 % and 49.63 % while removal efficiency (E %) was calculated and found to be 94 %, 90 % and 81 % after 30 h of incubation Elevated gene expression of carboxylesterases and phthalate-4, 5- dioxygenase enzyme was seen in the bacterium indicating their role in converting phthalate di-esters to phthalic acid, which may be further mineralized into carbon dioxide and water by the Krebs cycle. Thus it can be predicted that *Enterobacter mori* BI1245 contributes to *Chironomus circumdatus* larvae to survive in plasticizer polluted water.

Keywords: Phthalates; Carboxylesterases; Phthalate-4, 5- Dioxygenase; Biodegradation; p-Nitrophenyl esters;

Paper ID: 041

Bimetallic (Zr-Zn)-organic frameworks-based catalysts for improved performance of microbial fuel cells

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ABSTRACT

The sluggish nature of the oxygen reduction reaction (ORR) at the cathode continues to pose significant challenges to operate the microbial fuel cells (MFCs) because it hinders their energy conversion performance. The advantages of platinum catalysts within ORR kinetics remain limited by their expensive manufacturing costs together with their susceptibility to degradation making large-scale applications impractical. Bimetallic metal-organic frameworks (BMOFs) make effective cathodic augmentations possible through their stability benefits together with wide surface area potential and customizable porosity properties mainly from their Zr and Zn metal components. Zr-based MOFs maintain stable structures combined with thermal stability, but Zn-based MOFs show excellent electrochemical properties together with lower toxic elements that benefit microbial processes.

This study investigates the performance of MFCs equipped with a Zr-Zn bimetallic-organic framework (Zr-Zn BMOF) catalyst, focusing on chemical oxygen demand (COD) removal efficiency, energy recovery, and long-term stability. Over 40 days of operation (10 cycles, 4 days each), MFCs with Zr-Zn BMOF achieved an average of 75% COD removal efficiency from sucrose-based wastewater (initial COD: ~3 g/L), significantly outperforming carbon black (65%) and control (58%). The system exhibited a peak open circuit voltage (OCV) of 0.715 V and an operating voltage (OV) of 0.15 ± 0.01 V, demonstrating robust electrochemical activity. Coulombic efficiency reached 29.04 ± 1.54%, indicating efficient energy recovery for MFC with Zr-Zn BMOF compared to Pt-based MFC (33.12 ± 1.05%). Structural characterization (SEM, EDAX) confirmed the BMOF's porous morphology (91% Zr, 5% Zn composition) and stability throughout the operation. The catalyst's cost-effectiveness (4.4× cheaper than Pt) and durability position it as a sustainable alternative for scalable bio-electrochemical systems. These results highlight the potential of Zr-Zn BMOFs to advance energy recovery and wastewater treatment technologies by integrating high catalytic performance with economic viability.

Keywords: Bimetallic-organic frameworks; Bio-electrochemical systems; Energy recovery; Microbial fuel cells; Wastewater treatment

Paper ID: 043

Green synthesis of zinc oxide nanoparticles and its applications in treatment of wastewater

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ABSTRACT

Nanoparticle that lies in the range of 1-100 nm in one dimension are used significantly in the areas of medicinal chemistry, atomic physics, and all other known fields. They are used due to their small size, physical properties, and orientation. The synthesis of nanoparticles can be done by various chemical, physical, and biological approaches. The emerging approach is the biological synthesis process, because this method is more accessible, eco-friendly, and cost-effective. Zinc oxide, an emerging nanoparticle with a band gap of 3.37 eV and a high excitation binding energy of 60 meV, is one of the best nano adsorbents for the removal of pollutants. However, the synthesis of zinc oxide nanoparticles by the chemical method involves the utilization of toxic chemicals and expensive instruments, along with tedious process control. Therefore, it is necessary to develop a simple, low-cost, and environmentally friendly green method for synthesizing zinc oxide nanoparticles. The present study investigated the use of Azadrichtaindica leaf in the synthesis of zinc oxide nanoparticles under ambient conditions. Zinc oxide nanoparticles were synthesized using Azadrichtaindica leaf extract as a reducing and capping agent. The reduction of zinc acetate dihydrate confirmed the synthesis of zinc oxide nanoparticles. The synthesized Zinc oxide nanoparticles have been characterized using FTIR spectroscopy, SEM, XRD, and UV spectroscopy. The mean crystalline size of the nanoparticles was found to be 43.69 nm, and functional groups of 546 cm^{-1} of zinc oxide bands were found. SEM images showed the aggregation of particles with a diameter of 96.2nm. Factors affecting the pollutant adsorption, including the contact time, initial concentration, and dosage, were also investigated. The synthesized nanoparticles obtained a removal efficiency of 98.37% for lead and 99.61% for copper in 10 minutes. The Freundlich model well explained the adsorption of Pb and Cu. The maximum adsorption of Pb(II) and Cu(II) in the binary system is 206.34 mg/g and 612.38 mg/g. In the kinetic study, the experimental data fitted well with the pseudo-second-order kinetics for Pb^{2+} and Cu^{2+} adsorption.

Keywords: Wastewater treatment; Zinc oxide nanoparticles; Green synthesis; Characterization; Adsorption.

Paper ID: 059

A comparative analysis of *Canna indica* and *Saccharum spontaneum* in macrophyte-assisted vermifiltration treatment of cattle feedlot wastewater

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ABSTRACT

Macrophyte-assisted vermifiltration (MAVF) is an emerging technology for the treatment of cattle feedlot wastewater, proving to be efficient and sustainable compared to conventional methods. However, the selection of plant species for better removal in Indian conditions has not yet been reported. Thus, in the present study, we performed a comparative analysis between two locally available macrophyte species, Canna indica and *Saccharum spontaneum*, for the treatment of cattle feedlot wastewater in MAVFs. The removal efficiency of Chemical Oxygen Demand (COD), Total Nitrogen (TN), Total Phosphorous (TP) and antibiotics in the influent (i.e., cattle wastewater) through different macrophyte species in the MAVF system was evaluated. Two Horizontal subsurface flow MaVFs were set up, namely R1 and R2. R1 was planted with Canna indica, while R2 was planted with *Saccharum spontaneum*. The experiment was conducted with a hydraulic loading rate of 0.6 m3/m2·day. The final effluent was collected at the end of the MaVF units. The average COD removal efficiency for R1 and R2 was 64.3±1.9 and 58.3±1.1, respectively. The average DO in R1 and R2 effluent was 2.54 mg/L and 4.46 mg/L, respectively. The pH for influent wastewater was in the range of 9.16±0.4, whereas the effluent pH ranged between 8.46-8.97 for all the reactors. The removal efficiency of TN for R1 and R2 were 39.7±1.1% and 35.6±1.1% respectively. Removal efficiency for TP for R1 and R2 was 60.3 ± 1.4%, 58.6±1.2% respectively. The higher organics and nutrient removal efficiency in Canna indica in comparison to Saccharum spontaneum can be attributed to the dense and extensive root structure of Canna indica in comparison to the fibrous root system of Saccharum spontaneum. Thus, the preliminary analysis revealed that *Canna indica* is more efficient in removal of organics and nutrients in comparison to *Saccharum spontaneum* in a MAVF system.

Keywords: *Canna indica*, macrophyte-assisted vermifiltration, *saccharum spontaneum,* antibiotics

Paper ID: 066

Leachate treatment using herbal waste derived biochar and bentonite clay: a sustainable approach

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ABSTRACT

Leachate is a liquid waste generated during the biodegradation process that occurs after municipal solid waste is disposed of in landfill sites. Leachate is characterized by high concentrations of organic contaminants, including elevated levels of chemical and biological oxygen demand (BOD/COD), total dissolved and suspended solids (TDS/TSS), and toxic heavy metals. Herbal waste is often disposed of in landfills, further exacerbating leachate generation and its associated complexities. Therefore, the present study investigates, for the first time, the potential utilization of biochar derived from herbal waste for effective leachate treatment. Biochar is an organic product obtained through the thermal decomposition of the studied herbal waste. To enhance its sorption capacity and specific surface area, the biochar was combined with bentonite clay, renowned for its high sorption potential. Biochar was mixed with sodium bentonite at various proportions to determine the optimal dosage through kinetic batch studies. The results demonstrate that the proposed mixture, at its optimum proportion, exhibits remarkable removal of TDS from the leachate while simultaneously maintaining COD, BOD, TSS, and pH within acceptable limits, thereby transforming herbal waste-derived biochar into a value-added product. This novel and sustainable treatment approach also proved viable for leachate containing highly interfering organic and inorganic compounds. Overall, this study highlights the potential of utilizing biochar derived from herbal waste, in conjunction with bentonite clay, as a promising and sustainable solution for enhancing leachate treatment efficiency and mitigating the environmental impacts associated with landfill leachate.

Keywords: Herbal Waste, Sodium Bentonite, Leachate, Total Dissolved Solid, Chemical Oxygen Demand.

Paper ID: 069

Biochar-amended tire-derived aggregates for sustainable stormwater treatment

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ABSTRACT

Tire-derived aggregate (TDA) is a promising filter medium for stormwater treatment, but its application is constrained by the leaching of heavy metals, particularly zinc and copper. This study advances prior batch-scale findings by assessing a continuous-flow column system designed to overcome this limitation. Wire-exposed TDA (WE–TDA) was blended with biochar to evaluate the synergistic potential for mitigating inherent leaching while enhancing the removal of spiked heavy metals, nutrients, and organic pollutants from synthetic stormwater. Four fixed-bed column reactors with varying WE–TDA/biochar ratios were tested: Reactor A (50% biochar + 50% WE–TDA), Reactor B (25% biochar + 75% WE–TDA), Reactor C (15% biochar + 85% WE–TDA), and Reactor D (100% WE–TDA, control). Across six observation cycles, reactor performance was evaluated Regarding total nitrogen (TN), total phosphorus (TP), total organic carbon (TOC), total organic carbon as well as heavy metals including zinc, copper, chromium, lead, cadmium, and arsenic biochar strongly suppressed heavy metal leaching compared to the control system (Reactor D), which Cu, Zn, and Cd leaching. All biochar-amended systems (A–C) showed consistent removal of chromium and lead (>98% removal). In biochar-rich reactors (A and B), phosphorus removal exceeded 97% while also significantly reducing TOC. Removal of nitrogen was lower and more variable at 72% on average, though it was more stable in biochar-rich systems. Moreover, biofilm formation in the columns improved the stability and resilience of the system for organic pollutants over the long term. The data indicate that WE–TDA filters with biochar amendments offer effective and sustainable solutions for decentralized stormwater treatment with robust pollutant removal and waste valorization

Keywords: Biochar; biofilm; heavy metals; nutrients; decentralized treatment

Paper ID: 071

Advancing microbial electrosynthesis: MXene as cathode catalyst for efficient CO_2 capture and sustainable biochemical production

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ABSTRACT

Microbial electrosynthesis (MES) offers a sustainable approach for converting carbon dioxide (CO_2) into value-added products, primarily acetate. However, the low product yield remains a critical bottleneck for field-scale implementation. Enhancing cathode performance using a biocompatible catalyst is therefore essential. An electrode with high conductivity and a large surface area can significantly promote biofilm growth, improve electron transfer, and CO_2 reduction efficiency. In this study, we used an MXene-coated carbon felt (CF) biocathode to improve MES efficiency. MXene was selected due to its unique two-dimensional layered structure, offering high conductivity and high surface area, while CF provided a robust, cost-effective support with favourable physicochemical properties. The characteristics of the electrodes were examined using X-ray diffraction (XRD), scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS), and Fourier transform infrared spectroscopy (FTIR). Electrochemical properties were evaluated through cyclic voltammetry and electrochemical impedance spectroscopy. The MXene-coated CF cathodes led to a 1.69-fold increase in acetate production, reaching 6.34 g L^{-1} of maximum concentration, compared to the unmodified CF cathode. This improvement is attributed to better microbial growth and enhanced electron transfer at the cathode surface. These findings highlight MXene as an efficient cathode catalyst for enhanced MES performance. This work provides valuable insights into cathode modification, advancing MES as a promising technology for CO_2 capture and sustainable biochemical synthesis.

Keywords: Bioelectrochemical systems (BES); Microbial electrosynthesis (MES); CO_2 capture and utilisation; Cathode modification; MXene.

Paper ID: 073

A sulfate-radical based advanced oxidation system using FEAL-LDH loaded on biochar for treatment of textile wastewater dye bath

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ABSTRACT

Textile wastewater is characterized by high chemical oxygen demand and low biodegradability and is challenging to treat using conventional biological processes. While the Sulfate Radical-based Advanced Oxidation Process (SR-AOP) can partially degrade such wastewater and enhances the biodegradability ratio, making subsequent biological treatment more effective. In this study, FeAl-LDH@BC catalyst was synthesized via the co-precipitation method and characterized using SEM, XRD, and FTIR techniques, confirming successful synthesis. The FeAl-LDH@BC/PMS system was evaluated for the degradation of Rhodamine B dye in synthetic wastewater, achieving a maximum removal efficiency of 92.16% under optimal conditions (pH = 9, catalyst dosage = 0.9 g/L, PMS dosage = 0.9 g/L, contact time = 120 min, initial dye concentration = 50 mg/L). Based on these promising results, the FeAl-LDH@BC/PMS system was then applied to actual textile wastewater, combined with ozonation treatment to enhance removal efficiency. The combined system achieved a 90.27% COD removal, with a reduction in pH from 9.82 to 7.54 and effective dye removal. The optimal PMS-catalyst dosage ratio of 4:1 and a 3-hour contact time were found to be crucial for maximizing treatment efficiency. Additionally, a seed germination test using mung beans was conducted with treated effluent mixed with tap water, demonstrating that the treated wastewater had no significant toxic effects, as indicated by the healthy growth of the plants. The results of this study demonstrate the potential of the FeAl-LDH@BC/PMS system, in combination with ozonation, as an effective and environmentally friendly solution for textile wastewater treatment. This integrated approach not only offers high pollutant removal efficiency but also shows promise for reducing toxicity and promoting sustainable wastewater management in the textile industry.

Keywords: Textile wastewater; Biodegradability; Toxicity; Rhodamine B

Paper ID: 076

Recent progress in biochar composite adsorbents for mitigating PFAS contamination in water sources: a critical review

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ABSTRACT

This review provides a comprehensive analysis of the development and application of engineered biochar composites for adsorbing per- and polyfluoroalkyl substances (PFAS) from contaminated water systems. Based on a systematic review from over 150 primary research articles published in the recent past and identified through systematic, extensive and related search, this work critically examines the transition from laboratory innovation to practical implementation. The analysis demonstrates that strategic modifications through metal oxide impregnation, polymer functionalization, and nanomaterial integration significantly enhance PFAS removal capacity by introducing crucial electrostatic attraction sites, amplifying hydrophobic interactions, and optimizing pore structures tailored for specific PFAS chain lengths.

However, a critical finding reveals substantial limitations in current research approaches. Most studies report performance metrics derived from idealized single-solute systems that fail to predict real-world efficacy, where natural organic matter and competing anions can reduce adsorption capacity by 30-60%. Furthermore, the review identifies that adsorption merely transfers PFAS from aqueous to solid phase, creating significant challenges in managing spent sorbents and potential risks of secondary contamination through leaching. These findings underscore the urgent need for standardized testing protocols that employ environmentally relevant conditions and comprehensive assessment of long-term stability.

The review concludes that future progress requires integrated approaches combining adsorption with destructive technologies such as electrochemical oxidation or advanced reduction processes to achieve complete PFAS mineralization. Additionally, research must prioritize pilot-scale validation, life-cycle assessment, and environmental impact studies to ensure sustainable implementation. This work emphasizes that successful application of biochar composites depends on addressing these critical gaps through multidisciplinary collaboration between materials science, environmental engineering, and policy development to develop effective solutions for global PFAS contamination.

Keywords: PFAS; Forever Chemicals; Biochar Composites; Adsorption; Water Treatment; Engineered Biochar; Environmental Impact; Life-Cycle Assessment.

Paper ID: 090

Photoelectrochemical oxidation of a mixture of pharmaceuticals in secondary treated wastewater

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ABSTRACT

Organic micropollutants such as pharmaceuticals pose significant environmental and public health risks. These contaminants not only contribute to the spread of antibiotic resistance but also disrupt aquatic ecosystems. Advanced oxidation processes are known to effectively degrade pharmaceuticals, and among these, photoelectrocatalysis (PEC) offers a promising method for removing contaminants present at trace levels (µg/L to ng/L). The focus of the presented study was to assess the influence of five quaternary ammonium compounds (QACs) on $BiVO_4$ photoanodes, modifying the structural properties and enhancing photoelectrocatalytic performance. The QAC-modified $BiVO_4$ photoanode variants were characterized using X-ray diffraction, scanning electron microscopy, energy-dispersive X-ray spectroscopy, X-ray photoelectron spectroscopy, UV-Vis spectroscopy, and linear sweep voltammetry. PEC degradation experiments were conducted using effluent, collected after secondary treatment, at a wastewater treatment plant, spiked with 10 selected pharmaceuticals at an initial concentration of 10 µg/L. The removal efficacy of the modified $BiVO_4$ photoanodes was evaluated under simulated solar irradiation. Among the tested variants, the photoanode modified with the alkyl trimethyl ammonium compound ATMAC C18 modified exhibited the most rapid degradation, with several pharmaceuticals removed within the first 15 minutes. However, dialkyl dimethyl ammonium compound DADMAC C18 modified photoanode was identified as the best-performing variant, with sulfamethoxazole emerging as the critical compound due to its longest half-life.

Keywords: Pharmaceuticals; Advanced Oxidation; Wastewater treatment; Photodegradation

Paper ID: 119

AI & ML for sustainable wastewater treatment: A bibliometric and trend analysis

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ABSTRACT

Artificial Intelligence (AI) and Machine Learning (ML) are increasingly being recognized as transformative tools in the domain of sustainable wastewater treatment. These technologies offer novel opportunities for process optimization, predictive monitoring, and decision support, enabling more efficient, cost-effective, and environmentally sustainable solutions. Despite their growing adoption, a comprehensive understanding of global research progress, collaborative patterns, and thematic trends remains limited. This study addresses this gap through a bibliometric and trend analysis of AI- and ML-driven wastewater treatment research. Using the Scopus database as a source and VOSviewer as the primary analytical tool, we evaluated publications to map research hotspots, identify collaboration networks, and explore thematic clusters shaping this emerging field.

The analysis highlights a steep growth in publications over the past decade, particularly after 2015, reflecting the increasing convergence of environmental engineering with data science. Cluster mapping reveals four dominant thematic areas which include optimization of treatment processes and pollutant removal, including nutrient management and energy-efficient operations; prediction and monitoring of emerging contaminants such as pharmaceuticals and antibiotics; modelling of microbial and biological processes through advanced learning algorithms and sustainable water reuse, reclamation, and resource recovery. Overlay visualization indicates a research shift from conventional wastewater engineering approaches to intelligent, data-driven frameworks. Emerging topics include antibiotic resistance risk prediction, microbial fuel cell performance optimization, integration of AI with Internet of Things (IoT) platforms, and climate-resilient wastewater management. This bibliometric assessment not only documents the rapid expansion of AI and ML applications in wastewater treatment but also underscores their potential in addressing pressing global challenges of water scarcity, environmental pollution, and public health. By outlining key research trajectories and collaboration networks, the study provides valuable insights for researchers, policymakers, and practitioners aiming to advance smart and sustainable wastewater management strategies.

Keywords: Wastewater treatment; Bibliometric analysis; VOSviewer; Artificial Intelligence; Machine learning

Paper ID: 145

Laundry wastewater treatment for microplastics removal using electrocoagulation

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ABSTRACT

Microplastic pollution has emerged as a critical environmental concern due to its persistence and potential environmental and human health impacts. Laundry wastewater is a major source of microplastics pollution due to the release of synthetic materials during washing. Further, the efficient removal of microplastics from wastewater during its treatment poses a significant challenge. Electrocoagulation has emerged as a promising technique due of its simplicity and high pollutant removal efficiency. This study evaluates the performance of stainless steel plates in batch mode electrocoagulation for removing microplastics from laundry wastewater. Experiments were conducted under optimized conditions, having electrode dimensions (8 cm × 8 cm × 0.1 cm), 12 V applied voltage, and 1 cm spacing. Water quality parameters, including pH, COD, electrical conductivity and turbidity were monitored periodically while other parameters like microplastics, sulphate, nitrate and phosphate removal was assessed at the end of the treatment. SS plates achieved significant microplastics removal (55%) from laundry wastewater. The study shows that electrocoagulation with stainless steel plates is effective method to reduce microplastics in laundry wastewater.

Keywords: Electrocoagulation; Wastewater treatment; Microplastics; Laundry wastewater; Stainless steel.

Paper ID: 146

Heavy metal ions removal from waste water by using biosurfactant from *Bacillus subtilis* SB1 as a collector via micro-flotation method

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ABSTRACT

Biosurfactants, owing to their eco-friendly nature and strong interfacial and colloidal characteristics, are emerging as potential candidates for next-generation reagents in metal recovery through bioflotation. A biosurfactant-producing bacterial species isolated from oil contaminated soil sample was identified as *Bacillus subtilis* SB1. It was grown in MSM (mineral salt medium) medium with glucose as a carbon source and energy. The biosurfactant was extracted by using acid precipitation method and solvent extraction method. Biosurfactant recovery was 1.8 g/L (gram per liter) by acid precipitation method, 1.75 g/L by solvent extraction method. The extracted biosurfactant was partially characterized as lipopeptide using TLC (thin-layer chromatography), and FTIR (fourier transform infrared chromatography). The biosurfactant was analysed using high-performance liquid chromatography.

The critical micelle concentration of biosurfactant was determined by measuring the surface tension. The biosurfactant exhibited emulsification stability of 70% with olive oil, 56.7% with kerosene, 23.3% with benzene, and moderate stability with other tested hydrocarbons and oils. Micro-flotation was employed to remove and recover different heavy metal ions from synthetic wastewater using the extracted biosurfactant from *Bacillus subtilis* SB1. The aeration rate, pH, ionic strength, concentration of SDS, and biosurfactant were considered as variables during the flotation experiment. The extracted biosurfactant showed promising heavy metal removal efficiencies. Spectroscopic analyses XPS and IR ((X-ray photoelectron spectroscopy and infrared spectroscopy) were performed to confirm the metal ion binding with the extracted biosurfactant. As a biodegradable and environmentally safe agent, the biosurfactant makes this approach a sustainable wastewater treatment strategy, enabling eco-friendly heavy metal removal, water reuse, and potential metal recovery.

Keywords: Biosurfactant; *Bacillus subtilis*; Surface tension; Floatation; Heavy metal ions

Paper ID: 158

Sequestration of tetracycline from stimulated wastewater by ayurvedic medicinal plants extract

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ABSTRACT

The widespread occurrence of antibiotics such as tetracycline in marine environments poses a serious threat to the flora and fauna and to human health due to the increase in antimicrobial resistance. The present study investigates the elimination of tetracycline from the stimulated wastewater by using an economically viable and sustainable extract of Ayurvedic medicinal plants waste. Experiments were conducted with varying concentrations of tetracycline, medicinal plants waste extract dosage, pH, temperature & time. The adsorption process was analysed through isotherm and kinetic models to understand the interaction mechanism. Results were in accordance with the effective affinity of tetracycline towards the surface of the medicinal plants waste extract, with maximum adsorption capacity fitting well to the Langmuir model, indicating monolayer coverage. Kinetic studies indicated pseudo-second-order behaviour, suggesting chemisorption as the limiting step. The different functional groups present on the surface of the medicinal plants waste extract, which are interacting with tetracycline, are analysed by Fourier Transform Infrared Spectroscopy (FT-IR), and the textural characteristics are studied with the help of Scanning Electron Microscope (SEM). The pore size and the surface area are analysed with the N_2 adsorption-desorption isotherm at 77K by using the Brunauer-Emmett-Teller (BET) equation. The study highlights how beneficial the new type of adsorbent, i.e. extract of an Ayurvedic medicinal plant waste, is in the mitigation of tetracycline.

Keywords: Tetracycline; Extract of Ayurvedic medicinal plant waste; Adsorption; Sustainable adsorbent; Antibiotics

Paper ID: 162

Microplastics removal from water using Fe based coagulant

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ABSTRACT

Microplastics (MPs), characterized as plastic particles that are less than 5 mm in diameter, have become ubiquitous pollutants in water bodies. These particles have considerable potential for bioaccumulation and can interact with numerous other contaminants. Given their durability, MPs present substantial risks to both ecological systems and human health, emphasizing the importance of developing efficient removal techniques. Research has shown that standard treatment processes, such as screening and sedimentation, can achieve removal rates of 50% to 80% for microplastics larger than 100 µm. However, traditional methods fall short in treating particles smaller than10 µm. Advanced treatment technologies, particularly membrane filtration, show remarkable removal efficiency, reaching up to 98%, yet they are challenged by issues like membrane fouling. Coagulation has emerged as a strong and effective strategy for the removal of microplastics among alternative methods. The success of coagulation is determined by several essential parameters, including the amount of coagulant used, modifications to the coagulant's surface, pH, ionic strength, and the characteristics of the microplastics in terms of type and size. These factors together dictate the interactions between microplastics and coagulants, enabling processes such as destabilization, bridging, and hydrophobic interactions. Iron-based coagulation stands out as a promising and scalable technique for addressing the issue of microplastic pollution in aquatic environments. The key iron salts employed as coagulants are ferric chloride (FeCl3), ferrous sulfate (FeSO4), and ferric sulfate (Fe2(SO4)3). There is an urgent demand for the development of rapid, eco-friendly, and efficient iron-based coagulants. To effectively tackle microplastic contamination, it is recommended to adopt integrated coagulation strategies, such as those that merge coagulation with adsorption or photocatalytic oxidation. Utilizing these techniques in large-scale water treatment facilities presents a practical solution for decreasing microplastic pollution, elevating water quality, and ensuring the protection of ecosystems and public health.

Keywords: Microplastics, Coagulation, Fe-based coagulant, Aqueous media

Paper ID: 167

Sustainable biopolymer-based films reinforced with coir nanocellulose and inulin for efficient remediation of *p*-phenylenediamine dye

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ABSTRACT

Paraphenylenediamine (PPD) is an aromatic amine extensively used in hair dyes, textiles, and rubber industries, but its persistence and toxicity pose severe environmental and health risks. Conventional treatment methods often fail to efficiently remove PPD from aqueous systems, necessitating the development of eco-friendly and sustainable alternatives. In this study, a novel sodium alginate-based bio-composite film reinforced with coir-derived nanocellulose and inulin was synthesized via solution casting for the biosorption of PPD from aqueous solutions. The physicochemical and structural properties of the films were characterized using Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and Thermogravimetric Analysis (TGA). FTIR spectra confirmed the successful incorporation of nanocellulose and inulin into the alginate matrix through hydrogen bonding and carboxyl–hydroxyl interactions. SEM micrographs revealed a porous and heterogeneous surface morphology, favorable for dye adsorption. XRD patterns indicated semi-crystalline behavior with improved structural stability upon reinforcement. TGA demonstrated enhanced thermal resistance compared to pristine sodium alginate films. Batch adsorption experiments showed that the developed bio-composite exhibited strong affinity toward PPD molecules, attributed to electrostatic interactions and hydrogen bonding with functional groups present in the matrix. The findings highlight the potential of coir nanocellulose–inulin reinforced sodium alginate films as sustainable, low-cost, and biodegradable adsorbents for the remediation of PPD-contaminated wastewater.

Keywords: Paraphenylenediamine; Bio-composite film; Biosorption; Wastewater treatment; Nanocellulose; Sustainability.

Paper ID: 168

Treatment of pulp and paper industry wastewater using biochar-derived proton exchange membrane in microbial fuel cell

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ABSTRACT

Microbial fuel cells (MFCs) provide a dual sustainable solution for energy generation and wastewater remediation but are still evolving for pulp and paper wastewater application. Proton exchange membrane (PEM) is an essential component and a major cost driver, accounting roughly 40% to 60% of total cost of MFC. The present study focuses on developing PEM using pine needle and rice straw biochar for treatment of pulp and paper industry wastewater. To enhance the desirable characteristics of PEM, pristine biochar was modified with sulphuric acid. Various concentration of pristine and acid-treated biochar from 10% to 40 % w/w were mixed with MMT clay. Among all the fabricated membrane, A-PB_40 exhibited best overall performance. The addition of 40 % wt. of acid-treated pine needle biochar to membrane enhance the key properties: water uptake (42.29 ± 1.45 %), proton mass diffusion (3.44 ± 0.23 x 10^{-6} cm^2/s), ion exchange capacity (0.44 ± 0.02 meq/g). The performance of MFC equipped with A-PB_40 membrane was assessed for 15 days in batch mode. The system treatment efficiency for pulp and paper wastewater was evaluated by an average COD removal of 81.88 ± 0.88 % and lignin removal of 64.02%. The bio-energy generation was evaluated across 100 Ω external load and achieving a power density of 2480.60 ± 121.04 mW m^{-2} and current density of 5.32 ± 0.24 mA m^{-2}. These results demonstrate that biochar-based clay membrane (A-PB_40) show as a promise PEM for MFC application, offering high treatment efficiency of pulp and paper wastewater and better proton conductivity at 9.45 times cheaper than Nafion.

Keywords: Bioelectricity; Sulphonation; Cation exchange membrane; Waste valorization; Clay membranes

Paper ID: 170

Energy Efficient Organic and Nitrogen Removal in Diverse Wastewater Using a Moving Bed Biofilm Reactor (MBBR)

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ABSTRACT

The growing diversity and volume of wastewaters from domestic, municipal, and industrial sources, particularly brewery effluents, necessitate sustainable and efficient treatment solutions. This study evaluates an integrated biological system using Moving Bed Biofilm Reactor (MBBR) for the simultaneous removal of organic matter and nitrogen from three wastewater types with distinct characteristics: domestic, municipal, and brewery. A 90-day operational assessment demonstrated stable performance under fluctuating influent compositions. For domestic wastewater, average chemical oxygen demand (COD) removal was 92±5% with total nitrogen (TN) removal of 85±4%. Municipal wastewater exhibited COD removal of 90±4% and TN removal of 83±3%. Brewery wastewater, characterized by higher organic loading, achieved COD removal of 88±6% and TN removal of 75±4%. The system maintained resilience across variable hydraulic retention times and organic loading rates, indicating adaptability to diverse wastewater sources. The key contribution is the demonstration of a single, integrated configuration capable of treating both low and high strength wastewaters with comparable efficiency. In contrast to conventional activated sludge processes that require high aeration energy and produce substantial sludge, the proposed approach reduces aeration demand by more than 40%. This technology offers an energy-efficient and environmentally sustainable alternative for wastewater treatment. These results highlight the potential of integrated pathways to address concurrent organic and nitrogen pollution across diverse wastewater matrices, aligning with broader goals in resource recovery, climate mitigation, and sustainable sanitation.

Keywords: Wastewater Treatment; Biological; MBBR; Brewery; Energy Efficient.

Paper ID: 179

Bibliometric insights into comammox research and its microbiological foundations for wastewater applications

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ABSTRACT

Comammox, or the Complete Ammonia Oxidizers are distinguished by their ability to completely oxidize ammonia in a single cell. The objective of this review is to conduct a bibliometric analysis of comammox research and acquire microbiological insights, with the aim of identifying characteristic traits that can be harnessed for advancing wastewater treatment applications. A bibliometric analysis was conducted across 577 publications using Scopus-Indexed literature since 2015. The analysis revealed a sharp rise in research in the areas of Environmental Microbiology and Biotechnology. Country-level analysis showed a leading research output from China about 59%, collaborating with the US and European countries. India stands as an emerging country with an overall contribution of 3% and of 82.4% as a Single-Country Publisher, whose outputs dominated lab-scale enrichment and community-profiling/nitrification studies, with wastewater treatment as the primary application track and strong parallel work on ecology/phylogeny. Comammox bacteria stand out for their microbial and molecular characteristics making them ecologically significant competitors to other AOB and AOA, with a potential for efficient nitrogen removal under low-ammonia levels, offering a sustainable alternative to conventional nitrification pathways in wastewater treatment. While challenges like slow growth, enrichment difficulties, long start up time, biofilm dependence, primer mismatches for amoA & nxrB, variability in qPCR calibration persist, absence of standardized detection assays serve as a key research gap. This review-oriented bibliometric analysis highlights emerging application of comammox in wastewater treatment. The findings provide a foundation for microbiological understanding and applied studies.

Keywords: Ammonia, amoA, nxrB, Nitrogen, Wastewater treatment

Paper ID: 180

A laboratory-scale batch study of biological phosphate removal from simulated wet market wastewater

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ABSTRACT

The wastewater discharged from the traditional wet market comprises various pollutants. These effluents are highly contaminated with organic carbon and nutrients due to the mechanical processing of fish, poultry and/ or goat. The use of floor washing detergents and melting of salted ice, along with the excessive mixture of blood muscular tissues etc., substantially contributes to the dissolution of nutrients like phosphorus and nitrogen, into the water. Phosphate, at elevated levels, results in eutrophication, leading to the depletion of dissolved oxygen, a decrease in sunlight penetration, and eventual loss of biodiversity. To limit the phosphate contamination, the Central Pollution Control Board delineates the total phosphate and the dissolved phosphate levels within 5 mg/L and 1 mg/L, respectively, for inland surface waters. This paper focuses on the laboratory-scale biological removal of phosphate from the collected wet market wastewater. For acclimatization and growth of necessary bacterial seeds, a sample of digested sludge was collected from an anaerobic chamber of a slaughterhouse wastewater treatment plant. Under suitable laboratory conditions, in a 2L glass-made aspirator bottle, the seed was kept under alternate anaerobic and aerobic conditions, with each spanning 12 hours. Synthetic feed was added every 72 hours, so that the reactor BOD and phosphate concentrations could be about 1500, and 20 mg/L, respectively. For customary wet markets located in urban Kolkata, namely Maniktala, Lake Market, New Market (fish), and New Market (chicken and meat), the BOD was found to be 465±10.22, 1362±12.5, 1428±15.5, 1496±15.5 mg/L, respectively, while the phosphate surged up to 12.49±0.86, 21.81±0.74, 16.43±0.33, 31.8±0.73 mg/L, respectively. Different concentrations of phosphate, BOD, and alteration of Dextrose and Sodium Acetate ratio were studied on the basis of percentage removal of phosphate with simulated synthetic wastewater, keeping the MLVSS as 1500-1600 mg/L and pH at 6.8-7. The best phosphate removals were observed at the batch with initial phosphate concentration of 20 mg/L, initial BOD of 1000 mg/L, and Dextrose: Acetate of 1:3 (55.92%). Hence, it can be stated that in the context of present biological phosphate removal from wet market wastewater, a considerable amount of phosphate can be effectively removed from the system.

Keywords: Wet market wastewater; Biological wastewater treatment; Biological phosphate removal; Eutrophication; Nutrient pollution

Paper ID:181

Enhancement of hybrid constructed wetland performance through crucial parameter prediction based on machine learning regression

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ABSTRACT

A constructed wetland system is a highly regarded nature-based wastewater treatment unit that facilitates an environmentally friendly and cost-effective solution. The hybrid system typically combines Horizontal Flow Constructed Wetlands (HFCWs) with Vertical Flow Constructed Wetlands (VFCWs) or employs different permutations and combinations. This paper presents the performance prediction of organic removal in the hybrid constructed wetland system through predictive modelling using machine learning. The comprehensive comparative study consists of six distinct machine learning techniques, namely Linear Regression (LR), Support Vector Regression (SVR), Decision Tree Regression (DTR), Random Forest Regression (RFR), Adaptive Boost Regression (ABR), and Gradient Tree Regression (GTR). Experimental data from the literature on constructed wetland systems were used to develop these regression models and train and validate their efficacy in identifying crucial parameters and predicting their impact. The selection of an effective regression model is mostly influenced by the coefficient of determination, which is ultimately determined by the assessment of accuracy and error metrics. For predicting COD efficiency, the RFR model demonstrates higher accuracy, achieving an R^2 value greater than 0.87. While BOD, the GTR model exhibits low error and high accuracy, with R^2 value greater than 0.83. Overall, the proposed regression model enhances the performance and efficacy of the system, providing an effective tool for predicting influential parameters in the constructed wetland system.

Keywords: Constructed wetland, Random Forest regression, Gradient Tree regression, Organic matter

Paper ID:182

Non-thermal plasma based wastewater treatment for agricultural reuse: A review

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ABSTRACT

Wastewater reclamation has become a critical requirement with rising water scarcity and demand for sustainable agriculture. Conventional wastewater treatment plants are designed to remove organic matter, total solids, and nutrients but fail to remove the emerging micropollutants. Non- Thermal Plasma (NTP) has emerged as a novel technology for wastewater treatment for its sustainable recovery and reuse in agriculture, offering effective microbial inactivation, rapid degradation of organic pollutants, and minimal chemical residues. For micropollutants removal, integrating advanced wastewater technologies should be considered as well as advanced analytical instruments for proper monitoring.

This study summarizes research advancement on the utilization of NTP, especially dielectric barrier discharge (DBD) reactors for treatment of wastewater from different sources focusing on seed germination and sustainable reuse in agriculture. Recent surveys demonstrate that reactive oxygen and nitrogen species (RONS) generated by plasma treatment plays a significant role in decomposing complex contaminants and acquiring microbial inactivation, along with consistent improvements in water quality indicators such as pH stabilization (within 0.5 units), COD removal (≈30-35%) and turbidity reduction (≈65-67%). Plasma-treated wastewater applied for seed germination and irrigation purposes, has shown (10-20%) higher germination rates, improvement in root–shoot growth, and better vigor indices compared to untreated water, indicating its potential role in boosting overall crop productivity.

The review highlights that non-thermal plasma could serve as dual-benefit approach for both pollution control and agricultural enhancement, aligning with circular economy principles. Since most studies conducted so far are in laboratory settings, results from NTP treatment strongly suggest that scaling up to field applications could deliver significant benefits for both wastewater treatment and agriculture. Future research should aim to improvise plasma reactor designs, combining NTP with hybrid treatment systems, and validate findings in real-world agricultural settings. With focused development, plasma based wastewater treatment could serve as sustainable option for connecting water reuse with food security.

Keywords: Non-thermal plasma; Wastewater reclamation; Dielectric barrier discharge; Seed germination; Sustainable agriculture

Paper ID: 185

A Review of Non-Thermal Plasma Enabled Advanced Oxidation Processes for the Removal of Persistent Emerging Contaminants from Wastewater Effluents

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ABSTRACT

Persistent emerging contaminants (PECs), such as personal care products, pharmaceuticals, per/polyfluoroalkyl substances (PFAs), endocrine disruptor chemicals (EDCs), pesticides, and surfactants, are being found in treated effluents from industrial treatment plants, treated effluents from domestic sewage wastewater plants, ground water, storm water, and surface water. These PECs generally found traces of concentrations in the range of ng/L to mg/L, which are minimal concentrations and challenging to detect. Prolonged exposure to these contaminated effluents can lead to adverse effects on humans, aquatic organisms, flora, and fauna. Conventional wastewater treatment techniques are designed to treat higher pollutant dosages; however, they often fail to handle PECs effectively. To handle traces of PECs and disinfection, in the tertiary treatment stage, advanced oxidation processes (AOPs) such as photocatalysis, electrochemical oxidation, ultrasonication, and Fenton/photo Fenton techniques were used to mineralize the traces of PECs before discharging the treated effluents using conventional treatment methods. These AOPs require various oxidizing chemicals for generating radical oxygen species within the water medium, which are activated by high-energy UV irradiation and sonication. On the other hand, the non-thermal plasma-based oxidation process requires a high applied voltage with less power input and low catalyst dosage to generate RONS for mineralization of PECs.

This review paper primarily focuses on explaining the potential methods for generating radical species using various non-thermal plasma systems to remove emerging contaminants from liquid matrices. It explains how various operating parameters, such as applied voltage, feed gas flow rate, various catalyst dosages, and treatment time, can improve the removal efficiency of PECs. It discusses the combined effect of various advanced oxidation processes coupled with non-thermal plasma, which can improve the removal of PECs within shorter treatment times and in an energy-efficient manner.

Keywords: Advanced Oxidation Processes; Non-Thermal Plasma; Electrical Discharges; Wastewater Treatment; Persistent Emerging Contaminants.

Paper ID: 195

Wastewater quality prediction and classification through AI for safe reuse and resource recovery

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ABSTRACT

Freshwater is becoming increasingly scarce, making it more important than ever to safely reuse treated wastewater in agriculture and industry. Biochemical oxygen demand (BOD) is an important measure of water quality, but direct testing can be slow, expensive, and require significant effort. To solve this problem, we developed a Deep Learning model that predicates BOD using commonly measured parameters such as Chemical Oxygen Demand (COD), Total Nitrogen (TN). Based on the predicted BOD and COD values, water samples are classified as safe for agricultural use, suitable for reuse, or requiring safe disposal. This classification assists decision-makers in managing wastewater safely while minimizing the risk of contaminants entering the food chain. In addition, water safety, the framework also estimates the amount of recoverable nutrients, such as nitrogen and phosphorus, supporting sustainable resource recovery and circular economy practices.

The results show that AI-driven prediction and classification provide a fast, cost-effective, and reliable alternative to traditional methods. By integrating deep learning into wastewater management, this approach ensures safe reuse and enhances the recovery of valuable nutrients. In our experiments, traditional machine learning models did not achieve high performance in predicting Biochemical Oxygen Demand (BOD), showing relatively low accuracy and higher errors. In contrast, the deep learning model provided a significant improvement, achieving an R^2 of 0.92, which means it could explain 92% of the variance in BOD values. With an RMSE of 5.43mg/L and MAE of 3.21 mg/L, the deep learning model demonstrated reliable predictive ability, making it more effective than conventional approaches for water quality assessment. Overall, this study highlights the potential of AI/ML to make water reuse practices safer, more sustainable, and economically beneficial, supporting both environmental protection and efficient resource management.

Keywords: BOD Prediction; Water Reuse Classification; Nutrient Recovery; AI; Deep Learning

Paper ID: 211

Ultrasonication-assisted removal of congo red dye using green synthesized nano-catalyst prepared using lantana camara leaf extract.

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ABSTRACT

The dye effluents from the industries in the water streams pose an ecological threat. Congo red, an azo dye, is particularly harmful due to its non-degradability, carcinogenic characteristics. On the other hand, Lantana camara is considered an invasive species in India and can have serious ecological impacts and cause habitat disruption due to natural and human-induced activities. A composite nano-catalyst was prepared using titanium dioxide (TiO_2) and ferric chloride ($FeCl_3$) as precursors and Lantana camara leaf extract as a reducing agent. The dye degradation experiment was carried out using the prepared nano-catalyst under ultrasound (US) irradiation. The characterization of the nano-catalyst confirmed the nano-size of the green synthesized catalyst (average crystallite size of 42 nm) and the formation of Ti and Fe nanoparticles in the anatase phase. Batch studies were conducted with different combinations of experimental conditions in optimum conditions, such as amplitude, dosage of catalyst, and pH. Nano-catalyst prepared by green synthesis removed 73.8% of Congo dye along with ultrasound (US) treatment. The maximum removal efficiency of Congo red dye was 90.8% at a pH of 2.5, a reaction time of 30 min and an initial concentration of 40 mg/L. The treatment can be considered a green alternative treatment for dye industries' wastewater.

Keywords: Lantana camara; Green synthesis; Nano-catalyst; Congo red dye; Ultrasound treatment

Paper ID 217

Solar photocatalytic degradation of methylene blue using magnetic sawdust biochar supported bismuth oxybromide nanocomposite

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ABSTRACT

Methylene Blue (MB), a cationic dye extensively used in textile and medical industries, is known for its persistence and toxicity, posing a serious environmental threat in wastewater treatment. This study investigates the solar photocatalytic degradation of MB using magnetic sawdust biochar-supported bismuth oxybromide (BiOBr) composites synthesized in varying ratios of 1:1, 1:2, and 3:2, designated as B_1S_1, B_1S_2, and B_3S_2, along with pristine sawdust biochar and pure BiOBr for comparison. The magnetic biochar, prepared via co-precipitation with iron salts, enabled efficient catalyst recovery after treatment. Under initial conditions of 1 g/L catalyst dosage, pH 7, and 10 mg/L MB concentration, B_1S_1 exhibited the highest photocatalytic efficiency of 74.6% after 120 min in direct sunlight, outperforming B_1S_2 (45.5%), B_3S_2 (69.2%), pristine biochar (58%), and pure BiOBr (49.4%). Characterization using XRD, FTIR, SEM, EDX, and proximate analysis confirmed the crystallinity nature, presence of C–H, C═C, OH, C≡C functional groups, a porous structure with successful incorporation of Fe_3O_4 and BiOBr onto the biochar surface that enhanced adsorption and photocatalytic activity. Optimization through central composite design identified the optimum parameters at pH 8.9, 12 mg/L initial dye concentration, and 1.645 g/L catalyst dosage in direct sunlight, achieving 88.27% degradation efficiency with excellent model predictability (adjusted R^2= 0.9806, predicted R^2= 0.9394). Scavenger studies revealed that holes and superoxide radicals were the dominant reactive species, while reusability tests showed that B_1S_1 retained 79.71% efficiency after four cycles. Overall, the magnetic sawdust biochar-supported BiOBr composites demonstrated high stability, reusability, and efficiency, offering an efficient approach for dye-contaminated wastewater remediation.

Keywords: Solar Photocatalysis; Magnetic biochar; BiOBr; Sawdust; Methylene blue; Wastewater treatment

Paper ID: 219

Combined acoustic cavitation with advanced oxidation process for the degradation of hexamethyl pararosaniline chloride

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Abstract

In the textile Industry, large quantities of dyes are released into natural water bodies, posing a significant threat to aquatic life. The dye components in such wastewater contribute significantly to environmental pollution. If these wastewaters are discharged without proper treatment, the dyes can persist in the environment for a long time. Hexamethyl pararosaniline chloride is one of the synthetic triphenylmethane dyes commonly used in the textile industry. This study investigates the Acoustic cavitation-based degradation of hexamethyl pararosaniline chloride in combination with oxidizing agents such as hydrogen peroxide, zinc oxide, and potassium persulfate. The effect of operating parameters such as ultrasonic power (250-500), duty cycle (50-90), pH (2-7), and initial concentration(50-300mg/L) on the extent of dye degradation using acoustic cavitation has been analyzed based on the removal of color, TOC, and TN. The optimum values observed for pH, amplitude intensity, duty cycle, and initial concentration are 2, 500w, 90%, and 100 mg/L, respectively, with 29.96% removal of TOC in 120 min. The main Novelty of the present work, which highlights the combination of acoustic cavitation with a Fenton-like process, showed effective treatment of hexamethyl pararosaniline chloride dye.

Key words: Hexamethyl pararosaniline chloride, Combined oxidation, Acoustic cavitation, Hydrogen peroxide, Zinc oxide.

Paper ID: 221

Modification of the cathode electrode in a microbial fuel cell using a titanium wire for the treatment of domestic wastewater

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ABSTRACT

Municipal wastewater poses growing pollution and energy challenges, as conventional treatment methods (e.g., activated sludge) require intensive aeration and significant energy consumption. Microbial fuel cells (MFCs) have emerged as a promising alternative, using electroactive microbes to convert organic waste into electricity while simultaneously treating pollutants. By harvesting bioelectricity from wastewater, MFCs align with the goals of a circular economy. However, practical MFC deployment is hindered by low power output due to sluggish electrode reactions, underscoring the need for improved electrode designs.

In this work, a two-chamber MFC was operated on raw domestic wastewater, and the cathode electrode was modified by embedding a titanium wire within a carbon-felt matrix. Carbon felt was chosen for its high conductivity and resistance to corrosion. A 1.0 mm titanium wire was then woven through the felt to act as an integrated current collector. A control MFC with an unmodified carbon-felt cathode was run in parallel. The systems were evaluated under identical conditions, measuring open-circuit voltage (OCV), polarization curves, and Chemical oxygen demand (COD) removal. An ANOVA analysis was used to validate the significance of observed performance differences. The titanium-wire cathode substantially outperformed the control. The modified MFC reached an OCV of roughly 0.50–0.55 V (about 20–30% higher than the baseline), and its peak power density increased by a similar margin. COD removal efficiency also improved, exceeding 90% under steady operation. The performance gains are attributed to the titanium wire's excellent conductivity and stability, which lowered cathode resistance and enhanced oxygen reduction. Statistical analysis confirmed that these improvements were significant ($p < 0.05$), indicating that the wire modification effectively enhanced electron transfer and bioenergy recovery.

Integrating a titanium wire into the MFC cathode provides a straightforward and robust approach to enhance waste-to-energy conversion in domestic wastewater treatment. The modification significantly raised power output and treatment efficiency without requiring costly catalysts. This approach could be further optimized for scalable systems, advancing sustainable wastewater management by coupling pollutant removal with renewable electricity generation.

Keywords: Microbial fuel cell; Cathode modification; Titanium wire; Domestic wastewater; Waste-to-energy

Paper ID: 225

Optimization of electro-fenton parameters for COD reduction in brahmapuram landfill leachate

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ABSTRACT

Landfill leachate from the Brahmapuram Municipal Solid Waste Treatment Plant (MSWTP) in Kochi, Kerala, poses significant environmental challenges due to its high organic and toxic content, with a COD of 4590 mg/L, suspended solids of 24950 mg/L, and a pH of 9. The Electro-Fenton process, integrating electrocoagulation and Fenton oxidation, was evaluated for its efficacy in removing organic compounds from this leachate, which is recalcitrant to conventional biological treatments due to toxic and xenobiotic compounds. Batch experiments using graphite cathode and iron anode strips investigated the effect of key operational parameters, including H_2O_2 concentration, initial pH, current, and electrode spacing, on the removal of COD. Optimal conditions were identified at 2250 mg/L H_2O_2, pH 3, 1 A current, and 1 cm electrode spacing, achieving a maximum COD removal efficiency of 97% after 60 minutes of electrolysis, reducing COD to 137 mg/L, well within the discharge standard. Higher H_2O_2 concentrations above the optimum led to hydroxyl radical (•OH) scavenging by excess H_2O_2, forming less reactive hydroperoxyl radicals (HO_2•), thus reducing efficiency. Increased electrode spacing to 3 cm decreased COD removal to 86.96% due to higher electrical resistance, reduced current density, and limited oxidant-pollutant interactions. Acidic pH (2 - 3) significantly enhanced performance by favoring Fe^{2+} generation and hydroxyl radical production, with pH 3 being optimal, while neutral (pH 7) and alkaline (pH 9) conditions resulted in poor efficiencies of 28.65% and 7.19%, respectively, due to iron precipitation and suppressed radical activity. Higher currents (1.5 - 2 A) reduced efficiency due to side reactions, radical scavenging, H_2O_2 decomposition, and electrode passivation. These findings highlight the Electro-Fenton process as an effective solution for landfill leachate treatment under optimized acidic conditions and moderate current, offering a robust alternative for managing high-strength, toxic leachates. However, initial lowering of pH to 3 for optimized removal can limit the practical implementation of the process in treatment plants due to necessity of external addition of concentrated acids. Further research in this regard would address this limitation making the large-scale application of Electro-Fenton process to treat landfill leachate.

Keywords: Landfill Leachate; Electro-Fenton process; COD removal; Parameter optimization

Paper ID: 242

Performance of rice husk-based biochar for wastewater treatment

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ABSTRACT

Wastewater treatment systems are a critical component of sustainable urban infrastructure, intricately linked to the water-energy-climate nexus. The pursuit of environmentally sustainable treatment solutions necessitates the exploration of locally sourced renewable materials that align with the circular economy framework. In this context, potassium hydroxide (KOH) activated-rice husk biochar emerges as a viable adsorbent candidate, mainly due to its enhanced specific surface area and porous morphology. This study proposes a systematic investigation into the adsorption performance of KOH activated-rice husk biochar with respect to a model organic compound representative of the biodegradable fraction of organic pollutants typically found in sewage matrices. A series of batch adsorption experiments will be performed under controlled laboratory conditions, employing a range of initial sorbate concentrations to elucidate the biochar's adsorption behaviour and capacity. Equilibrium data obtained from these experiments will be utilized to construct adsorption isotherms. This modelling will provide mechanistic insights into the adsorption process and facilitate quantitative estimation of the biochar's maximum adsorption capacity. The selection of a model organic pollutant for the study enables precise and reproducible quantification of adsorption efficacy, thereby offering foundational data critical for the subsequent design of dynamic column experiments simulating real-world sewage treatment scenarios. Ultimately, this research underscores the significance of integrating batch adsorption methodologies with robust analytical techniques to evaluate biochar- based adsorbents' efficacy comprehensively. Such investigations are pivotal to advancing sustainable wastewater treatment technologies, particularly those leveraging locally abundant biomass resources, contributing to resource recovery and environmental protection within the water-energy-climate nexus.

Keywords: Activated-rice husk biochar; Wastewater treatment; Adsorption; Circular economy; Sewage.

Paper ID: 264

Integration of bioelectrochemical system with advanced oxidation process (BES-AOP) for the efficient treatment of industrial wastewater

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ABSTRACT

The complex and highly contaminated nature of industrial wastewater makes it difficult to treat effectively using conventional treatment technology. Generally, a single treatment process is inefficient; therefore, combining advanced oxidation processes (AOPs) with biological treatment can significantly achieve treatment goals. To enhance the degradation of organic contaminants in microbial electrochemical systems (MES), there is potential for integrating advanced oxidation processes (AOPs). AOPs have been shown to effectively degrade toxic and recalcitrant compounds in industrial wastewater. This study investigates the enhanced treatment of industrial effluents using a sulfate-reducing bacteria (SRB)-based bio-electrochemical system (BES) in combination with persulfate (PS). A single-chamber microbial electrochemical cell (MEC)-based BES, operating in batch mode with a two-stage configuration, was used. In Stage I, SRB-based treatment was applied, while Stage II involved the integration of BES with a PS-based AOP. Results from Stage I (BES-150 mV) indicated a total organic carbon (TOC) reduction of 51.52%, whereas Stage II achieved an 83.14% reduction after the first cycle, reflecting a significant 30-43% improvement in TOC reduction due to persulfate application. COD removal was more pronounced during the first two cycles of Stage II, with subsequent cycles showing a decreasing trend in both stages. Reactors with 300 mV and 450 mV potentials exhibited notable COD reductions. Additionally, ammonia levels increased after Stage I treatment but were reduced in Stage II. The integration of BES with persulfate oxidation not only enhances treatment efficiency but also holds promise for reducing operational costs, making this combined system a reliable option for industrial wastewater treatment.

Keywords: Advanced oxidation process, Sulfate-reducing bacteria; Bio-electrochemical system, Industrial effluents

Paper ID: 271

Impact of thermal hydrolysis on codigestion of SBR sludge and municipal solid waste

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ABSTRACT

The objective of this study was to examine the effect of thermal hydrolysis process (THP) using SBR sludge and Municipal solid waste (MSW) under Indian conditions. Examine THP at different temperatures, pressures on degree of solubilisation and methane yields on: (1) SBR sludge with high sludge retention time of 40 d and (2) co-digestion of MSW with SBR sludge.

Two sets of experimental design using 350 mL batch assays (biomethane potential, BMP) were investigated. Sewage sludge was obtained from two SBR process (64 MLD) near Haridwar and (3 MLD) from Indian Institute of Technology (IIT) campus at Roorkee in India. The MSW samples (paper, garden and cooked kitchen waste, fruit and vegetable scraps) were collected from the hostels of the IIT Roorkee campus. BMPs were carried out with ISR 1:1 at 35°C. The CambiTHP pilot plant included a steam generator, a 5L reactor, and a flash tank. Dewatered SBR sludge (14% TS) was pretreated at variable pressures (2, 3.5, 6 and 10 bar) and pretreatment times (30- 60- 90–120 min) using steam injection into the THP reactor.

For the SBR sludge, The BMP test at 120°C and variable reaction times, a maximum CH_4 yield of 325 mL CH_4/g VS_{added} was observed at 120°C at 90min, i.e., 2.7 times higher than the control. Among all the studied THP conditions, the highest cumulative yield of 507 mL CH_4/g VS_{added} was achieved at 160°C-30min. For the codigested sludge, among all the THP conditions studied, the highest cumulative biogas volume (4524 mL) and biogas yield (603 ml/gVS_{added}) were achieved at 140°C and a reaction time of 60 min. The values were 3.7 times higher than those attained in the control.

THP pretreatment of 140°C- 60 min shows the best potential for maximum methane recovery (506mL/gVSadded), VS reduction (59%), and soluble chemical oxygen demand (sCOD) removal (71%). These efficiencies were almost 4.0 (CH_4 generation), 2.2 (VS reduction), and 2.5 (sCOD removal) times higher than the control assay. Among the tested BMP conditions on SBR sludge, 160ºC at 30 min had the best condition after that there was no significant methane yield. For organic fraction MSW codigestion, an optimized mixing ratio of 80:20 (VS basis) and a C/N ratio of 24 were considered best for THP pretreatment-mediated anaerobic co-digestion of the OFMSW-SS mixture. The highest COD solubilization of 40% was achieved at a 160°C temperature regime.

Keywords: Anaerobic Co-Digestion; Biosolids; Municipal Solid Waste; Sequencing Batch Reactor; Thermal Hydrolysis Process

Paper ID: 273

Dewatering centrifuge performance: G-volume as a key metric for centrifuge scaling

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ABSTRACT

Decanter centrifuges significantly influence the operational and disposal economics of wastewater treatment plants, where performance directly affects solids recovery, polymer consumption, and sludge handling costs. Conventional selection practices rely heavily on bowl diameter as the comparative parameter; however, this approach lacks accuracy for predicting real capacity or dewatering performance. This study introduces G-volume (G-force × working volume) as a scientifically robust metric that more reliably characterizes a centrifuge's separation capability and provides a scalable methodology for equipment comparison. The primary objective of the research is to validate G-volume as a dependable affinity law for estimating throughput and cake dryness across different centrifuge sizes and operating speeds. Two hypotheses were tested: (i) geometrically similar centrifuges with equal volume but higher G-volume will exhibit proportionally higher throughput or dryness, and (ii) centrifuges with different diameters but equivalent G-volume will demonstrate similar performance and capacity outcomes. Full-scale comparative trials were conducted at WWTP Langenberg and WWTP Oldenburg in Germany. Tests were performed under tightly controlled conditions, ensuring identical sludge characteristics, feed concentration, solids recovery targets, and polymer dosing strategies. Independent sludge dewaterability measurements were conducted by KBKopp (Dr. Julia Kopp) to provide scientifically neutral validation of achievable dryness limits.

Results clearly demonstrate that G-volume shows strong and direct correlation with centrifuge performance, whereas bowl diameter exhibits only an indirect and often misleading relationship. In geometrically identical machines, higher G-volume achieved either increased dryness at constant throughput or higher throughput at constant dryness. Conversely, centrifuges with different bowl diameters but equivalent G-volume produced nearly identical performance curves, confirming the relevance and accuracy of the G-volume scaling law. The findings establish G-volume as a superior and practically applicable criterion for centrifuge selection in wastewater treatment plant design. Using G-volume enables engineers to optimize equipment footprint, reduce polymer and energy consumption, and lower CO_2 emissions associated with sludge treatment. The study offers a paradigm shift from diameter-based selection toward a physics-based, efficiency-driven methodology that directly supports sustainability and circular-economy goals within modern wastewater management.

Keywords: Dewatering; Centrifuge scaling; G-volume; Wastewater treatment; Decanter centrifuge performance.

Paper ID: 276

Electrocoagulation with Al-Cu hybrid electrodes: feasibility and RSM-based optimization for treatment of simulated coal bed methane produced water

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ABSTRACT

Coal bed methane produced water (CBMPW) is a complex industrial wastewater that contains high salinity, suspended solids, and organic matter, posing significant environmental and disposal challenges. Sustainable and effective treatment solutions are therefore essential to enable their safe discharge and potential reuse. Electrocoagulation (EC) is gaining prominence due to its low chemical requirement, operational simplicity, and ability to simultaneously remove dissolved and colloidal contaminants. In this study, the feasibility of EC for CBMPW treatment was investigated using synthetic saline water formulated with Na^+ and Mg^{2+} salts (TDS: 1500-3500 mg/L), which represents field conditions. The performance of a novel aluminium–copper (Al-Cu) hybrid electrode system was evaluated and optimized using Response Surface Methodology (RSM) with a Central Composite Design (CCD). Key variables, including pH (2-8), current density (4-8 mA/cm²), electrolysis time (30-90 min), and salt concentration (1500-3500 mg/L), were examined through 30 experimental runs. RSM optimization predicted optimum operating conditions at a pH of 6, a current density of 6 mA/cm², and a treatment time of 60 min. Validation experiments achieved 94% turbidity and TDS removal, with strong statistical correlation (R^2 = 0.90 for turbidity and 0.84 for TDS). The Al-Cu hybrid electrode demonstrated enhanced floc formation, reduced electrode passivation, and lower sludge generation compared to conventional single-metal electrodes. This feasibility study highlights the potential of hybrid-electrode-based EC as an energy-efficient and environmentally friendly solution for CBMPW treatment and future reuse applications. Ongoing work focuses on testing with real CBMPW and scaling up for decentralized industrial deployment.

Keywords: Electrocoagulation; Hybrid electrodes; Central Composite Design; CBM produced water; Salinity reduction; Sustainable treatment.

Paper ID: 284

Synergistic effects of Fe_3O_4–hap composite on aerobic granule formation and pollutant removal performance

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ABSTRACT

The present study investigates the effect of hydroxyapatite (HAP) and Fe_3O_4–HAP composite additives on aerobic granulation and pollutant removal performance in sequencing batch reactors (SBRs) treating synthetic wastewater. Both materials were incorporated as nucleation and microbial aggregation promoters to enhance granule formation and system stability. The comparative evaluation focused on granule morphological characteristics, structural integrity, and organic and nitrogen removal efficiencies. Results demonstrated that the Fe_3O_4–HAP composite significantly accelerated granule formation and produced more compact, spherical aggregates with superior settling ability compared to the HAP-added and control reactors. The average mean particle size in the Fe_3O_4–HAP system was notably higher, corresponding with improved sludge volume index and reduced fine biomass fraction. Enhanced extracellular polymeric substance (EPS) secretion and higher specific oxygen uptake rates (SOUR) supported stronger microbial adhesion and activity in the composite-assisted reactor. In terms of treatment efficiency, the Fe_3O_4–HAP system achieved higher chemical oxygen demand (COD) and total nitrogen (TN) removal rates, indicating synergistic effects between magnetite and hydroxyapatite that facilitated both adsorption and biotransformation processes. The magnetic nature of Fe_3O_4 further contributed to better biomass retention and stability under fluctuating operational conditions. Overall, the findings confirm that Fe_3O_4–HAP composite addition provides a more conducive microenvironment for aerobic granule development, leading to stable granulation dynamics and superior pollutant removal efficiency. This study underscores the potential of composite additive-assisted strategies for developing robust aerobic granular sludge systems in advanced wastewater treatment applications.

Keywords: Aerobic granulation; Fe_3O_4–HAP composite; Wastewater treatment; granule characteristics.

Track – 2

Water Quality Monitoring & Treatment

Paper ID: 032

Microplastics in mahanadi river: distribution and assessment of pollution level

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ABSTRACT

Microplastic debris is one of the most significant emerging pollutants, due to their extreme durability and synthetic nature, possessing a tremendous threat to the aquatic environment. Plastic particle smaller than 5mm are known as microplastics, and they can be deliberately produced or the particle originated from larger plastics by deterioration. Less research has been done on MPs in the Indian river system; hence this study aims to elucidate the distribution, occurrence, and pollution level of microplastics in the river water from India. In the present study desired volume of wastewater was collected using grab sampling methods and processed for extraction. Seiving, Wet peroxidation, density separation and vacuum filtration sequentially to extract microplastics from river water sample.

Quantitative analysis shows a mean concentration of 26 particles /L (62000 particles m^3), 28 particles/L, 25 particles/L from site 1, site 2, and site 3 respectively. FTIR analysis conclusively identified PE, PP, PET, SBR & PS polymer type. FE-SEM analysis was employed to investigate the morphological feature, determine particle size, and elemental composition of the microplastic particle. Raman spectroscopy was also carried out for further confirmation of polymer type identified by FTIR analysis. Fragment (46%), filament (29%), fiber (10%), film (7%), triangular (5%) & pallet (2%) are the shape that was observed from the sample. The MPs colour was detected in the sample were blue, red, black, violet, brown, grey, and white. Microscopic examination and particle size distribution characterization revealed that the microplastic particles ranged from 10 µm to 5000 µm in diameter. Water that comes from domestic, industrial, and wastewater treatment plants is finally released into the natural environment such as river and the run off from the river to agriculture land, and living beings are the major concern in case of microplastic pollution. The Mahanadi River, originating from Dhamtari district (Chhattisgarh), flows into Odisha, where it joins the Hirakund Dam at Sambalpur, and moving forward, it is finally released into the Indian Ocean through the Bay of Bengal. Therefore, assessing the presence of microplastics in river is essential for understanding this environmental threat. This study enhances the understanding of microplastic pollution in Mahanadi River and provides vital reference data essential for effective mitigation strategies.

Keywords: Microplastics, River, Pollution, Analysis, Mitigation.

Paper ID: 42

Evaluation of water pollution trends and their ecological impacts in Chandapura lake, Bengaluru.

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ABSTRACT

This study offers a thorough evaluation of seasonal patterns in water pollutants and their effects on ecology in Chandapura Lake, Bengaluru, based on three years of observations. Water quality indicators—Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Fecal Coliform, Dissolved Oxygen (DO), pH, Ammonia, and Nitrate—were all found to be above recommended limits in both pre-monsoon and post-monsoon periods, indicative of a substantial decline in water quality. The concentrations of BOD, COD, and TDS were elevated in the pre-monsoon period due to the lower dilution of pollutants and accumulation during dry periods. While there were increases in fecal coliforms, ammonia, and nitrate in post-monsoon readings due to surface runoff carrying agricultural and domestic waste into the lake. Dissolved oxygen levels were critically low, same for pH; both seasons stressed ecology. The cumulative effects include eutrophication, loss of aquatic biodiversity, and reduced fitness for consumptive and recreational use. Seasonal variability demonstrates the necessity for adaptive management techniques. The study provides a recommendation of interventions, such as storm water filtration, decentralized wastewater treatment approaches, and riparian buffer restoration efforts, to improve pollution concentrations in the ecosystems and ecological resiliency. These findings provide a scientific rationale for policy to guide development and engage the community in protecting urban freshwater ecosystems.

Keywords: Water quality assessment; Chandapura lake; Ecological impact; Pollution indicators; Remediation strategies

Paper ID: 47

Assessment of the Environmental Impact of Landfill Sites: A Review on Groundwater Contamination Due to Leachate Infiltration

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ABSTRACT

An increasing environmental concern worldwide, especially in developing nations, is the careless disposal of municipal solid waste (MSW) in landfills. Groundwater contamination from leachate intrusion is one of the most serious environmental problems related to landfills. Rainwater seeping through waste material produces leachate, a highly contaminated liquid that contains a complex mixture of heavy metals, organic and inorganic pollutants, and developing contaminants. This paper provides an overview of the physico-chemical properties of leachate, its effects on the environment and human health, the mechanisms of leachate migration and formation, and the hydrogeological factors impacting contamination. In order to illustrate practical implications, case studies from nations such as Egypt, India, and the United Kingdom are examined. The study also examines risk assessment and leachate modelling techniques. According to research, poorly designed landfills are a major factor in the decline of groundwater quality. Advanced leachate management techniques, the use of predictive algorithms, and more stringent regulatory oversight are suggested in the review's conclusion.

Keywords: Landfill; Leachate; Municipal Solid Waste; Risk Assessment; Environmental Impact.

Paper ID: 51

Ground water analysis of different areas in Kolkata and comparison with different states of India

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ABSTRACT

Ground water has become a resource under stress due to the increasing human consumption and leading to the contamination of ground water resources. The chapter deals with the analysis of ground water parameters collected from different locations of Kolkata city, West Bengal state, India and to check its suitability for drinking purposes. Water Quality Index (WQI) is determined for each location to access the current ground water conditions, taking into consideration the various parameters and their respective weight values. Thirty-five ground water samples from different locations of eastern, western, northern and southern Kolkata city were taken. Water quality parameters were analyzed as per the Standard methods and laboratory grade chemicals. Water quality parameters such as pH, turbidity, total hardness, total dissolved solids, total alkalinity, chloride and iron concentration were analyzed and checked against drinking water standards as per IS-10500-2012. The results obtained were also compared with different parts of India and Water Quality Index (WQI) were interpreted. The analysis of samples were done for objective to determine the portability of drinking water in communities. WQI values were further co-related with CPCB (India- Central Pollution Control Board) and interpretation of water was done as per the chart provided. The results show most areas of Kolkata being heavily effected by the contaminants and unfit for drinking purposes, thereby depleting the natural resource and lack of ground water recharge.

Keywords: Ground water; Water quality index; Chemical characteristics; pH; Hardness

Paper ID: 57

Comparative study of water pollution potential from domestic use of chemical and herbal products in day-to-day activities

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ABSTRACT

This work compares the environmental impact of regular chemical cleaners and eco-friendly alternatives. Common household products such as detergents, soaps, floor and toilet cleaners were tested along with herbal formulations. Each product was diluted in water and analyzed for key water quality indicators, including pH, alkalinity, salinity, electrical conductivity (EC), total dissolved solids (TDS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). The results were compared with standards set by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO). Eco-friendly products showed values closer to neutral pH, lower salt content, and reduced BOD and COD, suggesting that they are safer for the environment and more biodegradable. In contrast, conventional detergents like Surf Excel and Ariel placed a greater burden on water quality. The study underlines the benefits of herbal formulations and the importance of adopting green chemistry practices for sustainable product development.

Keywords: Physicochemical analysis; Water quality assessment; Environmental Sustainability; Soap; Detergents

Paper ID: 65

Hydrogeochemical and geospatial appraisal of groundwater contamination and susceptible zones in western Odisha, India: implications for pollution control and clean environment

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ABSTRACT

Groundwater is the primary source of drinking and irrigation water in western Odisha, yet it is increasingly threatened by both scarcity and quality deterioration. Nuapada district, one of the most drought-prone regions of Odisha, is severely affected by fluoride, nitrate, and iron contamination, posing significant risks to public health and livelihoods. This study evaluates groundwater quality, identifies contamination sources, and delineates susceptible zones through an integrated hydrogeochemical and geospatial framework.

Seventy-nine groundwater samples were collected from dug wells and tube wells across Nuapada and Komna blocks during pre- and post-monsoon seasons. Physicochemical parameters were analyzed following APHA standards. Hydrogeochemical facies were determined using Piper and Gibbs plots, while statistical tools such as correlation analysis and principal component analysis (PCA) were employed to identify dominant processes controlling groundwater chemistry. Groundwater Quality Index (GWQI) was computed, and GIS-based spatial interpolation was used to map contamination hotspots and vulnerable zones.

Results show that groundwater in the study area is dominated by Na–Cl and Ca–Cl facies, controlled largely by geogenic processes including rock–water interaction, mineral dissolution, and evaporation. Concentrations of fluoride, nitrate, and iron frequently exceeded WHO and BIS standards, with their combined impact more evident in deeper aquifers. GWQI assessment indicated that ~3% of the area is unfit for drinking, while ~35% is highly susceptible to future contamination. Seasonal variation highlighted post-monsoon deterioration due to leaching and ion accumulation.

The findings confirm that groundwater contamination in western Odisha is primarily geogenic, but exacerbated by climatic variability and land-use practices. The integrated hydrogeochemical–geospatial approach provides a practical model for identifying risk zones and guiding pollution control, aquifer recharge, and safe water supply strategies in drought-prone regions.

Keywords: Groundwater quality; Hydrogeochemistry; Geospatial analysis; GWQI

Paper ID: 70

Graphene–modified bagasse biochar as an adsorbent for phenol removal from river water

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ABSTRACT

Water contamination by industrial, agricultural, and municipal discharges has become a global concern, as it introduces a wide range of toxic organic and inorganic pollutants into aquatic systems. These contaminants not only deteriorate water quality but also pose serious risks to ecosystems and human health. Among them, phenolic compounds are of particular concern due to their high toxicity, persistence, and resistance to natural degradation. There is a need for new and efficient removal processes for phenol from water. Adsorption is one of the widely studied and applied processes for water treatment. In this work, bagasse, an abundant sugarcane processing by-product, was converted into biochar and subsequently modified with graphene oxide to enhance its porosity, surface area, and oxygen-containing functional groups. The graphene-modified bagasse biochar (GBB) was systematically evaluated for phenol removal from both synthetic solution and river water. Batch mode adsorption experiments were conducted at different contact times (10, 20, 30, 60, and 120 min), pH 2-10, temperatures (25 °C, 30 °C, 35 °C, and 40 °C) and phenol concentrations (20, 40, 60, 80, and 100 mg/L). The optimum performance was achieved at 60 min contact time, pH 6 and 25°C temperature with an initial phenol concentration of 100 mg/L**.** When applied to river water, GBB exhibited consistently high performance despite the presence of competing natural organic matter and dissolved ions. Removal efficiencies reached up to 94%**,** confirming the material's effectiveness under real water conditions. Further studies on continuous mode water treatment using GBB will help to assess the real-time application potential of the process.

Keywords: Adsorption; Graphene oxide; Phenol; Biochar; Water treatment

Paper ID: 75

Pollution of the hooghly river due to urban outfall canal wastewater in Kolkata and its suburbs: A systematic pre-monsoon water quality assessment

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ABSTRACT

The rapid pace of urbanization and industrial development in the suburban regions of Kolkata has significantly impacted the water quality of nearby rivers and the health of aquatic ecosystems in urban water bodies. A key contributor to this degradation is the unchecked discharge of inadequately treated or completely untreated interception and diversion (I&D) wastewater. These discharges, comprising combined sewage and urban runoff, are funnelled through outfall canals into major rivers, such as the Hooghly. Originally designed for stormwater drainage, these open channels now carry a complex mix of domestic sewage and industrial effluents, laden with organic pollutants, pathogens, toxic chemicals, and suspended solids.

To investigate the extent of this pollution, a comprehensive water quality study was carried out during the pre-monsoon season. Water samples were collected from eight canals situated in urban and peri-urban zones, specifically at low tide near their outfall points. The analysis focused on both physicochemical and microbiological indicators such as pH, electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS), ammoniacal nitrogen (NH_4^+-N), nitrate nitrogen (NO_3^--N), chemical oxygen demand (COD), biochemical oxygen demand over five days (BOD_5), sulfate (SO_4^{2-}), orthophosphate (PO_4^{3-}), and the most probable number (MPN) of coliform bacteria. These values were compared against discharge norms set by the Central Pollution Control Board (CPCB).

The findings revealed alarmingly high BOD_5 levels, ranging from 32 to 125 mg/L, which surpass the CPCB threshold of 30 mg/L for wastewater entering inland surface waters. Furthermore, MPN counts ranged from 1.14×10^4 to over 1.1×10^6 per 100 ml, reflecting a significant presence of pathogenic microorganisms. Such elevated BOD_5 and coliform levels not only indicate serious organic contamination but also render the waters near bathing ghats, situated close to these outfalls, unfit for recreational use, breaching Class B water quality criteria. This pre-monsoon analysis highlights the pressing need for robust wastewater treatment interventions and long-term mitigation measures. The untreated effluents discharged through these canals are emerging as a major source of pollution for the Hooghly River, posing a direct threat to environmental sustainability and public health.

Keywords: Interception and diversion wastewater; Outfall canals; Most probable number; Biochemical oxygen demand; River water pollution

Paper ID: 77

Comparative study on drinking water quality analysis for public use in Delhi

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ABSTRACT

Over the past few decades, rapid urbanization and the exploitation of water resources in India, particularly in metropolitan cities like Delhi, have led to water scarcity and health issues within society. To ensure a safe and sufficient water supply to healthcare institutions, such as hospitals and medical facilities, it is crucial to control water quality, specifically in terms of hygiene, which is key to preventing waterborne diseases. Despite preventive measures, organisms can persist or even proliferate within the hospital's water infrastructure, leading to infections. Therefore, the present study focuses on assessing the physicochemical and microbiological properties of treated drinking water in various government hospitals of the Delhi region. A total of 20 grab samples were collected from hospital premises having water purification facilities such as reverse osmosis and UV systems. The collected water samples were analyzed for pH, turbidity, total dissolved solids (TDS), total alkalinity, total hardness, chloride, calcium, magnesium, sulphate, residual chlorine, nitrate, iron, total *coliforms*, and *Escherichia coli* using Standard Analytical Procedures. The observed pH value of samples ranged from 6.5 to 7.5, with turbidity below the detection level and a maximum of 1.0 NTU. The TDS of all the samples ranged from 70-80 mg/L, with total alkalinity varying from 10-30 mg/L, and total hardness ranged from 20-30 mg/L. Also, the concentration of true color was less than 5hazen, with chloride concentration in all the samples ranged from 2-8 mg/L. The calcium concentration in all the samples ranged from 18-24 mg/L, with a magnesium concentration of 10-15 mg/L, and the sulphate concentration from 18-30 mg/L. However, the residual chlorine concentration in all the water samples was less than 0.2 mg/L, with nitrate concentration ranging from 0.002-0.54 mg/L, and iron concentration ranging from 0 to 1.0 mg/L. On the other hand, the microbiological parameters, including total *coliforms* and *Escherichia coli* were not detected in any of the samples. The obtained results were compared with the Indian Standards (IS 10500) specification and World Health Organization (WHO) guidelines for drinking-water quality. The results from the present study ensured that the water is safe, palatable, and suitable for consumption across the hospital environment. However, the research emphasizes the need for ongoing monitoring and maintenance regarding the safety of the water available.

Keywords: Treated water; Physicochemical parameter; Microbiological parameter; Drinking water quality; Standard analytical properties

Paper ID: 138

Application of multivariate statistics in understanding of variability and clustering of groundwater data: case study from Narwapahar

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ABSTRACT

Groundwater is an indispensable natural resource, serving as a primary source of drinking water for billions of people and a critical component for agriculture and industry. Groundwater monitoring is the systematic process of collecting and analysing data on groundwater levels and quality over time. Groundwater monitoring involves systematic and periodic measurements of different variables/features simultaneously. The variability of those features is linked to various biological and chemical processes. In this context, there arises the need to implement multivariate statistical tools for analysing groundwater data. Traditional univariate methods, which focus on one variable at a time, often fail to capture the complex interrelationships and spatial dependencies among various hydrogeochemical parameters. Groundwater quality is influenced by a multitude of factors, including geological formations, land use, anthropogenic activities, and seasonal variations. Therefore, a comprehensive understanding requires a holistic Multivariate statistical technique, such as Principal component analysis (PCA) and Cluster Analysis (CA). PCA can reveal underlying factors that explain the majority of the variance in a dataset, while CA can group samples with similar characteristics, aiding in the zonation of contaminated areas. Ultimately, the application of these tools provides a more robust and objective framework for interpreting complex groundwater datasets.

An extensive environmental monitoring program is routinely conducted in the vicinity of the Uranium Corporation of India Limited (UCIL) Narwapahar mines. This monitoring effort is comprehensive, encompassing the areas on both sides of the facility: towards the Jaduguda side and the Turamdih/Jamshedpur side. The monitoring focuses on six key variables—pH, uranium (U)(nat), ^{226}Ra, chloride (Cl^-), sulphate (SO_4^{--}), and Hardness as Calcium Carbonate ($CaCO_3$)—to assess the environmental impact. To understand the complex relationships and sources of variability within this dataset, multivariate statistical tools especially principal component analysis followed by k-means clustering analysis has been employed. The application of principal component analysis on the data set resulted into 3 principal components accounting for 82.4% of the variance; after getting the data points plotted on the principal component space k-means clustering analysis is performed to make the dataset supervised in principal component space.

Keywords: Groundwater; Variability; Multivariate statistics; Principal component analysis; K-means clustering

Paper ID: 151

Dimethyl sulfoxide - based carbon cloth anode for enhanced groundwater treatment in microbial desalination cells

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ABSTRACT

Microbial desalination cells (MDCs) are versatile bioelectrochemical systems, which can simultaneously desalinate water and generate bioelectricity while treating wastewater. The MDC technology, originally developed for desalting saline/brackish waters (10-35 g/L salt content), is explored for its potential in treating groundwater (GW), which typically exhibits low salinity. However, treating low saline water like GW in MDC is constrained by limited power generation, weaker concentration-gradient-driven ion migration, and consequently slower desalination rates. In this study, a carbon cloth (CC) was engineered using dimethyl sulfoxide (CC_{DMSO}) through a facile modification method. CC_{DMSO} was used as anode in MDC to improve groundwater treatment efficiency, wastewater treatment, and power output. Structural characterisation of electrode using FTIR, Raman spectroscopic, and XPS analysis confirmed successful DMSO functionalisation onto CC. DMSO modification introduced the oxygen functional groups such as –COOH (carboxyl), S–O (sulfoxide), and O–C–O (carbonyl) onto CC_{DMSO}, which helps in improving the electrochemical characteristics of the same. The superiority in electrochemical performance was further confirmed through cyclic voltammetric (CV) and electrochemical impedance spectroscopic (EIS) analyses. The CC_{DMSO} anode in MDC increased the GW treatment efficiency – total hardness (TH) from 33.56 to 47.88%, F^- from 40 to 50.57%, and Cl^- from 34 to 39% from GW, along with a 2.26-fold increase in power density (PD) compared to CC. The findings demonstrate that DMSO modification is a simple yet effective strategy to improve MDC efficacy for GW treatment, underscoring both the potential of MDCs for decentralised low-salinity water remediation and the pivotal role of electrode engineering in optimising reactor performance.

Keywords: Microbial desalination cell; DMSO modification; Oxygen functionalization; Groundwater treatment; Bioelectricity generation

Paper ID: 156

Evaluation of electrocoagulation process for removal of fluoride from water

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ABSTRACT

Fluoride in drinking water above permissible level is responsible for human being affected by skeletal fluorosis .The present study was carried out to evaluate the ability of electrocoagulation process with aluminium electrode in order to remove fluoride from water .Several working parameters, such as fluoride concentration , pH, applied voltage and reaction time were studied to achieve a higher removal capacity .Variable concentrations (2,5 and 10 mg/l) of fluoride solutions were prepared by mixing proper amount of sodium fluoride with deionized water .The varying pH of the initial solution (5,6,7,8 and 9) was also studied to measure their effects on the percentage of reduction in concentration of fluoride. Results obtained with synthetic solution revealed that the most effective removal capacities of fluoride could be achieved at 12V electrical potential. Also maximum percentage reduction in fluoride concentration was obtained at pH 7 and pH 8. Finally, it can be concluded that the electrocoagulation process has the potential to be utilized for the removal of fluoride from water.

Keywords: Fluoride removal; Electrocoagulation; Applied voltage; Reaction time; Electrical potential

Paper ID: 197

Sustainable solutions for clean water scarcity in Tirthali: A community-centric approach to water management

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ABSTRACT

The shortage of clean water in rural areas poses severe risks to public health and agricultural sustainability. Tirthali, a small village in Uttar Pradesh, India, faces this challenge due to groundwater depletion, poor infrastructure, and inadequate waste management. The objective of this work is to develop affordable and sustainable solutions that directly address local water scarcity through community involvement.
The methodology combines environmental engineering approaches with social participation. Initial field studies assessed groundwater usage and contamination levels to guide the selection of interventions. Four eco-friendly methods were piloted: solar disinfection (SODIS) for pathogen removal, bio-sand filtration using local materials for bacterial reduction, rainwater harvesting for supplementary supply and soil conservation, and phytoremediation using aquatic plants for gradual removal of pollutants. Alongside these technical measures, workshops and awareness programs were conducted to train residents in system operation and maintenance, ensuring long-term sustainability. Pilot implementations revealed that integrating SODIS, bio-sand filtration, and rainwater harvesting significantly improved drinking water quality and availability, while phytoremediation provided long-term ecological benefits despite slower effectiveness. Community engagement proved essential, with local participation enhancing adoption, accountability, and system maintenance. Ongoing monitoring and feedback further supported the refinement of solutions to local needs. The results highlight that simple, low-cost interventions, when combined with community ownership, can substantially improve water security in resource-limited regions. The study provides a replicable framework that can be scaled to other villages too.

Keywords: Water scarcity; Community participation; Sustainable water management; Solar disinfection; Bio-sand filtration

Paper ID: 200

Hydrological modelling of suspended sediment load in the Krishna-Godavari River, India

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ABSTRACT

Soil erosion is a serious issue in India which further gives rise to sediment load generation at the basin outlet. In the absence of a precise estimation of sediment load in the country, this paper presents a method to estimate sediment load on a daily time scale. An empirical sediment model (HBV-SED) was applied to simulate riverine suspended sediment transport in 4 different catchments in south India. HBV-SED model requires rainfall and runoff inputs to generate daily sediment yield where runoff is generated from HBV hydrological model. The unit hydrograph method is extended to sediment analysis and hence considered as a unit sediment graph that decouples sediment generation and sediment routing. Liden (1999) expressed the effective sediment (ES) as a function of rainfall (R) only: $(ES) = X.R^m$. In this study, we assume the range of m as $0.3 - 3$ and X as $0.1 - 100$. The model performance was evaluated in the form of a performance index as NSE concerning observed data. HBV-SED in combination with discharge routing appears to be more reliable with a median NSE of 0.31.

Keywords: Effective sediment; HBV hydrological model; HBV-SED; Unit sediment graph.

Paper ID: 201

Experimental study on cadmium transport in saturated homogeneous porous media using a 2-dimensional sand tank

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ABSTRACT

Cadmium (Cd) is a highly toxic heavy metal and a priority contaminant due to its persistence, bioaccumulation potential, and mobility in groundwater systems. Its presence poses serious risks to human health, including kidney damage and cancer, and threatens aquatic ecosystems. Understanding the transport behaviour of cadmium under controlled conditions is essential for predicting its fate and designing effective remediation strategies. This study investigates cadmium transport under saturated and homogeneous conditions using a two-dimensional laboratory sand tank to generate high-quality experimental data. Initially, a conservative tracer test with sodium chloride (NaCl) was performed to verify uniform flow distribution and hydraulic connectivity in the medium-packed sand tank, thus ensuring representative conditions for solute transport analysis. After achieving steady-state flow, a cadmium transport experiment was carried out by introducing a 100 ppb Cd solution tagged with a visible dye under constant water-table conditions. Water samples were collected from ten observation ports over a 912-hour monitoring period at progressively increasing time intervals. Samples were analysed using inductively coupled plasma mass spectrometry (ICP-MS) to measure cadmium concentrations, and breakthrough curves (BTCs) were constructed for each port. The experimental results revealed delayed cadmium breakthrough relative to the conservative tracer and pronounced tailing behaviour, indicating that processes such as hydrodynamic dispersion and sorption significantly influenced transport even in a homogeneous porous medium. These results highlight the importance of accounting for non-ideal transport phenomena when modelling heavy-metal transportation. The data set generated provides a robust basis for the calibration and validation of reactive transport models, enabling improved prediction of contaminant fate under field conditions. This experimental framework also establishes a foundation for future research involving heterogeneous porous media, coupled geochemical interactions, and scaling approaches to bridge laboratory findings with field applications. The outcomes of this work contribute to advancing predictive tools for groundwater quality management and support science-based decision-making in contaminated site remediation and risk assessment.

Keywords: Cadmium transport; Groundwater contamination; Tracer test; breakthrough curve; Reactive transport modelling

Paper ID: 203

AI-driven aquabot swarm for monitoring and treating river pollution

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ABSTRACT

Indian rivers suffer severe water pollution, even in sacred rivers like the Ganges. This challenge, exacerbated by climate change, threatens public health, food security, and environmental sustainability. In response, we propose a novel, futuristic solution: the AI-Driven Aquabot Swarm an AI-integrated approach leveraging advanced robotics and real-time data intelligence.

The Aquabot Swarm consists of autonomous micro-robots operating collectively to clean and monitor polluted rivers. These self-navigating bots use machine learning to identify pollution hotspots, extract contaminants, and transmit environmental data to a centralized system. This approach will ensure cleaner, healthier rivers even during mega events such as the Maha-Kumbh and will provide effective and economical solution for dealing with the issue of water pollution.

Keywords: Water quality; Pollution; AI integrated approach; Aquabot Swarm

Paper ID: 227

Spatio-temporal trends in groundwater quality and associated health risks in 21st century India

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ABSTRACT

Groundwater serves as a critical source of drinking water, particularly in regions where surface water availability is limited. In India, groundwater remains the primary source of drinking water and is often consumed untreated in rural areas, underscoring the need for careful monitoring and sustainable management. However, groundwater quality is increasingly being compromised by factors such as over-extraction, erratic monsoon patterns, and intensive agricultural practices, thereby heightening risks to drinking water safety and public health. To assess long-term changes in groundwater quality between 2000 and 2023, key physico-chemical parameters were analysed, including Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Chloride, Sulphate, Nitrate, Fluoride, Calcium, Magnesium, Alkalinity, Sodium, Potassium, Carbonate, and Bicarbonate from more than 61,000 monitoring well data. Spatio-temporal trends in groundwater quality were evaluated at the individual well level (location-specific, ≥8 years of data) and at the district level (≥4 sampling points per district), using a 24-year dataset (2000–2023). Theil-Sen's slope, and Mann–Kendall trend analysis were used to identify significant trends in individual parameters. A non-carcinogenic health risk assessment was conducted to identify locations where groundwater quality poses a significant risk to human health. Among the wells studied, 28.75% had median nitrate concentrations above the permissible limit, with more than 49.5% showing an increasing trend (positive Theil-Sen slope). For fluoride, 14.74% of wells exceeded the drinking water standard, and 36% exhibited rising trends, while 31.71% of wells recorded TDS levels above the standard, and 51.29% showed an increasing trend. In 2000, 58.83% of wells (n = 5,404) posed a non-carcinogenic health risk to children ($HI_{children} > 1$); this remained nearly unchanged in 2011 at 57.28% (n = 4,937), before improving to 47.01% (n = 15,258) in 2023. District-wise groundwater quality mapping indicated that many districts in northwestern and southern-central India had 24-year median nitrate concentrations above the permissible limit, while fluoride contamination was largely confined to Rajasthan. Elevated 24-year median TDS concentrations were observed across districts in northwestern, central, and southern India. These findings highlight persistent concerns over nitrate, fluoride, and salinity in large parts of India, with notable regional disparities. The study underscores the need for long-term monitoring, region-specific interventions, and sustainable groundwater management to safeguard drinking water quality and public health.

Keywords: Groundwater quality; Human health risk; Spatio-temporal trends: Sen slope; Sustainable groundwater management

Paper ID: 235

Advancing water quality control in India: Integrating science, policy and institutional mechanisms for sustainable resource management

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ABSTRACT

Ensuring safe and sustainable water quality is a critical challenge in developing countries like India, where rapid urbanization, industrialization, and agricultural intensification have severely impacted surface and groundwater resources. Despite existing regulatory frameworks such as the Water (Prevention and Control of Pollution) Act, 1974 and the National Water Policy, 2012, gaps in enforcement, fragmented institutional responsibilities, and limited monitoring capacity continue to undermine effective water quality control. An evaluation of data from the Central and State Pollution Control Boards reveals persistent exceedances of permissible limits for key parameters such as biochemical oxygen demand (BOD), nitrates, and heavy metals across several water bodies, reflecting inadequate pollution management and weak compliance mechanisms. Moreover, contaminants of emerging concern (CECs)—including microplastics, pharmaceuticals, and endocrine-disrupting compounds—remain poorly regulated and largely unmonitored, posing significant environmental and health risks. Addressing these challenges requires a shift toward integrated, science-based governance supported by robust institutional frameworks. Strengthening water quality management in India demands the adoption of real-time monitoring and data-driven decision-support tools, establishment of a unified regulatory authority for harmonized standards, and enhanced coordination among the Central Pollution Control Board (CPCB), Central Ground Water Board (CGWB), and local bodies. In addition, promoting risk-based water management, public data transparency, and stakeholder participation can significantly improve compliance and accountability. Integrating scientific innovation with coherent policies and institutional reforms will be essential to ensure long-term water security and align national water governance efforts with Sustainable Development Goal 6—Clean Water and Sanitation.

Keywords: Water quality; CECs; Groundwater governance; SDG 6

Paper ID: 236

Interlinking physico-chemical parameters and microplastic abundance in the Yamuna River: Indicators of anthropogenic stress and water quality degradation

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ABSTRACT

Microplastics (MPs) have emerged as critical indicators of anthropogenic pollution and deteriorating the water quality of river systems. This study aims to investigate the interrelationship between microplastic abundance and key physico-chemical parameters of the Yamuna River, focusing on how variations in water chemistry influence MP distribution along the Delhi stretch. Water samples were analyzed for pH, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), and salinity, and correlations were established using Pearson analysis. The findings of the study reveals strong negative correlations between pH and conductivity ($r = –0.99$) and TDS ($r = –0.99$) suggest that acidic conditions may correspond to elevated ionic concentrations, likely influenced by industrial effluents and urban runoff. Conversely, pH and DO exhibited a strong positive correlation ($r = 0.88$), reflecting cleaner and photosynthetically active zones. Microplastic abundance showed strong positive correlations with conductivity ($r = 0.95$) and TDS ($r = 0.94$), and negative associations with pH ($r = –0.96$) and DO ($r = –0.81$), indicating that MPs accumulate in low-oxygen and high ionic strength typical of polluted waters. A moderate positive correlation with salinity ($r = 0.68$) further suggests that sedimentation and reduced flow velocity enhance MP deposition. These results reveal that microplastic contamination is closely governed by the river's hydrochemical characteristics and can serve as an indicator of ecosystem degradation. Integrating microplastic monitoring with traditional water quality assessments offers a more comprehensive understanding of pollution dynamics and can inform policy decisions aimed at improving river health. The findings underscore the need for strengthening water quality management frameworks through interdisciplinary monitoring approaches and evidence-based strategies for sustainable restoration of the Yamuna River.

Keywords: Microplastics; Water quality; Physico-chemical parameters; Yamuna River; Anthropogenic pollution

Paper ID: 244

Evaluation of spatiotemporal variations of surface water quality using geospatial interpolation techniques in the Brahmani river basin

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ABSTRACT

Faced with increasing pressures from industrial discharge, agricultural runoff, and domestic sewage, the basin's water quality has become a critical concern for ecological health and human use. To assess this, water samples were collected from 25 pre-determined monitoring stations across the basin over a period of three year. This study presents a comprehensive evaluation of the spatiotemporal variations in surface water quality within the Brahmani River Basin spreading over Sundergarh District, one of India's major river systems. Physicochemical and biological parameters were analysed as per standard methods. The Geographic Information System (GIS) was employed as a powerful tool to visualize the samples were collected from strategic upstream, midstream, and downstream sites. A spatial distribution of pollutants was analysed using ArcGIS using inverse distance weighting (IDW) and ordinary kriging interpolation techniques. The integration of GIS with water quality analysis proved highly effective, providing clear visual evidence of pollution hotspots and trends. While both IDW and Kriging generated valuable spatial visualizations, Ordinary Kriging demonstrated superior predictive accuracy by accounting for spatial autocorrelation, resulting in a lower Root Mean Square Error (RMSE) compared to the distance-based IDW method. There is a similarity between the cross-validation results for OK and IDW for every pollution point and the prediction accuracy of spatial distribution trend under specific spatial correlation. Our findings reveal significant pollution hotspots directly correlated with industrial discharge points, showing a clear degradation of water quality from upstream to downstream regions deteriorating notably downstream near major industrial and urban centres, such as Rourkela, Talcher and Dhenkanal. This study concludes that the Brahmani River is under significant stress and recommends continuous monitoring, stringent pollution control measures, and recommend stringent enforcement of industrial wastewater treatment regulations and propose the adoption of advanced spatial analysis techniques as a critical tool for continuous environmental monitoring and sustainable water resource management.

Keywords: Water Quality Index (WQI); Geographic Information System (GIS); Spatiotemporal variation; Brahmani river; Inverse Distance Weighting (IDW); Ordinary kriging

Paper ID: 252

POSEIDON-Net: Physics-guided spatio-temporal deep learning for marine aquaculture water quality monitoring using ocean color observations

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ABSTRACT

The sustainability and performance of marine aquaculture systems largely depend on maintaining high water quality, which faces increasing challenges in the southeast Indian Ocean due to fluctuating environmental factors, nutrient accumulation, and intensified anthropogenic pressures. Conventional monitoring techniques relying on field sampling and laboratory analysis provide limited spatial and temporal resolution, making them insufficient for large-scale, real-time aquaculture management. To address these challenges, this study presents POSEIDON-Net (Physics-Guided Spatio-Temporal Deep Learning Network), a novel hybrid architecture designed to predict and monitor marine aquaculture water quality using satellite-based ocean color observations from NASA MODIS-Aqua and Sentinel-3 OLCI datasets. The model integrates physics-informed priors within a deep learning framework that combines a Tri-Stream Encoder (Spectral Transformer, Swin-CNN, and Radiative Transfer physics block) and a Graph-Temporal Transformer to learn spatial dependencies, optical variability, and seasonal dynamics. POSEIDON-Net predicts ten key marine water quality parameters—Chlorophyll-a, Total Suspended Matter (TSM), Colored Dissolved Organic Matter (CDOM), Sea Surface Temperature (SST), Turbidity, Secchi Disk Depth (SDD), Dissolved Oxygen (DO), pH, Nitrate (NO_3^-), and Phosphate (PO_4^{3-})—that are vital for aquaculture health assessment and pollution detection. Comparative experiments against 18 deep learning architectures, including conventional models (CNN, LSTM, RNN, GNN, GAN, LNN, KAN, FAN, GINN, PINN) and their hybrid physics-integrated counterparts, demonstrated that POSEIDON-Net achieved the best performance, with an average $R^2 = 0.947$, Nash–Sutcliffe Efficiency (NSE) = 0.934, and normalized RMSE = 0.112. Parameter-specific results indicated substantial improvements (20–25%) for nutrient and optical clarity metrics (NO_3^-, PO_4^{3-}, Turbidity, SDD), critical for detecting eutrophication and harmful algal bloom risks in aquaculture zones. The explainable AI (XAI) module using SHAP and Grad-CAM confirmed physically consistent dependencies, such as SST–DO interactions and Chl-a–Nutrient coupling, enhancing scientific transparency. The results establish POSEIDON-Net as a robust, interpretable, and scalable framework for real-time aquaculture water quality monitoring, supporting India's Blue Economy and Clean Ocean Mission by enabling sustainable coastal resource management and early pollution detection.

Keywords: Marine aquaculture; Physics-informed deep learning; Ocean color remote sensing; Water quality monitoring; Sustainability

Paper ID: 260

Review of fluoride contamination in groundwater of Telangana state: Remediation strategies aligned with SDG 6

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ABSTRACT

Groundwater is one of the most essential natural resources for sustaining human life and livelihood. However, in several regions of Telangana, naturally occurring fluoride-bearing minerals such as fluorite, apatite, biotite, and muscovite have been identified as the primary sources contributing to high fluoride concentrations in groundwater. The gradual dissolution of these minerals into aquifers leads to excessive fluoride accumulation, and prolonged consumption of such water can result in dental and skeletal fluorosis, severely affecting public health. To gain a comprehensive understanding of this issue, the present study conducted a systematic review of existing research retrieved from the Scopus database using relevant keywords. The compiled data revealed that fluoride concentrations in numerous districts of Telangana exceed the permissible limits recommended for safe drinking water.

A health risk assessment was performed following the United States Environmental Protection Agency (USEPA) guidelines to evaluate the potential non-carcinogenic risks to adults and children. The results indicated that children are more vulnerable (Hazard Index > 1) than adults due to their lower body weight and higher rate of water consumption. This finding highlights the urgent need for effective defluoridation measures before groundwater is used for drinking purposes. The study further reviews emerging fluoride removal technologies, including adsorption, electrocoagulation, membrane filtration, and photocatalysis, focusing on their mechanisms, efficiency, limitations, and site-specific applicability.

This review emphasizes the serious health implications of fluoride-contaminated groundwater and the necessity for cost-effective, community-based treatment systems. It also advocates for regular groundwater monitoring and public awareness initiatives to ensure the sustainable supply of fluoride-free drinking water, thereby contributing to the achievement of Sustainable Development Goal 6 (Clean Water and Sanitation).

Keywords: Health risk assessment; Defluoridation; Clean water and sanitation; Cost-effective; USEPA guidelines

Paper ID: 262

Improved monitoring in wastewater treatment plants using Kolmogorov- Smirnov-based monitoring scheme

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ABSTRACT

Rapid and accurate fault detection in wastewater treatment processes is extremely important for reliable operations and avoiding system failures. In this work, an effective fault detection (FD) scheme is proposed that integrates dynamic principal component analysis (DPCA) model and a non-parametric fault indicator based on the Kolmogorov-Smirnov (KS) test. The data from any industrial water treatment plants tend to have strong process dynamics, and this is incorporated using the DPCA modeling framework. The KS test is used as an indicator to identify the presence of an abnormality in the process plant. The combined DPCA-KS FD scheme utilizes the DPCA method for modeling and for generating the residuals, which are then validated by using the KS test for identification of sensor faults. The proposed scheme's capability in monitoring is demonstrated on Benchmark Simulation Model (BSM1) wastewater plant for monitoring three different faults. The results clearly suggest that the proposed DPCA-KS scheme performs better than the conventional FD schemes, thus aiding in improved fault detection capabilities.

Keywords: Fault detection; Wastewater treatment plant; Kolmogorov Smirnov test; Dynamic principal component analysis

Track – 3

Air Pollution Control

Paper ID: 002

Site selection for installation of air quality monitoring station using AHP, Fuzzy and TOPSIS based hybrid MCDM techniques: A case study of Amaravati city, India

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ABSTRACT

Since last few decades, air pollution issues have become serious environmental problem throughout the world including the major Indian cities. Therefore, monitoring of air quality in regular basis has become imperative for large cities with high degree of industrialization. To obtain the accurate air quality index (AQI) value, the installation of air quality monitoring station (AQMS) is very essential in the appropriate locations of a particular city. In this study, different locations of Amaravati city (Andhra Pradesh, India) were chosen for installing AQMS as the ambient air quality (AAQ) in this city had been deteriorated seriously over the last few years. Thus, the main objective of this study is to identify the most appropriate locations for installing the AQMS in the Amaravati city. Two hybrid multi-criteria decision making (MCDM) approaches (AHP-TOPSIS and Fuzzy-TOPSIS) were explored in order to select the most appropriate locations for establishing AQMS in the Amaravati city. Ten different criteria were selected in this study to evaluation seven different locations of the considered city as alternatives. The considered criteria are all weather connectivity and accessibility of site (C1); security against theft, loss, and tempering (C2); accessibility of power supply (C3); sites long term feasibility (C4); density of population (C5); traffic density (C6); sensitive receptors (C7); distance from existing station (C8); industrial growth (C9); and distance from the emission sources (C10). The obtained result clearly shows that, the overall performances of each alternative have significant variation for both the proposed hybrid MCDMs, which help to eradicate the worst locations. Based on results, site A1 (Mangalagiri) is found to be the most suitable alternative, and site A7 (Thullur) is observed to be the second-best alternative for installing the AQMS in the Amaravati city. Thus, this study demonstrated that hybrid MCDM have the potential to identify the most suitable locations for installation of new AQMS, and the outcome of this research will be highly useful to the policy makers for taking decision for installation of AQMS.

Keywords: Air Quality Monitoring Stations, Analytical Hierarchy Process (AHP), Fuzzy MCDM, TOPSIS MCDM, AHP-TOPSIS, Fuzzy-TOPSIS

Paper ID: 018

Data-Driven Urban Health Protection: Leveraging 10-Year Air Quality Analytics for Proactive Public Health Interventions

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ABSTRACT

This study contributes to an in-depth study of the monitoring and forecasting of air quality in an urban environment- Jaipur, Rajasthan, based on the integrated framework approach, after conducting the correlation analysis. The paper uses ten years of hourly data sets of the pollutants recorded in 15 monitoring stations in Jaipur and which include six Central Pollution Control Board (CPCB) and nine National Ambient Air Quality Monitoring Programme (NAMP) stations. The results of our research provide important information about spatiotemporal pollution trends, and particulate matter ($PM_{2.5}$ and PM_{10}) is demonstrated to be the most prominent factor influencing changes in the Air Quality Index (AQI) in various urban areas. The study indicates that there are strong positive correlations between $PM_{2.5}$ and PM_{10} (riguez-0.67 to 1.00), although there are negative correlations between ozone and the other pollutants. Temporal review shows considerable differences in the aspect of air quality, with the majority of stations in satisfactory to moderate (51-200) AQI values, and concerning tendencies of increasing throughout the country-wide industrial areas after 2022. The paper provides a basis to work on a proactive approach to the management of pollution planning decision-making to form healthier communities in fast-developing Indian cities.

Keywords: Air Pollution ; Urban Environment; PM2.5; PM10; AQI.

Paper ID: 019

Metaheuristic whale optimization algorithm for performance-boosted CNNs in satellite image analysis of climate change and air pollution

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ABSTRACT

Monitoring climate and air-quality signals from satellite image demands CNNs that are both accurate and efficient; however, manual hyper-parameter and architecture tuning is costly and often sub-optimal. We present a Whale Optimization Algorithm (WOA) driven deep pipeline that jointly searches convolutional depth/width, kernel sizes, dilation, dropout, learning rate, weight decay and augmentation strength to yield performance-boosted CNNs for multi-class air-pollution assessment. Each candidate network is encoded as a vector and evaluated with a composite fitness that maximizes macro-F1 on a stratified validation split while penalizing FLOPs and expected latency. The integrated WOA's adaptive encircling and spiral operators balance exploration and exploitation whereas the early-stopping and a lightweight surrogate reduces search cost. Training uses ImageNet initialization, class-balanced focal loss and augmentation (color jitter, haze simulation, CutMix). Experiments on a public benchmark air-pollution image dataset from India and Nepal demonstrate consistent gains over strong baselines. The WOA-optimized CNN attains 97.2% top-1 accuracy, 0.968 macro-F1, 0.990 macro-AUROC, and 0.982 mAP, improving macro-F1 by +3.0 points relative to the best non-WOA baseline. The proposed architecture reduces batch-1 GPU latency by 18%, while improving calibration (ECE 1.9%). Robustness tests with synthetic haze and contrast shifts show ≤1.2 percentage-point accuracy degradation (vs. 4.6 for baselines). Grad-CAM visualizations confirm attention to pollution-relevant structures (smog/haze plumes and emission corridors), supporting model interpretability. These results indicate that a WOA-guided neural architecture and hyper-parameter search reliably identifies high-performing, well-calibrated and efficient CNNs for satellite-based air-pollution monitoring. The approach is general and transferable to other climate-relevant remote-sensing tasks (e.g., wildfire smoke, dust storms, urban heat) with minimal training.

Keywords: Whale optimization algorithm; Neural architecture search; Convolutional neural networks; Satellite image analysis; Air pollution monitoring

Paper ID: 023

Use of Low-cost sensor to detect air pollution levels in construction sites of central Delhi during GRAP implementation

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ABSTRACT

Air pollution Improvement in Delhi require rigorous efforts from different stakeholders. Apart from stakeholders' different technologies are required to detect and eliminate pollution. Low-cost sensors are one among them. These sensors are used for hotspots identification in the city. In this study sensors are used to study the pollution concentration in 5 different construction sites. This was analysed during the different phases of GRAP implementation in the year 2024 and 2025. The study revealed that the $PM_{2.5}$ and PM_{10} concentration trend observed in sensor follows similar trend to the CAAQM monitoring station. The $PM_{2.5}$ concentration in the study region ranged up to 600 µg/m³, and for PM_{10} it was upto 800 µg/m³. In construction site III concentration were observed with a value of > 200 µg/m³ for both the $PM_{2.5}$ and PM_{10}. The GRAP was implemented during different phases based on the concentration. The period before the GRAP and post GRAP was considered as the period with lower concentrations. During GRAP IV and GRAP III higher concentration of PM values were found. The usage of Low-cost sensors in construction sites during GRAP revealed that the emission sources reduced during GRAP IV and the concentration decreases gradually. The GRAP policy implementation revealed that the stringent GRAP phases were established during the period of 2024 to 2025 which have major impact air pollution in construction sites. Reduction in concentration of particles were observed more for PM_{10} concentrations. Stringent implementation of mitigation measures with use of advance technology leads to improve in air quality in a region.

Keywords: *Low cost sensor, construction sites, Air pollution, Delhi*

Paper ID: 026

Evaluation of roadside plants using APTI and API: A green solution for mitigating air pollution in traffic corridors

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ABSTRACT

Air pollution poses a significant challenge in traffic-dominated environments, necessitating the identification of tolerant plant species for sustainable greenbelt development. This study evaluated the air pollution tolerance of 30 predominant roadside species along National Highway 16, Kharagpur, India, during Winter using the Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API). Physiological and biochemical parameters, including ascorbic acid content, relative water content, total chlorophyll, and leaf extract pH, were analysed to calculate APTI, while API integrated these values with biological and socio-economic attributes. The APTI values ranged from 13.34 ± 1.07 to 30.73 ± 0.76, with *Duranta erecta* exhibiting the highest tolerance while *Hibiscus rosa-sinensis* exhibited the lowest, serving as a potential phytoremediator and bio-indicator of air pollution, respectively. Based on API scores, species such as *Azadirachta indica*, *Acacia auriculiformis*, *Neolamarckia cadamba*, *Duranta erecta*, *Pithecellobium dulce*, and *Alstonia scholaris* (82.4% – 88.2%) were classified as "excellent" performers, whereas *Bougainvillea glabra*, *Bougainvillea spectabilis*, *Delonix regia*, *Lagerstroemia speciosa*, and *Hibiscus rosa-sinensis* (41.2–47.1%) were categorized as poor performers. Pearson's correlation analysis demonstrated a strong positive relationship between ascorbic acid and APTI ($r = 0.95$). Multiple Linear Regression (MLR) further confirmed that all predictors significantly influenced APTI ($p < 0.001$), with ascorbic acid emerging as the most influential factor ($\beta = 0.943$; $p < 0.001$). These findings emphasize the critical role of ascorbic acid in determining tolerance and provide a scientifically validated framework for selecting effective species for traffic-related air pollution mitigation.

Keywords: Green belt development; APTI; API; Phytoremediator; Bio-indicator

Paper ID: 034

Comparison of indoor plants for CO_2 removal in built environments

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ABSTRACT

Current studies have highlighted that people spend most of their time indoors, making indoor air quality a critical concern. Indoor air pollution can have detrimental effects on human health, and the concentration of carbon dioxide (CO2) in indoor environments is a crucial factor that needs to be monitored and controlled. Plants have been recognized globally as environmentally friendly and natural air purification mechanisms. Therefore, the viability of using indoor plants as an indoor air pollution mitigation measure was investigated in this study. Therefore, this research focus to assess the capacity of selected indoor plant species in chamber to reduce CO2 levels in indoor environments. Study aims two plant species, including *Dracaena marginata and Sansevieria trifasciata*, were evaluated for their ability to remove CO2 from indoor environments. The study found that Spathiphyllum blandum was the most efficient species in CO2 removal gradually. This research is significant because it provides insight into the potential use of indoor plants in tropical climates as a sustainable and natural way of improving indoor air quality.
Current studies have highlighted that people spend most of their time indoors, making indoor air quality a critical concern. Indoor air pollution can have detrimental effects on human health, and the concentration of carbon dioxide (CO2) in indoor environments is a crucial factor that needs to be monitored and controlled. Plants have been recognized globally as environmentally friendly and natural air purification mechanisms. Therefore, the viability of using indoor plants as an indoor air pollution mitigation measure was investigated in this study. Therefore, this research focus to assess the capacity of selected indoor plant species in chamber to reduce CO2 levels in indoor environments. Study aims two plant species, including *Dracaena marginata and Sansevieria trifasciata*, were evaluated for their ability to remove CO2 from indoor environments. The study found that Spathiphyllum blandum was the most efficient species in CO2 removal gradually. This research is significant because it provides insight into the potential use of indoor plants in tropical climates as a sustainable and natural way of improving indoor air quality.

Paper ID: 037

Seasonal characteristics of $PM_{2.5}$ pollution: source apportionment and health risk assessment in rural northern India

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ABSTRACT

The mass concentration and elemental composition of $PM_{2.5}$ aerosols were measured in a rural region of northern India, with a focus on contrasting the relatively cleaner monsoon season and the more polluted post-monsoon season. Continuous 24-hour $PM_{2.5}$ sampling was carried out over 21 consecutive days in each season, and alternate-day filter samples were subjected to elemental analysis using inductively coupled plasma–mass spectrometry (ICP–MS). A total of twenty-three major and trace elements were quantified to characterize seasonal differences in chemical composition.

The Mean $PM_{2.5}$ concentrations during post-monsoon (315.76 ± 55.85 µg/m³) were more than 3 times higher than those in the monsoon season (93.12 ± 12.85 µg/m³), both far above the Indian air quality standards. Enrichment factor analysis showed strong enrichment of combustion-related elements (K, Cu, Zn, Pb, Sb, Bi) during the post-monsoon, reflecting dominant anthropogenic inputs, whereas crustal elements (Ca, Al, Fe, Mg, Ti) exhibited low EF values, indicating natural soil and dust contributions.

Principal Component Analysis and inter-element correlation analysis further differentiated natural and anthropogenic sources, with co-emission groupings aligning with EF results. HYSPLIT back trajectory modeling revealed potential regional transport pathways, while wind rose analysis clarified the influence of local meteorology on pollutant dispersion and accumulation. Notably, health risk assessment revealed significantly higher post-monsoon risks, with carcinogenic risks increasing ~1.8-fold in children and ~1.3-fold in adults, and non-carcinogenic hazards rising ~1.28-fold and ~1.24-fold, respectively, driven mainly by Cr, V, and Mn.

Overall, the integrated approach of this study demonstrates that post-monsoon $PM_{2.5}$ pollution is primarily driven by enhanced anthropogenic emissions coupled with limited atmospheric dispersion, providing crucial insights for source control and health risk reduction.

Keywords: Particulate matter; Principal component analysis; Enrichment factor; HYSPLIT; Health risk assessment.

Paper ID: 038

Analysis of particulate matter transport in Shillong using the HYSPLIT Model

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ABSTRACT

Particulate matter (PM) released from anthropogenic sources like exhaust emissions, industrial stacks, and road dust is transported into the atmosphere, impacting the climate system and human health. The dispersion and concentration of these pollutants are heavily influenced by local meteorological conditions and topographical features. The study intends to reveal the causes of particulate transport throughout the year by tracking its transport in Shillong, India. The main sources of particulate matter in Shillong are due to increasing traffic density, causing exhaust emissions, construction activities, and thus increasing urbanisation. These are influenced by weather parameters like wind speed and wind direction, and the built environment. Global Data Assimilation System (GDAS) archival is used for meteorological data. The Hybrid Single-Particle Lagrangian Integrated Trajectory (HSPLIT) trajectory cluster analysis is used to compute the forward and backward trajectories of the particulates. Forward and backward trajectories reveal the seasonality of particulate transport throughout the year. The concentration of particulate matter is typically higher in both the winter and summer seasons. During winter, it's often due to stable atmospheric conditions that trap pollutants near the ground. In the summer, specific weather patterns can also contribute to higher particulate matter levels. With the change in the season and climate, the transport of particulate matter takes a different path. When the particles reach higher altitudes, they travel further due to the interaction between the particles and the wind speed. This study assesses the effectiveness of the HYSPLIT model in simulating atmospheric particulate transport.

Keywords: PMs; Air Quality; HYSPLIT; Forward trajectory; Urban environment

Paper ID: 039

Modeling and sensitivity analysis of hydrogen chloride (HCl) gas dispersion using ALOHA, R, and GIS tools

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ABSTRACT

The pollutants, hazardous gases, chemicals, and other airborne waste materials emerging from industries are well recognized as a threat to the environment. These emissions certainly have an impact in multiple areas, including agriculture by degrading soil quality, tourism by diminishing the natural beauty of clean environments, infrastructure by increasing the likelihood of acid rain, public health by raising the incidence of respiratory diseases, and communities by causing displacement and relocation. Industries such as chemical plants, mining, refineries, manufacturing units, petrochemical facilities, cement, and food processing units are prime sources of airborne pollutants to the environment. Safeguarding society from the discussed emissions is a necessity today, not only for humankind but also for the future.

In this study, the focus is on hydrogen chloride (HCl) gas, which is generally considered corrosive and has varied environmental impacts depending on its physical state at different temperatures. Collection of data related to HCl is a tedious task; however, site-specific, meteorological, and emergency response parameters were collected and validated in accordance with standard statistical methods, using software R. Site coordinates were mapped using GIS tools, and the resulting spatial intelligence was integrated with ALOHA software to identify safe zones, escape routes, and critical resource locations. This study explores the use of ALOHA software and predicts gas dispersion based on site-specific data in real time, providing accurate solutions using ML techniques. The input parameters in this study were chosen based on the chemical properties of HCl under the corresponding atmospheric conditions. The model developed in ALOHA identifies threats in three different zones: greater than 100 ppm, 22 ppm, and 1.8 ppm categories. A detailed sensitivity analysis has been proposed and has simultaneously identified the critical input parameters that have a greater impact on the environment. Furthermore, the reliability of both the data and the results has been computed, which ultimately supports emergency response systems and fulfills the needs of the environment.

Keywords: Plume Modeling, Risk Assessment, Surrogate analysis, ALOHA, Software

Paper ID: 058

Particulate and VOC emission assessment in LDPE-modified asphalt production

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ABSTRACT

The use of waste plastics in road construction helps manage plastic waste while improving pavement strength, durability, and cost-effectiveness. This practice has led to the development of plastic-modified asphalt (PMA), which has demonstrated promising performance. However, despite these benefits, its potential environmental consequences remain insufficiently understood. This study investigates emissions of volatile organic compounds (VOCs) and particulate matter ($PM_{2.5}$ and PM_{10}) during the production of hot mix asphalt (HMA), at a ±20 °C variation from MS-2 recommended temperatures. The study evaluates emissions from PMA (via dry process) in comparison with a control mix. LDPE, sourced as waste milk pouches from the IIT Jodhpur mess facility, was incorporated (2% and 10% by bitumen weight) at an optimum binder content of 6%. Emissions were monitored across five heating stages: (i) aggregate heating (180 °C), (ii) bitumen heating (160 °C), (iii) LDPE melting (110 °C), (iv) control mix preparation (155 ± 5 °C), and (v) PMA mixing.

Results showed a consistent increase in PM emissions with rising temperature across all heating stages. At stage 3, LDPE exhibited particulate release near its melting point (110 °C), with $PM_{2.5}$ reaching 350 µg/m³ and PM_{10} 908 µg/m³. When incorporated into asphalt, 2% LDPE reduced emissions ($PM_{2.5}$ = 370 µg/m³, PM_{10} = 890 µg/m³) compared to the control mix ($PM_{2.5}$ = 460 µg/m³, PM_{10} = 1080 µg/m³). In contrast, a 10% dosage increased emissions ($PM_{2.5}$ = 560 µg/m³, PM_{10} = 1200 µg/m³), confirming a dosage-dependent effect. Similarly, VOC analysis revealed that while aggregates alone contributed minimal emissions, the addition of bitumen and especially plastics led to a marked increase in hazardous compounds. At stage 5, mixing with LDPE resulted in high concentrations of benzene (175.8 µg/m³), toluene (130.5 µg/m³), and styrene (138.6 µg/m³), along with substantial levels of n-hexane (92.6 µg/m³) and p-xylene (71.5 µg/m³). The detection of chlorine-based compounds further highlighted the risk of secondary pollutant formation. Emissions were consistently higher in stages 3 and 5 than in stage 2, with the 10% LDPE mix releasing more VOCs than the 2% dosage. In contrast, PMA mixes demonstrated higher Marshall stability than the control mix, highlighting the balance between improved mechanical performance and increased environmental risk. Overall, the associated VOC and PM emissions from PMA highlight the need for careful evaluation and mitigation measures. The findings emphasize the importance of proactive strategies such as effective dust suppression, localized fume extraction, use of personal protective equipment, and continuous air quality monitoring.

Keywords: Plastic Modified Asphalt; LDPE; $PM_{2.5}$; PM_{10}; VOC.

Paper ID: 068

Apportioning PM_{10} sources using positive matrix factorization and trajectory analysis with HYSPLIT

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ABSTRACT

Particulate matter (PM_{10}) has significant impacts on air quality and human health, making source identification and transport assessment essential. Particulate matter (PM_{10}) significantly affects ambient air quality and human health, underscoring the need for effective source identification and transport assessment. This study investigates the source apportionment of PM_{10} particulate matter at two outdoor sites in Ranchi, Jharkhand, India, covering the period from mid-November 2024 to mid-June 2025. PM_{10} samples were collected and chemically characterized to understand variations in dust composition. Measured levels frequently exceeded the NAAQS limit of 60 μg/m³, with peaks up to 255 μg/m³. Chemical analyses identified multiple components, such as trace metals (As, Sb, Se, Sr, Ti, V, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn), major crustal elements (Al, Ba, Si, Ca, Mg, K, Na), carbonaceous fractions (Organic Carbon and Elemental Carbon), and water-soluble ions (SO_4^{2-}, PO_4^{3-}, F^-, NO_3^-, Cl^-, NH_4^+, K^+, Ca^{2+}, Mg^{2+}). Positive Matrix Factorization (PMF) receptor modeling was employed for source apportionment, enabling quantitative attribution of emission sources. Additionally, the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was utilized for backward and forward trajectory analyses, enabling evaluation of pollutant transport pathways and dispersion dynamics. Positive Matrix Factorization (PMF) identified major contributing sources, while HYSPLIT trajectory analyses highlight the transport pathways of pollutants, revealing the influence of both local and regional atmospheric transport. The results indicate distinct temporal variability, with several episodes surpassing national and WHO air quality standards. These findings provide critical insights for targeted mitigation strategies and improved regional air quality management in Ranchi.

Keywords: Particulate matter (PM_{10}), Source apportionment, PMF, HYSPLIT, Trajectory analysis, Air quality

Paper ID: 098

Study of airborne siliceous dust in Banduhurang open cast uranium mine

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ABSTRACT

Increasing energy demands has led to significant increase in the mining activities across the country, which has the potential to cause environmental damage and pollution, unless well-regulated. Among the various environmental hazards in mining industries, the mine dust is generally considered to be one of the major threats with respect to occupational and public health. Unlike other mining industries (coal, copper etc), in uranium mining industry, apart from the radiation hazards due to the radiation exposure, conventional hazard may be a concern due to the presence of the airborne dust.

Eastern India has low grade uranium deposits around Singhbhum thrust belt where silica contributes a major portion of the ore. Banduhurang is the only open cast mine present in East Singhbhun district of Jhrakhand, India. It is also the largest mine in terms of uranium ore production, having ore production capacity of 3500 tons per day (TPD). Mining operation includes activities like drilling, mucking, boulder breaking etc. which may generate respirable dust, if such activities were carried out without proper remedial action like sprinkling of water. Prolonged inhalation of dust may give rise health issues to the miners. Thus, it is important to have regulatory control on the airborne siliceous dust generated due to the various mining activities in the mining industries. To facilitate this, monitoring and assessment of dust has been carried out at various locations inside and outside the mine premises on a regular basis. The present abstract includes measurement of the airborne siliceous dust concentration around Banduhurang open cast mine for the year 2023 & 2024.

Personal Air Sampler is used to measure the concentration of the airborne respirable dust. A filter paper of 37 mm diameter is used to collect the dust particle of size in the range of 1.6– 5 micron. The accumulated dust on the filter paper is then analyzed for the determination of airborne siliceous dust concentration. According to the regulatory guidelines and based on the silica content in respirable siliceous dust, the applicable limit for respirable siliceous dust is adopted as 0.80 mg/m^3.

Study reveals that the dust concentration was found to be within the regulatory limit. The statistical data for 100 numbers of samples shows that the average value of dust concentration was observed to be 0.5 mg/m^3 with a standard deviation of 0.26 for both the year 2023 and 2024. Median was found to be 0.50 and 0.43 mg/m^3 for the year 2023 and 2024 respectively. The data also reveals that 25th percentile value was observed to be 0.34 and 0.33 mg/m^3 for the year 2023 and 2024 respectively. Thus, the results indicate that the mining activities in Banduhurang mine are in accordance with the regulatory controls.

Keywords: Air borne dust; uranium mining; open cast mine, dust concentration.

Paper ID: 101

Dynamical fingerprinting of urban air pollution: a method for diagnosing emission regimes

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ABSTRACT

A critical gap in urban air quality analysis is addressed by this research. While pollution concentrations are quantified by conventional monitoring, the intrinsic dynamical behavior of local emission sources often remains undiagnosed. As a result, the development of effective, site-specific mitigation strategies is hindered. To address this limitation, a novel, multi-modal framework termed "Dynamical Fingerprinting" is introduced, designed for the classification of urban pollution regimes through the analysis of their intrinsic time-series dynamics. To address this limitation, this study introduces and validates a novel, multi-modal framework termed "Dynamical Fingerprinting," Designed to classify urban pollution regimes by analyzing their intrinsic time-series dynamics. The framework was applied to high-resolution data for SO_2, NO_2, PM_{10}, and $PM_{2.5}$ from two functionally distinct sites in Agartala, India: a residential site (Kunjaban) and a commercial hub (Bordowali). A suite of techniques from non-linear dynamics was employed, including the quantification of system complexity using Multiscale Permutation Entropy (MPE) and the measurement of long-range memory with Detrended Fluctuation Analysis (DFA). These metrics were then synthesized into a novel Persistence-Complexity Phase Diagram to create a unique, data-driven fingerprint for each pollution environment. The results clearly showed the existence of two fundamentally different classes of pollution systems. The Kunjaban site was identified as a "Persistent & Simple" regime, a dynamical fingerprint characteristic of a predictable, cyclically-driven system dominated by residential and commuter activity. In stark contrast, the Bordowali site was fingerprinted as a "Persistent & Complex" regime, the a strong indicator of a chaotic, stochastically-driven system influenced by high-intensity, mixed-source commercial and transportation activity. This research demonstrates that the "Dynamical Fingerprinting" framework can successfully classify emission regimes based on their inherent dynamical behavior alone, offering a powerful, low-cost diagnostic tool that represents a paradigm shift from static monitoring to dynamic diagnosis, with significant implications for urban air quality management worldwide. By providing a tool for more effective, site-specific mitigation strategies, this research directly contributes to Sustainable Development Goals, including SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities).

Keywords: Urban Air Quality; Non-linear Dynamics; Permutation Entropy; Detrended Fluctuation Analysis (DFA); Emission Regimes.

Paper ID: 107

Feasibility Analysis of Blended Waste Transformer Oil (WTO) as an Alternative Fuel for Diesel Engines

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ABSTRACT

The rapid depletion of fossil fuel reserves and the escalating environmental hazards associated with industrial waste disposal necessitate the exploration of sustainable alternative energy sources. This study investigates the feasibility of utilizing Waste Transformer Oil (WTO)—a hazardous industrial byproduct—as a viable blend component for diesel engines. The primary objective is to convert a disposal liability into an energy asset by evaluating the physicochemical properties, engine performance, and emission characteristics of WTO-diesel blends. The WTO was dehydrated and filtered to remove impurities before being blended with commercial diesel in varying volume ratios (e.g., 10%, 20%, 30%, and 40%). Experimental trials were conducted on a diesel engine under varying load conditions at constant speed. Fuel property analysis revealed that while WTO possesses higher viscosity and density than neat diesel, its calorific value is sufficiently high for combustion. Test results indicated that lower percentage blends (specifically B20) exhibited Brake Thermal Efficiency (BTE) comparable to neat diesel, with a marginal increase in Brake Specific Fuel Consumption (BSFC). Emission analysis showed a reduction in Carbon Monoxide (CO) and Unburnt Hydrocarbons (HC) for optimized blends due to oxygenated compounds in the oil, though Nitrogen Oxide (NOx) emissions increased slightly due to elevated in-cylinder temperatures. The study concludes that blended WTO up to 20% can be effectively used in existing diesel engines without modification, offering a dual solution for hazardous waste management and energy conservation.

Keywords: Waste Transformer Oil, Alternative Fuels, Diesel Engine, Emission Analysis, Waste-to-Energy

Paper ID: 121

Beyond sensors: scalable air pollution identification using deep visual features

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ABSTRACT

Air pollution continues to pose a significant global threat, particularly in densely populated and low-resource regions where sensor-based monitoring is limited or infeasible. This study introduces a scalable, image-based framework for air pollution severity classification using Vision Transformer (ViT) models, offering a cost-effective alternative to traditional sensor networks. In this work three state-of-the-art ViT architectures-DINOv3 (self-supervised, Meta AI), PS3-1.5K-SigLIP (contrastive, NVIDIA), and ViT-H-14-378-quickgelu-dfn5b(CLIP-based OpenAI) were considered to extract more visual features from air pollution images. These models represent various diverse training paradigms: self-supervised learning, sigmoid-based image-text alignment, and contrastive multimodal embedding. Their complementary strengths enable robust feature representation of pollution indicators such as haze, colour distortion, and visibility degradation. The framework is evaluated across three geographically distinct datasets: SAPID (456 images, 6 classes), India and Nepal (12,240 images, 6 classes), and Dhaka (1,812 images, 5 classes). Each image is labelled into different categories based on its severity -Good, Moderate, Unhealthy, Very Unhealthy, Hazardous, etc. Extracted features are fed into a pool of 30 classifiers, including ensemble methods, tree-based models, and neural networks. The best-performing classifier is selected based on accuracy, F1 score, precision, recall, and confusion matrix analysis.

The results demonstrates that image-based classification can achieve high reliability: 98%+ accuracy on the India and Nepal dataset, 90%+ on Dhaka, and 85% +on SAPID. The results confirm that features extracted from Vision Transformers effectively encode pollution severity using visual information alone.The proposed pipeline enables real-time pollution assessment using mobile devices or surveillance cameras, making it highly suitable for deployment in low-resource settings. Extensive cross-validations were conducted across all datasets to guarantee the reliability and broad applicability of the proposed classification framework. Due to the inherent class imbalance present in the SAPID, India-Nepal, and Dhaka datasets, traditional accuracy metrics alone were insufficient for reliable performance assessment. Therefore, a suite of imbalance-aware evaluation metrics was utilized, including Index Balanced Accuracy (IBA), Balanced Accuracy, F1 Score, and Geometric Mean (G-Mean). These metrics offer deeper insights into classifier behavior across both minority and majority classes, enabling fair comparison and effective model selection under skewed class distributions.

Keywords: Air Pollution Classification; Vision Transformers; Image Based Monitoring; Environmental diagnostics.

Paper ID: 163

Clean mobility for a University campus – Preliminary Study on Retrofitting Diesel buses to CNG

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ABSTRACT

Sustainable transportation includes mobility systems which reduce adverse environmental impacts with a reduction in greenhouse gas emissions as well as air pollution. The main aim is resource conservation, while also ensuring affordability, passenger safety and energy efficiency. With a focus on Sustainability, educational institutions strive to reduce their carbon footprint, lower air pollution levels and operating costs in this regard retrofitting existing campus buses to alternative fuel such as Compressed Natural Gas (CNG) presents a viable solution. This approach not only aligns with environmental goals but also offers significant economic benefits. Air pollution is a significant issue in India with the country being home to several cities with high PM 10 levels in the world. In this regard it is important to highlight that the Indian government has set a target to reduce the PM 10 levels to 20-30% through the NCAP (National Clean Air Programme) by 2025-26. City of Chh.Sambhajinagar (formerly Aurangabad) is also included in the non-attainment cities of the country and transportation sector is an important contributor towards air pollution. This implies that the city must take varied steps for reducing PM 10 levels. The Government of India has set an ambitious target for electric vehicles (EV) alongside plans to reduce carbon emissions via diesel and petrol engines significantly by 2030. The number of buses on Indian roads is expected to reach over 2 million by the year 2030. Similarly, the volume of other transport vehicles is also expected to increase at a rapid pace. Thus, the viable solution is to add a limited number of EVs while upgrading the existing ones to cleaner CNG variants through retrofitting. In MGM University many campus buses for pick and drop of students and faculty members currently operate on internal combustion engines (ICE), primarily diesel. These buses contribute to urban air pollution and are subject to stringent emission norms, making their continued operation increasingly challenging.

In this research an attempt is made to study the retrofitting of diesel buses in JNEC (Jawaharlal Nehru Engineering College) MGM University Chh. Sambhajinagar, Maharashtra, into cleaner Compressed Natural Gas (CNG). The main objectives of this study are to evaluate the technical and economic feasibility of retrofitting the diesel engines to CNG and to provide a strategic, actionable roadmap for a phased transition. With this approach the reduction in GHG emissions and air pollutant levels will also be estimated. It is expected that such an approach will serve as a model for other University campuses to also switch towards clean mobility.

Keywords: Air Quality; Mobility; Diesel; CNG; Clean Fuel

Paper ID: 205

Event-driven toxic pollutant cocktails: rethinking air quality in the era of climate extremes

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ABSTRACT

Climate change is intensifying extreme events such as heatwaves, wildfires, and floods. These events alter atmospheric pollution, deteriorate air quality, and threaten public health and the environment. Concurrent rises in $PM_{2.5}$, ozone, as well as nitrogen oxides, produce deadly combinations that incur substantially higher health risks than those brought about by specific pollutants. Classical Air Quality Index systems determine pollutants individually, causing exposure risk during key episodes to be underestimated as well as generating a limitation on the ability to foresee as well as mitigate health threats. This research presents a novel monitoring framework that frames air pollution as an event-driven, dynamic phenomenon. The approach integrates satellite observations (TROPOMI, MODIS), governmental monitoring stations, meteorological reanalysis (ERA5), and publicly available sensor data to determine the event occurrence that triggers concurrent rises in pollutant concentrations. These diverse sources of data are combined into a Climate–Air Synergy Index (CASI). CASI generates hierarchical warnings, that complement the standard Air Quality Index by showing the collaboration between multiple pollutants and their augmented health effects. Analysis detects systematic signatures indicating that climate anomalies initiate multipollutant outbreaks with health consequences beyond those implied by single-species exposure. CASI captures these processes effectively, allowing specific alert protocols that indicate elevated risk levels during co-occurrence outbreaks. Comparison to health outcomes data shows improved prediction capability over conventional indices. The output advisory system provides actionable intelligence through warnings for individuals, planning time for hospitals, and support for policymaking. It utilizes existing satellite and community monitoring, with future IoT-based micro-sensors for real-time localized evaluation. By combining climate variability with the mixture dynamics of pollutants, this research redefines air quality monitoring. Transitioning from single-pollutant monitoring to event-based multipollutant speciation is critical to future-proofing infrastructure and safeguarding public health in the face of intensifying impacts from climate change.

Keywords:
Climate Change; Air Quality; Extreme Events; Multi-Pollutant Exposure;Public Health

Paper ID: 212

Automatic regulation of primary and secondary air for enhanced efficiency and reduced emissions in pellet cookstove

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ABSTRACT

Nearly 40% of world's population, approximately half of those living in developed nations, cook their food using traditional biomass cookstoves. This practice contributes significantly to indoor air pollution and adverse health effects due to the release of hazardous pollutants such as particulate matter ($PM_{2.5}$) and carbon monoxide (CO). To address this, forced-draft cookstoves were developed which outperformed the traditional stoves in terms of emissions and demonstrated better performance than other natural draft improved stoves. However, in conventional forced draft designs, controlling the primary and secondary air still requires manual intervention and continuous flame monitoring. To overcome this limitation, in this work, an automatic air controller was developed that eliminates the need for constant operator supervision. A microprocessor continuously checks the flame temperature and modifies the primary and secondary airflows in real time, activating both when the temperature drops below the predetermined threshold. Two forms of comparison trials were carried out, automatic control and manual air adjustment. According to the results, the automatic mode outperformed manual operation in terms of thermal efficiency by 5.42 %. Nonetheless, it was found that the automatic mode reduced CO and $PM_{2.5}$ emissions by 22 % and 5.09 %, respectively. These results demonstrate how automated air control can increase thermal efficiency and help in reducing emissions.

Paper ID: 214

Community-level insight into indoor particulate matter from biomass and LPG fuels in Rural Manipur

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ABSTRACT

Indoor Air Pollution (IAP) is one of the greatest environmental and public health risks, accounting for millions of deaths worldwide, particularly among women and children. Many rural communities in the country continue to rely on biomass fuels due to limited access to clean fuels and their high cost. This study aimed to compare particulate matter (PM) concentrations during cooking and non-cooking periods in households using firewood and LPG across five Naga communities in Manipur, highlighting potential health risks to women and children. The study was conducted in the Senapati District of Manipur, India. The particulate matter (PM) concentrations were measured using a Grimm Aerosol Spectrometer (Model 1.109), with cooking sessions recorded during morning and evening, and non-cooking sessions to monitor background levels. A total of five households, comprising four that used firewood and one that used LPG, were selected via purposive sampling. Data analysis and visualization were performed using R (ggplot2, dplyr, tidyr,lubridate), SPSS, and Excel.

Findings revealed that firewood use was associated with significantly higher PM concentrations across all particle size fractions (PM_{10}=106.9μg/m³, $PM_{2.5}$=71.2μg/m³, and PM_{1}=64.3μg/m³) for firewood, and (PM_{10}=46.8μg/m³, $PM_{2.5}$=29.04μg/m³, and PM_{1}=24.9μg/m³) for LPG. Firewood-using households among the communities, namely Mao, Maram, Poumai, and Zeliangrong, exceeded WHO air level guidelines by 1.2 to 3.7 times for PM_{10} and 2.5 to 7.4 times for $PM_{2.5}$. In contrast, LPG households remained near or below the guideline values, ranging from 0.7 to 1.5 times for PM_{10} and 1.1 to 3.3 times for $PM_{2.5}$. Real-time 24-hour monitoring revealed a sharp PM_{10} (2442.9ug/m3) increase during cooking in firewood homes, with elevated levels persisting during the non-cooking period likely attributed to mud floor and walls, which can retain and re-suspend particulate matter, as well as other activities like sweeping beyond cooking, contributed to elevated PM concentrations. Communities like Maram and Poumai exhibited especially high concentrations, indicating that housing characteristics, ventilation, and cooking practices may amplify exposures, while LPG use produced more consistent, lower PM levels. This study provides novel community-level evidence showing how fuel type, housing characteristics, and cooking practices jointly contribute to household air quality. It provides clear evidence that LPG not only offers reduced emissions during cooking but also ensures consistent protection across communities, while biomass amplifies health risks. This emphasizes the need for interventions that address both fuel transition and structural housing conditions to effectively mitigate IAP in marginalized rural settings.

Keywords: Indoor Air Pollution (IAP); Particulate Matter; Cooking and Non-Cooking; Biomass Fuel; Rural Communities

Paper ID: 216

Comparative Assessment of Black Carbon Variability within a Semi-Urban Campus and Adjacent Highway Corridor

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ABSTRACT

Black Carbon (BC), a light-absorbing carbonaceous aerosol produced from incomplete fuel combustion, strongly influences both air-quality degradation and near-term climate forcing. Although institutional campuses are often perceived as low-pollution zones, vehicular activities and localized emissions can still produce measurable BC accumulation. This study investigates the spatiotemporal variability of BC within the institutional campus and contrasts it with an adjacent highway environment to evaluate the effects of traffic intensity under controlled and open-road conditions. Real-time BC concentrations were recorded using a portable dual-spot Aethalometer (MA350, AethLabs) at a 1-minute resolution with a 2.5 µm cyclone inlet. Meteorological parameters- temperature, relative humidity, wind speed, and wind direction—were simultaneously monitored using a Kestrel 5500. On-site traffic volume and heavy-duty vehicle (HDV) counts were manually documented to capture emission intensity across traffic, commercial, and non-traffic microenvironments inside the campus.The traffic zone exhibited distinct bimodal peaks during morning and evening commuting hours (2.7–4.0 µg m^{-3}), while the commercial area showed episodic enhancements from cooking, two-wheeler movement, and pedestrian clustering, occasionally exceeding 5 µg m^{-3}. The background site maintained lower and steadier concentrations (0.6–1.2 µg m^{-3}) governed by boundary-layer evolution and precipitation scavenging. In contrast, the adjacent highway site recorded markedly higher BC levels, averaging around 15 µg m^{-3}.Overall, the findings highlight the sharp emission gradient between institutional and highway environments and underline the significant influence of localized anthropogenic activity and meteorology on BC concentration in semi-urban regions.

Keywords: Black Carbon; Traffic Emissions; Semi-Urban Campus; Meteorological Influence; Highway Comparison

Paper ID: 218

Air Pollution and Chronic Obstructive Pulmonary Disease (COPD): A Health Data-Based Study Focused on the Indian Subcontinent

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ABSTRACT

The outbreak of COVID-19 pandemic highlighted the critical impact of airborne diseases and underscored the devastating effects of air pollution on public health. Modernization, while bringing progress, has also intensified environmental costs, especially through deteriorating air quality. In 2019, air pollution was linked to approximately nine million premature deaths worldwide, with 62% of these deaths attributed to cardiovascular diseases. In 2016, the global annual average concentration of fine particulate matter ($PM_{2.5}$, particles smaller than 2.5 µm in diameter) was 34 µg/m³. Southeast Asia recorded substantially higher levels, averaging 54.3 µg/m³-more than 11 times above the World Health Organization (WHO) guideline. India faced even more severe pollution, with annual $PM_{2.5}$ averaging nearly 91 µg/m³ during 2016-2017, and Delhi consistently ranking as the world's most polluted capital from 2018 to 2022 with levels around 100 µg/m³.

Emerging evidence indicates a feedback loop where climate change exacerbates air pollution and vice versa. Rising temperatures and altered weather patterns increase the frequency and intensity of air pollution episodes, such as wildfires and dust storms, a dynamic termed the "climate penalty." Heat waves, characterized by extreme temperature and humidity, further amplify health risks on a population scale.

As a largely subtropical region, India is particularly vulnerable to these challenges. Persistent poor air quality correlates with a rise in cardiovascular conditions like atherosclerosis, myocardial infarction, and stroke. Respiratory health data reveal an alarming uptick in cases of asthma and allergic rhinitis among children under six - often without prior family history — and an increasing prevalence of Chronic Obstructive Pulmonary Disease (COPD) among individuals. These trends underscore air pollution's role as a silent killer, significantly impacting respiratory and cardiovascular health in the Indian subcontinent.

Keywords: Air pollution; Chronic Obstructive Pulmonary Disease (COPD); $PM_{2.5}$; Cardiovascular and respiratory health; Indian Subcontinent

Paper ID: 220

Vehicular emission trends and EV forecast for controlling air pollution: a case study in Bhubaneswar

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ABSTRACT

Rapid urbanization and motorization have made India's transportation sector the fastest-growing contributor to air pollution and greenhouse gas (GHG) emissions, intensifying environmental and public health challenges. This study presents a comprehensive assessment of vehicular emission trends in India, with a focus on Bhubaneswar, the capital of Odisha. A structured questionnaire survey was conducted to analyze vehicle age distribution and emission-standard compliance, revealing a predominance of Bharat Stage (BS) III, BS IV, and BS VI categories. Emission parameters—Average Fuel Consumed (AFC), Fuel Consumption (RF), and Total Pollutant Emission (RE)—were estimated for two-wheelers (2Ws), three-wheelers (3Ws), four-wheelers (4Ws), and heavy vehicles (HVs) following Intergovernmental Panel on Climate Change (IPCC) guidelines. The analysis incorporated traffic volume, on-road mileage, emission standards, and per capita pollutant levels to depict the current emission scenario. Results indicate that although successive BS norms have reduced permissible emission limits, real-world emissions are significantly influenced by factors such as vehicle type, occupancy, and fuel efficiency. Four-wheelers exhibited the highest per capita emissions—approximately 3.72 kg CO and 0.64 kg HC+NO_x—attributed to low occupancy, greater road space consumption, and moderate mileage (17–18 km/l). Two-wheelers, despite lower per-vehicle emissions, contribute substantially due to their high proportion (>60%) in total traffic. Conversely, heavy vehicles like city buses, with high occupancy rates, showed the lowest per capita emissions (~1.33 kg CO). However, since only about 5% of commuters use public buses, a major opportunity exists to reduce emissions through modal shift and electric vehicle (EV) adoption. Overall, the study underscores the intricate interplay of technology, behaviour, and regulation in shaping urban air quality and highlights the urgent need for policies promoting EVs and public transport to achieve sustainable mobility in India.

Keywords: Vehicular Emissions; Bharat Stage Norms; Fuel Consumption; Electric Vehicles (EVs); Sustainable Urban Transport

Paper ID: 234

Temporal variation of black carbon and source identification using CBPF and polar plots in the ambient air of Tezpur region of Assam.

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ABSTRACT

Black carbon (BC) is a short-lived atmospheric aerosol having light absorbing properties produced from incomplete combustion of fossil fuels and biomass. It influences climate directly by absorbing solar radiation, while also impacting human health. This study presents diel, weekly, monthly, and seasonal BC variation in Tezpur (2014). It investigates potential local source regions and assess the influence of meteorology on BC variability.

Continuous BC measurements were carried out at the MAPAN-AQM station at Tezpur University (26.7°N, 92.83°E) having a seven channel Aethalometer (Model AE-31, Magee scientific USA) with a flow rate of 4.0 litres per minute (LPM). Data analysis and visualisation were performed in R using ggplot2, openair and other packages.

The BC concentration exhibited statistically significant temporal variation ($p < 0.0001$), with mean seasonal values of 8.0 ± 3.5 µg m^{-3} in winter, 6.1 ± 3.4 µg m^{-3} in pre-monsoon, 5.9 ± 3.9 µg m^{-3} in post-monsoon, and a minimum of 3.9 ± 3.3 µg m^{-3} during the monsoon due to enhanced wet scavenging. Monthly means ranged from 3.6 µg m^{-3} (August) to 8.1 µg m^{-3} (January), demonstrating strong seasonality governed by boundary layer dynamics and emission intensity. The diurnal pattern revealed two pronounced peaks in the morning (07:00-09:00 h) and evening (18:00-21:00 h) associated with rush-hour traffic and shallow planetary boundary layer (PBL) heights, while midday minima corresponded to convective mixing. Weekly averages showed that BC levels peaked on Wednesday (5.95 ± 3.3 µg m^{-3}), and reached their minimum on Saturday (5.2 ± 3.5 µg m^{-3}), reflecting reduced traffic-related emissions and activity. Three complementary polar analyses: mean, weighted mean, and Conditional Bivariate Probability Function (CBPF) were employed to elucidate BC source sectors and meteorological modulation. Across all methods, the east-southeast (E-SE) wind sector emerged as the dominant contributor to high BC concentrations, implicating nearby urban and biomass burning sources. CBPF probabilities (0.6-0.8) indicated frequent high-BC episodes under calm E-SE winds during winter and post-monsoon, while low probabilities (<0.2) during the monsoon underscored the effectiveness of rainfall in atmospheric cleansing.

The findings revealed that black carbon (BC) variability over Tezpur is driven by local combustion sources, wet scavenging, traffic emissions, biomass burning, and prevailing meteorological conditions as key drivers. Seasonal and directional patterns underscore the combined influence of emission activities and atmospheric processes, emphasizing the need for targeted, sector-specific emission control strategies and the implementation of clean fuels to effectively mitigate BC pollution.

Keywords: Black Carbon; Ambient air pollution; Traffic; Biomass burning; CBPF

Paper ID: 239

Air quality analysis using fixed box model: a case study of Nagpur city in India

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ABSTRACT

This case study demonstrates the use of a fixed box model for the prediction of air pollutant concentration, mainly PM 2.5 for the year 2024 in Nagpur city. The basis of the fixed box model involves mass balance and assuming uniform pollutants concentration inside the box. For the model training and calculation, the meteorological data is obtained from the 4 different monitoring stations in Nagpur City in 2024. GPO Civil Lines, Ambazari, Ram Nagar, and Mahal are Continuous Ambient Air Quality Monitoring Stations (CAAQMS). For the model training, the area of the box is estimated using 40×40 km² of Airshed with source apportionment studies to further evaluate the annual source emission rate for the year 2024. The meteorological data is used to develop the wind rose diagrams to observe the direction of wind with respect to wind speed for the monitoring station points. Where Ambazari monitoring station is considered as the concentration entering the box at 43.021 µg/m3.

The fixed box model predicts the annual background concentration of 157.90 µg/m3. From the study, it is evident that the rate of pollutant concentration is increasing over time than India's annual National Ambient Air Quality Standards (NAAQS) of 60 µg/m3. There is a need to plan and implement best practices that can reduce air pollution in the city. Local administrations can benefit from this study to redefine standard limits for the PM 2.5 concentration.

Instead of a multi-source simulation model, a fixed box model can be utilized to find out the PM 2.5 concentration of the city due to its simple calibration and cost-effectiveness. Moreover, the study supports data-driven insights for local mitigation strategies. The cost-effectiveness of fixed box model makes it replicable for every emerging city of India.

Keywords: Air quality modelling; Fixed box model; PM 2.5 concentration; Wind rose diagram; Source emission rate; Air pollution control; Predictive modelling.

Paper ID: 261

Assessment of pollutant emissions resulting from crop residue burning activities

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ABSTRACT

Biomass burning is a significant source of atmospheric pollutants, contributing to regional air quality degradation and climate change. Among various biomass burning activities, crop residue burning is particularly prevalent in agricultural regions and is known to release substantial amounts of harmful pollutants into the atmosphere. The emission of pollutants such as particulate matter ($PM_{2.5}$, PM_{10}), carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) from crop residue burning poses serious environmental and health challenges. This study presents a comprehensive estimation of pollutant emissions from crop residue burning in the period 2020 to 2024, employing both top-down and bottom-up approaches. The top-down approach utilizes satellite-derived fire count and fire radiative power data to quantify emissions on a large scale, while the bottom-up approach integrates region-specific agricultural statistics and updated emission factors derived from recent field and laboratory measurements. These updated emission factors enable a more accurate and regionally relevant evaluation of pollutant loads. By combining these methodologies, the study achieves a robust and detailed assessment of emissions, providing valuable insights for policymakers and environmental management aimed at mitigating air pollution from crop residue burning.

Keywords: Biomass burning; Crop residue burning; Pollutant emissions; Top-down approach; Bottom-up approach

Paper ID: 274

Impact of vegetation and urban density on air pollutant concentrations in an industrial city: a case study

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ABSTRACT

Escalating urban expansion and population growth have increased air pollution in developing countries, posing a significant threat to environment and health. Urban greenery plays a balance act between economic development and ecological sustainability by mitigation of air pollution through pollutant absorption, regulation of microclimate and improvement in atmospheric conditions. An initiative has been taken to assess the impact of vegetation on urban development in an industrial city in eastern India and to identify the mitigation steps. This study assesses the relationship between green cover and air pollutant concentrations in the urban area of Rourkela. In this study, air quality data from three CAAQMS (Continuous Ambient Air Quality Monitoring Stations), namely Raghunathpalli, Fertilizer township and Sector-2 of Rourkela and four manual stations, namely, Sector-5, Kalunga, IDL outpost and Kuanrmunda were analysed. Study period chosen was during November 2022 to August 2025 for CAAQMS stations and January 2019 to July 2025 for manual stations. The air pollutants include PM2.5, PM10, NOx, SO2, O3, and CO, along with meteorological parameters, such as wind speed, wind direction, temperature, and solar radiation. During the study period, dominant air pollutants were observed in Raghunathpalli for the CAAQMS station, while Kalunga for the manual station. Preprocessing of the data is performed using the IQR (Interquartile Range) method, followed by imputation of missing values using a hybrid ARIMA with Kalman filter. Characterisation of vegetation and built-up density is done with monthly NDVI (Normalised Difference Vegetation Index) and NDBI (Normalised Difference Built-up Index) values derived from Sentinel-2A imagery. Indeed, negative relationship with NDVI and positive relationship with NDBI further confirm that urbanisation leads to increased pollution, whereas vegetation helps to mitigate it.

Keywords: ARIMA–Kalman imputation; Air quality; IQR method; Nature-based solution; Urbanisation

Track – 4

Solid Waste Management & Resource Utilization

Paper ID: 003

Hydrothermal carbonization of fruit waste for hydrochar production

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ABSTRACT

The scarcity of fossil fuels and environmental concerns are increasing the importance of biomass-derived energy. This study employed hydrothermal carbonization (HTC) to enhance the energy density of banana peel and orange peel waste biomaterials at temperatures varying from 150°C to 200°C, and reaction times of 2h to 24 h. The produced hydrochars were examined, and their fuel characteristics were investigated. Proximate study [volatile matter (VM), fixed carbon (FC), and ash] indicated that pre-treated biomass exhibited a reduced VM/ (VM+FC) ratio and increased amount of FC compared to raw biomass, hence enhancing fuel quality. The energy density of hydrochar improved with increased hydrothermal-reaction temperatures, exhibiting higher heating values compared to lignite. The development of biomass under hydrothermal carbonization, as assessed by TG-DT analysis, indicated that most of the hemicellulose and cellulose degraded at temperatures lower than 450°C, but lignin degradation occurred only at elevated temperatures. The hydrochar exhibited elevated ignition temperatures and higher combustion temperature ranges relative to raw biomaterials. An optimal temperature of 200°C was identified for the hydrothermal carbonization of waste biomaterials to generate hydrochar for heat generation. The hydrochars were found suitable for direct combustion or co-combustion with low-rank coals for energy generation. The present investigation revealed that hydrothermal carbonization reduced inconsistency in the fuel quality of biomass feedstock. It additionally presents a potential conversion procedure that might be utilized in coal-fired furnaces without alteration. Hydrochar with considerable energy density is generated.

Keywords: Fruit waste; Hydrochar; Solid fuel; Energy density; Alternate

Paper ID: 008

Sustainable management and environmental surveillance of uranium mill tailings in India: case study from Jaduguda

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ABSTRACT

In India, uranium resources are predominantly of low grade compared to many international deposits, with ore grades in the Singhbhum Shear Zone of Jharkhand often below 0.08% U_3O_8. The mining and processing of such ore result in the generation of large volumes of mill tailings relative to the uranium recovered. These mill tailings are the fine-grained residues left after ore processing, containing residual radionuclides (U(nat.), Ra-226, Th-230, Pb-210 and Po-210) along with potentially toxic heavy metals (Cd, Co, Cu, Mn, Ni, Pb, Fe, Zn etc.), posing long-term environmental risks through potential migration into soil, groundwater, and surface water systems. Safe management of uranium mill tailings requires the combined use of engineered impoundments, effective effluent treatment, remediation measures and long-term monitoring to minimize contaminant releases. Such practices are broadly consistent with international recommendations of the International Atomic Energy Agency (IAEA). Continuous environmental surveillance of critical matrices including air, water, soil, and biota is essential to ensure the long-term radiological and chemical safety of surrounding ecosystems and human populations.

At Jaduguda, the country's first and oldest uranium mine, mill tailings are neutralized with lime and stored in engineered valley-type impoundments, where natural hills on three sides and an engineered bund on the fourth ensure both structural stability and hydraulic containment. Decantation wells and a dedicated effluent treatment plant (ETP) ensure that discharged water meets national regulatory standards before release into local streams. To further minimize the environmental impacts, Inactive pond surfaces are revegetated and peripheral slopes stabilized to minimize erosion and dust resuspension, while staged pond design supports long-term containment and operational flexibility. Complementing these physical and chemical controls is a comprehensive environmental surveillance program covering critical matrices. Monitoring wells around the ponds, coupled with river and sediment sampling, provide early warning of contaminant migration, while bio-monitoring of fish and vegetation assesses ecological uptake. Thus, Sustainable tailings management at Jaduguda is achieved through an integrated approach combining engineered barriers (containment), effluent treatment, progressive remediation, and comprehensive surveillance. This integrated strategy keeps radiological and chemical risks within permissible limits, while aligning tailings management at Jaduguda with international best practices and the core principles of sustainability, regulatory compliance, and environmental protection.

Keywords: Uranium; Mill tailings; Jaduguda; Tailings management; Environmental surveillance

Paper ID: 029

Parametric optimization of biofuel yield from waste plastics and different biomass co-pyrolysis using response surface methodology

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ABSTRACT

Co-pyrolysis of waste plastic and biomass provides a sustainable approach to biofuel production while addressing waste management challenges. This work is dedicated to the co-pyrolysis of medical waste plastic (Polypropylene) and waste biomass (Kaneer seed and Karanja seed) collected from locality. Mixtures of feed stocks were co-pyrolyzed in a batch reactor at plastic/biomass feed ratios of 30:70, 50:50, and 70:30, and temperature ranging from 400 ºC to 550 ºC with an interval of 50 ºC , respectively. The Fourier transformed infrared spectroscopy (FTIR) and Gas Chromatography Mass Spectrometry (GCMS) tests were conducted for sample fuels to identify functional groups and compound composition, respectively, confirming suitability with diesel as alternative fuels. The effects of temperature, catalyst (CaO) loading and different feedstock proportion on bio-fuel yield were systematically investigated. Subsequently, Response Surface Methodology (RSM) approach was used to optimize the most suitable parametric conditions for maximum biofuel yield. This RSM-based optimization of co-pyrolysis study demonstrated that the plastic to feed ratio of 70:30, temperature 500 ºC and catalyst to feed ratio of 1:7.5 showed the highest yield of 72% as compared to other set combinations. This study highlights the synergistic effect of plastic–biomass blends and establishes RSM as a robust framework for enhancing yield, sustainable biofuel production, and contributing to sustainable energy solutions.

Keywords: Co-pyrolysis; Medical waste plastic; GCMS; FTIR; RSM

Paper ID: 030

Resource utilization of red mud, fly ash, and phosphogypsum in geopolymer mortar for sustainable construction

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ABSTRACT

The hunt for sustainable alternatives has accelerated due to the rising demand for building materials and the environmental issues surrounding the manufacture of Portland cement. The production of cement alone accounts for around 7% of CO_2 emissions worldwide, highlighting the need for environmentally beneficial alternatives. Because of its longevity, reduced carbon footprint, and capacity to absorb industrial by-products, geopolymer mortar a cement-free binder created by reacting aluminosilicate minerals with appropriate activators has become a viable option. Red mud, fly ash, and phosphogypsum are the three main industrial wastes that are used in this study to investigate the synthesis of geopolymer mortar. Alumina refineries produce red mud, a highly alkaline byproduct that presents serious disposal and environmental risks. Phosphogypsum, a byproduct of the fertilizer industry, has the potential to balance the alkalinity of red mud, whereas fly ash, which is produced in enormous quantities by thermal power plants, is rich in reactive silica and alumina. When combined, these resources offer a viable route to value-added use. Characterization of the raw materials, creation of geopolymer mixtures with different ratios of fly ash, phosphogypsum, and red mud, and assessment of the mixtures' possible appropriateness for building applications are all part of the research. Understanding how red mud stabilizes and neutralizes through its synergistic effect with fly ash and phosphogypsum is the main focus. This project lessens the environmental impact of the building industry while adhering to the principles of the circular economy by converting hazardous and bulk wastes into valuable construction goods.

Keywords: Geopolymer mortar; Red mud; Fly ash; Phosphogypsum; Sustainable construction

Paper ID: 033

Unveiling humification dynamics in rotary drum composting: transforming waste to black gold

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ABSTRACT

Aerobic composting is a common biochemical process that stabilizes organic waste and makes it harmless. During this process, organic matter breaks down and forms humic substances (HSs). HSs are an important component and a vital indicator of compost maturity, which can be used as a soil amendment. The formation of HSs is influenced by raw material properties, the activity of compost bacteria, temperature, pH, the C/N ratio, moisture content, oxygen levels, and particle size—all of which interact with one another. As a result, the formation of HSs is a complex process. Additionally, it is difficult to identify the specific structures of humic acids (HAs) and fulvic acids (FAs), the two main parts of HSs. A rotary drum composter was used for bioconversion of organic waste, involving the transformation of organic matter and humification. There was a significant 30.23% increase in humic compounds in the compost after 20 days compared to the initial mix. The Rotary Drum composting reactor's temperature reached 59.8°C, demonstrating a typical sterilizing capacity. The dissolved organic carbon in the compost sample decreased by 19.10% on the 20th day compared to the 1st day. The results showed that total Kjeldahl nitrogen rose by 40.38%, while moisture content decreased by 19.12%. Additionally, micronutrients increased by 40-53%, and organic matter decreased by 28.13%. Overall, HSs can serve as a soil amendment, fertilizer, and plant growth regulator. These functions improve the reuse potential of organic waste composts; however, this requires scientifically controlling various composting parameters and properly applying the final products.

Keywords: Humification; Rotary Drum Composting, Organic Waste; Dissolved Organic Carbon; Organic Matter

Paper ID: 040

Artificial Intelligence for End-to-End Solid Waste Management: Methods, Advances, Challenges and Future Directions

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ABSTRACT

The global increase in waste production is attributed to rapid urban development, population growth, and economic expansion. The management of solid waste (SW) is a vital concern for local governments, as it secures human health, protects the environment and conserves natural resources. Artificial Intelligence (AI) systems are predominantly considered an alternative technology that provides a possible way to address complex and ill-defined problems. AI addresses the complexities of solid waste management, such as nonlinear processes, variable data quality, and environmental uncertainty. The literature review was put together 80 research articles published in between 2003-2025 analyzing the implementation of AI across various waste management domains, including waste-to-energy conversion, intelligent waste receptacles, automated waste sorting, waste generation modelling, waste monitoring systems, plastic pyrolysis, differentiation between fossil and modern materials, logistics optimization, disposal methods, illegal dumping detection, resource recovery, smart city initiatives, process enhancement, cost reduction, and public health improvements. The review also discusses how AI can lower costs and increase efficiency in solid waste management, particularly for smart cities. The review presents a comprehensive study on various AI techniques, including Artificial Neural Network (ANN) based modeling, fuzzy logic, decision trees, and regression models, which have been applied to different aspects of solid waste. The models made by AI have the potential to perform perfect predictions on waste generation and establish accurate forecasting models. ANN can be applied to forecast the performance of various management processes, and the system's performance is robust, making it suitable for a diverse range of waste management systems. ANN-based models are considered very promising and take part in practical roles that develop a better cost-effective strategy for solid waste management in the near future. It can be inferred from the study that the outline and performance of a productive SW management system requires accurate estimation of future waste generation quantities.

Keywords: Solid waste (SW); Artificial Intelligence (AI); Artificial Neural Network (ANN); management; cost-effective strategy.

Paper ID: 050

Nutrient-enriched rice straw biochar nanocomposites for smart waste valorization and sustainable rehabilitation of coal mine overburden soils

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ABSTRACT

India's heavy reliance on coal for electricity production has a high environmental cost. Open-cast mining creates massive overburden dumps that lack nutrients and microbes, making land reclamation difficult. At the same time, the widespread burning of agricultural waste, especially rice straw, significantly contributes to air pollution. These two practices present major challenges for environmental sustainability.

The present study attempts to address these twin environmental concerns by synthesizing a biochar-based nanocomposite (BNC) derived from rice straw through slow pyrolysis and enriched with nitrogen, phosphorus and potassium (NPK) to enhance its fertilizer value. A controlled pot experiment was designed to evaluate the effectiveness of this amendment on mustard (*Brassica nigra*) cultivation in two contrasting substrates—coal overburden dump soil (OD) and garden soil (GS). Treatments included BNC applications at 1%, 1.5%, and 3% (w/w), alongside untreated controls. After a 50-day growth period, soil chemical characteristics, available nutrient levels, biological activity and plant growth parameters were systematically assessed.

The results showed that NPK-enriched biochar significantly enhanced nutrient availability, microbial activity, and plant biomass in both soils. The 1.5% (w/w) treatment yielded the greatest improvement, increasing available N, P, and K by approximately 35%, 30%, and 30% in OD, and 20%, 12%, and 36% in GS, compared to controls. Dehydrogenase activity rose by 5%, while plant height increased 13–14% in OD and 13–20% in GS. Biomass grew 20–30% in GS and 12–14% in OD, demonstrating the amendment's strong potential for restoring nutrient-deficient overburden soils.

This research underscores the dual benefits of utilizing rice straw biochar not only as a sustainable fertilizer alternative but also as an effective tool in rehabilitating mining-affected lands. The findings position biochar-based nanocomposites as an eco-friendly, cost-effective, and scalable solution for integrated agricultural waste management, soil fertility restoration, and sustainable mining.

Keywords: Biochar, Soil Fertility, agricultural waste, sustainable mining, Mine Overburden Dump, Rehabilitation.

Paper ID: 072

Pretreatment and real-time process control strategies for pyrolysis of organic fractions of municipal solid waste: Trends and applications

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ABSTRACT

Thermo-chemical conversion of organic fractions of municipal solid wastes (OFMSW) using pyrolysis is a rapidly growing technology for advancing urban resource recovery and circular economy goals. Excessive moisture content, feedstock heterogeneity, and contamination due to inert, compounded by insufficient source separation, remain the most practical challenges in the commercialization of pyrolysis technology. Addressing these challenges highlights the importance of developing novel, targeted pre-treatment methods and robust real-time monitoring to overcome the limitations associated with scaling on-site decentralized systems. Some of the key pre-treatment technologies that facilitate efficient thermal breakdown and produce superior yields are solar drying, bio-drying, torrefaction, co-blending approaches, and preprocessing via black soldier fly larvae. To reduce susceptibility to human errors, real-time monitoring and Internet of Things (IoT)-integrated smart controls can be employed, which include devices for sensing feedstock rate, assessing moisture content, temperature, and analyzing real-time gas composition at the reactor outlet, as well as sending timely alerts during critical situations. Beyond pretreatment and in-line sensing, the suitability of pyrolysis products for different end uses depends on their quality, necessitating application-oriented performance evaluation. This review highlights emerging pretreatment methods for feedstock standardization alongside an overview of real-time sensing platforms and IoT-integrated controls, ensuring the stability and reliability of the process. Emerging reactor technologies for efficient valorization, such as solar pyrolysis, hydro-pyrolysis, plasma pyrolysis, and induction-assisted pyrolysis, have also been discussed along with studies on the field performance of pyrolysis products to contribute to global sustainability goals and enhance circularity.

Keywords: Pyrolysis; Pre-treatment strategies; Internet of Things; Emerging technologies; Byproduct utilization

Paper ID: 081

Enhancing the environmental sustainability of legacy RDF through agro-waste blending: a case study with corn residues

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ABSTRACT

West Bengal's Refuse-Derived Fuel (RDF) utilization is limited by infrastructural and regulatory gaps, leading to higher logistic costs and underutilization of regional potential, while ~29.55 million tonnes of annual agricultural residue burning exacerbates pollution. This study investigates the potential of blending corn waste, with landfill derived legacy RDF to reduce greenhouse gas (GHG) emissions and enhance the environmental sustainability by waste-to-energy production. The research analysed physicochemical characteristics of the legacy waste combustible fraction at Howrah landfill. Combustible fractions of legacy waste and corn residues were characterized through proximate and ultimate analysing methods. Proximate analyses include determination of ash content, volatile solids and fixed carbon using muffle furnace, and moisture content using hot air oven. Ultimate analyses include measurement of C, H, N, O, and S using CHNS analyzer, total chlorine as per ASTM E776-23, and gross calorific value (GCV) using bomb calorimeter (ASTM E711-23). To maximize both environmental and energy benefits, an optimization analysis was conducted to identify the most effective blending ratio of RDF and corn stover. Legacy RDF showed high ash content (≈23%), high moisture (≈34%), and a GCV of 20 - 23 MJ/kg, while corn stover exhibited low ash (≈3%), high volatile matter (≈95%), and GCV of ≈11.5 MJ/kg. Blending corn stover with RDF enhanced fuel characteristics with 40:60 RDF-corn-stover ratio yielding GCVs of ≈ 15.6 MJ/kg, reducing ash content to ≈ 9.7% and lowering chlorine concentration to 0.12%. GHG emission analysis revealed a substantial reduction in CO_2-equivalent emissions with increasing corn stover content, ranging from 262.53 tonnes CO_2- eq/day (100% RDF) to 157.30 (60:40), 104.87 (40:60), 52.45 (20:80) for different blending proportions, and approaching zero for 100% corn stover. The findings highlight the dual advantages of this approach, enhancing environmental sustainability of RDF utilization while reducing the adverse impacts associated with open burning of agricultural residue.

Keywords: Legacy waste; Refuse-derived fuel; Agricultural waste; Co-processing; Waste-to-energy

Paper ID: 084

Anaerobic biodegradability of municipal solid waste of Delhi region: a batch test study

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ABSTRACT

Due to environmental concerns, the uncounted generation rate of municipal solid waste is now a global issue that contributes to environmental problems and socio-economic crises. Anaerobic digestion is a recognized technology that can be used for the treatment of a wide variety of organic matter and decomposable wastes and has been proven to be a sustainable technology for producing green energy. The present study has been undertaken to assess the biomethane production in anaerobic digestion of municipal solid waste (MSW) of Delhi and NCR. The batch test study was carried out using municipal solid waste with inoculum from the existing wastewater treatment plant at to food-to-mass ratio (F/M) of 0.75. Before the startup of the experimental study, the physicochemical characteristics of the MSW waste in terms of moisture content, pH, TOC, COD, nitrogen, and phosphorus were determined. The range of pH and TOC values of 4.7 to 7.1 and 37.80.91 to 45.78 ± 1.37 % were observed, respectively. However, the COD, nitrogen, and phosphorus of waste samples were found to be 30000 to 3500 mg/L, 0.78 to 0.98% and 3.0 to 3.3 mg/g, respectively. Also, the VSS and COD of the sludge sample were assessed and found to be 14.39 g/L and 12000 mg/L, respectively. Thereafter, the experimental setup to assess the anaerobic biodegradability was set up, and the methane generation was monitored daily for a time duration of around 30 days or till the gas generation ceases. Thereafter, the cumulative methane generation will be used in evaluating the methane generation rate and overall conversion efficiency of waste to biomethane. Further work is in progress, and the outcome of the study will be helpful in optimising and enhancing the energy efficiency as a dynamic passage to stimulate the sustainability of AD implementation. It will also help in the maximum exploitation of the renewable energy source and will improve environmental sustainability.

Keywords: Anaerobic Digestion; Food to microorganism ratio (F/M); sludge; Biomethane; waste management

Paper ID: 085

Microplastic-induced stress in plants: a biochemical examination of soil contamination

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ABSTRACT

Microplastics (MPs), characterized as synthetic polymer particles measuring less than 5 mm, are recognized as significant environmental contaminants. Microplastics can build in agricultural soils from multiple sources, such as pesticide residues, biosolid additives, wastewater irrigation, contaminated compost, plastic mulching materials, and atmospheric deposition. Upon deposition, these particles persistently engage with soil components, microbial populations, and plant root systems, ultimately impairing critical ecological and physiological processes. Plants, as the foundation of terrestrial food webs, are highly vulnerable to such disturbances. MPs can hinder plant growth by modifying root structure, limiting nutrient uptake, and reducing photosynthetic efficiency. Moreover, they disrupt cellular metabolic processes, influencing the synthesis and functionality of essential macromolecules, including proteins and lipids. This research investigates the effects of microplastic contamination on soil characteristics and plant biochemical responses through a regulated pot experiment, utilizing Cicer arietinum (chickpea) as the model organism. The treatments comprised one control group (0%) and four microplastic concentrations (1%, 5%, and 10% w/w) applied to the soil. Soil and plant samples were collected regularly to assess critical components. Soil pH and electrical conductivity (EC) were quantified to analyze physicochemical variations, while plant growth was assessed by measuring shoot and root lengths. Biochemical analyses were conducted to quantify the carbohydrate, protein, and lipid content in plant tissues. The results demonstrated that increased microplastic concentrations caused significant alterations in soil chemistry and negatively impacted plant growth and metabolic activity, showing a distinct dose-dependent relationship. The findings highlight the growing concerns over microplastic contamination in agricultural fields and its potential effects on crop yield and plant health.

Keywords: Microplastics, *Cicer arietinum*, Soil pollution

Paper ID:093

Shear strength parameters of bentonite-amended fly ash liners: considerations for landfill side slopes

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ABSTRACT

The occurrence of slippage at interfaces between lining components is a crucial factor to consider for landfill design and stability, as slope failures due to such slippage are not uncommon. Recent attention towards the beneficial reuse of fly ash has prompted investigations into its potential application in landfill liner systems. However, the hydraulic conductivity limitations of fly ash necessitate the addition of a low-permeable material to effectively function as a liner. This study investigates the addition of bentonite to fly ash in pursuit of this goal. Various fractions of bentonite were added to fly ash and tested to determine the optimal mix for the liner material. The tests performed include standard proctor compaction tests, UCS tests, and interface shear strength tests of the liner material with two types of geomembranes: HDPE textured (HDPET) and HDPE smooth (HDPES), using a large-scale direct shear device. The results showed an increasing pattern of UCS with an increase in bentonite content up to 20% bentonite, beyond which it started to decrease. The interface shear strength parameters with the HDPET interface exhibited a decrease in the interface friction angle (δ_0) and an increase in adhesion (ca) with an increase in bentonite content. Comparison of δ δ values obtained with HDPET and HDPES indicated lower values for HDPES compared to HDPET. Overall, the parameters obtained from the study can be useful in modeling the slope stability of landfills with bentonite-amended fly ash as liners. The study also highlights the importance of considering slippage at interfaces between lining components in landfill design and stability.

Keywords: Fly Ash, Landfill Liners, Interface Shear, Slope Stability.

Paper ID: 103

Utilization of black soldier fly larvae in a scale-up setup to segregate and valorize Indian unsegregated municipal solid waste

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ABSTRACT

Achieving segregation of Municipal Solid Waste at the household level has been a primary challenge for Indian Municipalities. This has been a persistent reason leading to inefficient MSW treatment and valorization, implementing existing available waste treatment alternatives (for e.g. composting, vermi-composting, incineration, etc.). The conventional waste treatment options necessitate segregation of waste at source to ensure a marketable value-added product at the end of the process, which ensures circular economy principles. Black soldier fly larvae (BSFL) is a saprophyte that feeds on a diverse range of organic waste and valorize it into its biomass. BSFL biomass has a myriad range of value-added products, such as protein feed, biodiesel, chitin, frass, among others.

In this study, BSFL was used as a tool to segregate the unsegregated MSW (UMSW) and valorize the organic fraction of the UMSW into its biomass. The UMSW was collected through a door-to-door collection campaign in an educational campus. The experiment was conducted using 2000 BSFL and the UMSW was incrementally added. The total UMSW added was 5kg. The final weight of BSF Pupae was 148±6.9 mg/larva. The waste to biomass conversion ratio and feed conversion ratio was 6.31±0.37% and 7.5 respectively. The total waste reduction and the volatile waste reduction was approximately 45% and 75.5% respectively. One of the potential benefits using BSFL for the treatment of UMSW was that the BSFL not only selectively consumed the organic part of the UMSW to accumulate them as their biomass but the mature BSFL also self-harvest themselves from the wet substrate in search of a dry place where they can pupate into a fly. Self-harvesting of BSF pre-pupa enables the remaining UMSW or the treatment residue, which primarily contains non-compostable components, to be either recycled to fulfil the circular economy regime, for e.g., depending on the calorific value of the treatment residue, it can be used in Waste-to-Energy plants as refuse-derived fuel (RDF). This study indicated that BSFL-based treatment technology could treat and manage the UMSW effectively at a scale-up level application, producing a sufficiently high proportion of BSFL biomass as a value-added product that can be used for commercial purposes, thereby effectively opening a new door for revenue generation while treating the UMSW. A further detailed study encompassing the cost-benefit analysis needs to be performed, including optimization of the process parameters, before the technology can be implemented for large-scale application at the community and municipality level.

Keywords: Sustainable Waste Management; Unsegregated Municipal Solid Waste; Waste Segregation; Black Soldier Fly Larvae; Waste Valorization

Paper ID: 111

Enhancement of interfacial transition zone using sustainable alternatives

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ABSTRACT

Recycled concrete aggregate (RCA) is in the spotlight as a sustainable alternative to natural aggregate. Yet, its use in structural applications is restricted by the presence of adhered mortar and the formation of a two-interfacial transition zone (ITZ). Higher porosity and lower ITZ strength than bulk paste led to reduced bond strength, diminished compressive capacity, and compromised durability. This study investigates the potential of three waste-derived powders: Waste foundry sand (WFS), Rice husk ash (RHA), and Cuttlebone powder (Samudra-Fen) as surface treatment materials for RCA to address these shortcomings.

WFS acts initially as a filler and later as a pozzolanic agent; RHA, with its high amorphous silica content, provides significant pozzolanic activity and pore refinement; while cuttlebone powder, composed mainly of calcium carbonate, contributes as a filler and nucleation site with relatively modest effects. Results drawn from experimental data in existing literature indicate that WFS and RHA treatments can increase bond strength by 15–25% and restore compressive strength close to that of natural aggregate concrete. At the same time, cuttlebone yields smaller but measurable gains. Microstructural evidence from FESEM images confirms ITZ densification in treated samples. These waste-based treatments are viable for enhancing RCA sustainability without compromising performance.

Keywords: Recycled aggregate concrete; Interfacial transition zone; Waste valorisation; Surface treatment; Waste foundry sand; Rice husk ash; Cuttlebone powder.

Paper ID: 118

Status and issues of municipal solid waste in India

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ABSTRACT

India, among the globe's most rapidly growing economies, is seeing speedy urbanisation and a marked spike in urban population, leading to a substantial explosion of municipal solid waste. A large share of this waste is still dumped in open areas and landfills, causing serious environmental and public health issues such as groundwater contamination from leachate and greenhouse gas emissions. Sustainable waste management requires an integrated approach focused on reduction, recycling, segregation at source, scientific treatment, and engineered landfills. To address this, India has introduced initiatives to strengthen waste collection, treatment, and disposal systems while encouraging innovative, low-cost technologies suitable for small and medium enterprises to enhance efficiency and sustainability. Building on the Swachh Bharat Abhiyan, the government has established the Waste-to-Wealth Authority to advance technologies for energy recovery, recycling, and resource extraction. A national technology database has also been created to help urban local bodies manage both current waste streams and legacy dumps. Urban areas are now prioritising decentralised waste processing, supported by the Ministry of New and Renewable Energy through policies and incentives promoting bioenergy and waste-to-energy projects. Moving forward, efforts must focus on overcoming technical challenges in existing waste-to-energy systems and raising public awareness about waste minimisation, proper segregation of wet and dry waste, and safe disposal practices, ensuring long-term sustainability in the environment.

Keywords: Urbanisation; Municipal Solid Waste; Waste reduction; Waste-to-Energy; Sustainability

Paper ID: 122

Enhanced CO_2 capture in LD slag via mechanical activation under ambient conditions and its kinetics

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ABSTRACT

Rapid industrialization and economic growth have intensified environmental issues, mainly solid waste discharge and greenhouse gas emissions, driving climate change. The global CO_2 emissions increased to 37.8 Gt, which pushed atmospheric concentrations to 425.5 ppm in 2024, nearly 50% above the pre-industrial baseline of 280 ppm and almost three times the level recorded in 2023. Global crude steel production has reached 1.95 billion tons. Each ton of steel production is associated with approximately 2 tons of CO_2 emissions and 600 kg of steel slag. As a result, the annual global generation of steel slag has surpassed 250 million tons.

LD slag is rich in calcium and magnesium oxides, along with other metal oxides such as SiO_2, Fe_2O_3, and Al_2O_3, making it a promising candidate for CO_2 capture. However, LD slag exhibits very low CO_2 capture capacity without any form of pretreatment. The current study aims to activate the LD slag and enhance its susceptibility for CO_2 using high energy planetary ball mill. Mechanical activation enlarges the suface area and induces phase change that enhances is susceptibity for CO_2 and adsorption rate.

The activation requires the use of grinding media of varying diameters (10, 8, and 6 mm). The rotation speed of the planetary ball mill is 1400 rpm, and the grinding duration is set to 12 hours. The CO_2 capture experiments are conducted on a custom-built fixed bed glass column. The CO_2 capture capacity shows a remarkable increase, from 4.48 mg/g to 149.80 mg/g. This study examines the effect of grinding media, adsorption time, and CO_2 gas flow rate on the adsorption of CO_2. It is further characterized using various analytical techniques such as XRD, FT-IR, FE-SEM to know the carbonated product. The experimental data is further fitted to multiple kinetic models, such as pseudo-first order, pseudo-second order, and Avrami's first order, to understand the kind of interaction and mechanism.

Keywords: Mechanical activation, LD slag, High-energy planetary ball mill, CO_2 capture, Adsorption and Desorption kinetics

Paper ID: 126

Plastic waste management for sustainability: composition, recycling, pathways, decision-making frameworks, and future perspectives: A review

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ABSTRACT

The durability of plastic waste, its lack of biodegradability and harmful impact on the environment and human well-being are critical environmental problems of the 21st century. This problem is globally widespread, with developing and underdeveloped countries facing the major brunt. Sustainable waste management, especially that of plastic, requires an array of integrated approaches comprising reuse and recycling. This paper comprehensively reviews plastic waste—its composition, categorisation, and management. Conventional approaches to handling plastic waste are being slowly replaced with multi-criteria decision analysis and AI-based segregation methods. Circular economy strategies for plastic waste management have been adopted in many countries, with a focus on maximum resource recovery. Recycling, a conventional approach, is also popular globally, though its success is based on factors such as the amount of waste generated and the scale of recycling. Incineration and landfill handle a significant amount of waste but have negative environmental impacts and contribute minimally to circularity. Plastic waste management has never been as crucial as at present. Effectively addressing the plastic waste problem is key to achieving the SDG goals, and all stakeholders must work collectively toward this.

Keywords: Plastic; Waste management; Circular economy; Recycling; Sustainable development goals

Paper ID: 130

Durability performance of self-compacting geopolymer concrete incorporating e-waste aggregates

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ABSTRACT

Rapid urbanization and industrial growth have accelerated the generation of solid wastes, creating challenges of land overburden, ecological degradation, and disposal concerns. Among these, electronic waste (e-waste) has emerged as a critical issue due to its massive accumulation and the complexities associated with its safe management. Parallelly, the construction industry, which is a major consumer of natural resources, is exploring sustainable alternatives to conventional materials. Self-compacting geopolymer concrete (SCGC) has gained significant attention as an eco-friendly construction material due to its use of industrial by-products as binders in place of cement, enhanced workability through self-compaction, and improved mechanical and durability performance. However, the continuous consumption of natural aggregates in SCGC still exerts pressure on depleting natural resources, thereby necessitating innovative resource conservation strategies.

In this study, e-waste was investigated as a sustainable partial substitute for natural fine and coarse aggregates in SCGC production. The e-waste materials were processed into e-waste fine (EWF) and e-waste coarse (EWC) aggregates. SCGC mixes were designed by incorporating EWF and EWC as partial replacements for natural aggregates at varying levels of 10% to 50%, with increments of 10%. Durability assessment becomes a decisive factor in evaluating the long-term service life of concrete, which largely depends on its resistance to environmental and mechanical actions. Accordingly, durability tests such as surface abrasion, water sorption, and carbonation resistance were conducted.

The results indicate that a replacement level of 30% EWF and 10% EWC provides the most favourable balance between durability and sustainability. At these proportions, the SCGC exhibited enhanced resistance to surface wear, reduced water ingress, and better carbonation performance compared to other mix variations. This demonstrates that e-waste incorporation not only conserves natural aggregates but also contributes to effective waste management by valorizing an otherwise hazardous by-product. The study highlights that e-waste utilization in SCGC can serve as a sustainable pathway for addressing dual challenges: reducing the environmental burden of electronic waste while conserving natural resources for future generations. These findings contribute to advancing green construction practices by integrating circular economy principles into concrete production.

Keywords: E-waste aggregates; Self-compacting geopolymer concrete; Durability performance; Sustainable construction materials; Resource conservation

Paper ID: 131

Sustainable construction practice using PET-Fibre reinforced recycled aggregate concrete

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ABSTRACT

Plastics are inherently durable in addition to not being biodegradable, which makes recycling of waste plastic highly difficult, thus jeopardizing solid waste management. Therefore, recycling waste plastic is extremely important to maintain sustainability. The construction industry is a major contributor to global warming, primarily due to the use of ordinary Portland cement (OPC) as binder in conventional concrete. The production process of OPC consumes a lot of energy and produces considerable amount of CO_2 emissions, which substantially contribute to global warming. Recycling construction and demolition (C&D) waste, particularly recycled coarse aggregate (RCA) in concrete, is critical for promoting sustainability in the construction industry. It minimises the environmental impact of excessive natural coarse aggregate (NCA) exploitation, conserving natural resources. In the current manuscript, ground granulated blast furnace slag (GGBFS) and fly ash are the industrial wastes used as partial replacement of OPC as binders. Equi-proportionate RCA and NCA is used as coarse aggregate for every mix. The concrete is reinforced with Polyethylene terephthalate (PET) fibers obtained from waste plastic bottles. PET fiber reinforced, binary binder-based recycled aggregate concrete is subjected to various fresh, mechanical (non-destructive and destructive), and durability property testing (water transport characteristics, chemical resistance, physical durability, and corrosion resistance). Obtained results reveal that incorporation of PET fibers, helped in increasing the tensile strength of concrete. Binary mixes based on OPC and GGBFS had higher strength, while binary mixes with OPC and fly ash exhibited enhanced durability.

Keywords: Supplementary cementitious materials; Ground granulated blast furnace slag; Fly ash; Recycled coarse aggregate; PET fibre

Paper ID: 136

Life cycle assessment of bioplastics: A review

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ABSTRACT

The mass production and adverse environmental impact of petroleum-based plastics have stimulated the need for research on sustainable alternatives like bioplastics. However, an understanding of their environmental viability is necessary to evaluate beyond their origin. This paper presents a systematic Life-Cycle Assessment (LCA) of bioplastics to critically analyze the environmental performance from "cradle to grave." Life Cycle Assessment (LCA) is a standardized methodology used to quantify the environmental impacts of products, processes, or services from raw material extraction to end-of-life management. For bioplastics, it will not only include raw material or feedstock cultivation (cradle) to disposal (grave), but also greenhouse gas emissions, water consumption, energy consumption, land use, and eutrophication potential. Analysis indicates that the environmental impact of bioplastics is deeply variable depending upon their types, raw materials, method of production, and energy sources. For example, in the agricultural phase, substantial land is used, biodiversity is reduced, and the usage of fertilizer and pesticides causes water and air pollution. Moreover, the end-of-life stage presents a significant challenge, as bioplastics require proper industrial composting facilities for proper degradation, but if they are thrown into landfills, they may undergo anaerobic decomposition and release potent greenhouse gases like methane. A nuanced and complete LCA is indispensable for identifying potential environmental hazards and avoiding "burden shifting" from one impact category to another. The findings show that the sustainability of bioplastics is linked to the entire supply chain, from the responsible sourcing of biomass to the establishment of efficient end-of-life infrastructure. Lastly, this paper demonstrates that bioplastics are not only a universal solution but also a complex component of a circular economy that must be strategically managed so that we can utilize their full environmental potential.

Keywords: Bioplastics**;** Environmental impacts; Circular economy; Waste management; Life-Cycle Assessment (LCA)

Paper ID: 139

Effect of partially replaced ferrochrome slag fine aggregate on fresh characteristics of GGBFS-based self-compacting geopolymer concrete

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ABSTRACT

The construction industry has been driven by the effects of global warming to explore environmentally friendly building materials like geopolymer concrete (GPC). With the incorporation of industrial by-products, GPC provides an environmentally conscious substitute to Ordinary Portland cement (OPC)-based conventional concrete, significantly reducing carbon dioxide emissions and preventing ozone layer depletion. However, one of the major disadvantages of GPC is its high viscosity, which can be countered by making GPC self-compacting in nature by increasing the fines content, thus yielding self-compacting geopolymer concrete (SCGC), which flows under its own weight without requiring mechanical compaction. SCGC constitutes 55%-60% of the total aggregate volume as fine aggregates. To achieve sustainability in construction, the current research initiative involves the utilisation of ferrochrome slag (FCS) as a partial replacement of fine aggregate in producing self-compacting geopolymer concrete (SCGC). The control mix consists of ground granulated blast furnace slag (GGBFS) as the sole precursor and comprises 100% natural fine aggregate (NFA). Seven other mixes were formulated by progressively replacing NFA with FCS from 15% to 90% at an interval of 15%, and another mix was prepared with 100% FCS as fine aggregate. Four consistent mix coefficients, i.e., a 12 M sodium hydroxide (SH) concentration, a 2.5 ratio of sodium silicate (SS) to sodium hydroxide (SH), a 7% dosage of superplasticizer (SP), and an additional water (AW) of 24% are employed to prepare all eight SCGC mix designs. Filling ability (FLA) tests, such as slump flow, T50cm slump flow, and V-funnel tests, passing ability (PA) tests like L-box and J-ring tests, and segregation resistance (SR) test through V-funnel at T5minutes test, are employed to measure the workability of the produced fresh SCGC. The test results illustrate that the optimal FCS replacement as fine aggregates is 30%, yielding sustainable GGBFS-based SCGC.

Keywords: Ferrochrome slag; Self-compacting geopolymer concrete; GGBFS; Fresh characteristics; Passing ability

Paper ID: 141

Management of multi-layered plastic waste through pyrolysis: process optimization and characterization of the resulting char

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ABSTRACT

The use of multi-layered plastic (MLP) in flexible food packaging has surged significantly in recent decades. While MLP offers numerous advantages, its complex, multi-layered structure makes it very hard to recycle. Consequently, vast amounts of MLP waste are accumulating in landfills or escaping into the environment, highlighting the urgent need for an effective management strategy. This study explores pyrolysis as a potential solution to this challenge, which not only tackles the waste but also provides a multi-functional product to position itself in the circular economic aspect. To assess the feasibility of MLP for pyrolysis, proximate and ultimate analyses were conducted, with results evaluated using Tanner's diagram and calorific value calculations. Thermogravimetric Analysis (TGA) provided insights into the temperature requirements and degradation behaviour of MLP for pyrolysis. Next, the pyrolysis process is optimized for a higher yield of char using Response Surface Methodology (RSM) by taking influential factors such as temperature, residence time and heating rate as independent variables. Further, the resulting char was analysed using X-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Field Emission Scanning Electron Microscope (FESEM), CHNS analysis, and Surface area analysis to evaluate its characteristics and recommend potential applications. The XRD analysis indicated significant changes in the crystallinity in char, while FESEM revealed pore formation on the surface, and the presence of different functional groups assessed by FTIR, suggesting its suitability for adsorption applications as a substitute for activated carbon, and use in soil for amendment. Moreover, the high calorific value of the char, determined through CHNS analysis, indicates its potential use as a fuel source. Given the promising feasibility of MLP for pyrolysis and the positive initial characterization of the resulting char, pyrolysis emerges as a viable approach for managing MLP waste.

Keywords: MLP; Pyrolysis; Char; RSM; Adsorption

Paper ID: 148

Agro-Waste in Sustainable Concrete: A Systematic Review with Meta-Analysis

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ABSTRACT

Agricultural waste is generated in vast quantities. According to the Food and Agriculture Organization (FAO), about 2 billion tons of trash are generated annually. Dumping that waste in a dump site in a field can affect the surrounding air quality by releasing gases like methane and CO2 during decomposition. It may increase the health risk to the nearby society and the farmers around it, and contribute to greenhouse gas emissions. The dumping of agro-waste in a landfill can cause a leaching effect, which can affect the groundwater and become a shelter for harmful organisms, like rats, snakes, cockroaches, etc. Even burning it can also pollute the air and the surroundings around it. Every approach has more disadvantages than advantages when it comes to managing. Therefore, managing this waste in the field of civil engineering can be a revolutionary approach for managing waste and reducing the use of cement. Agro-waste like fruit residue, oils, and husk ashes can enhance the sustainability and durability of the concrete. Using agro-waste in the form of ashes and aggregate can reduce the utilization of cement and reduce the depletion of natural resources. In this piece, articles from the last 10 years have been reviewed. In a nutshell, it has been found that research related to agro-waste has accelerated in the last few years, matching the global footprint to achieve a more sustainable infrastructural base.

Keywords: Agro-waste; Oil waste; Livestock; Aquacultural waste; Fruit waste

Paper ID: 150

Shear strength behaviour of rice straw reinforced soil

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ABSTRACT

Among the agricultural by-products that are readily available in nations that cultivate rice, such as India, rice straw is one of the most abundantly available. There is a significant amount of rice straw that is generated annually, and the disposal of this material is a big challenge. Farmers in the majority of regions burn it on the fields, which results in the release of greenhouse gases, as well as pollution of the air and smog. For the time being, there is a growing desire for sustainable and environmentally friendly solutions in geotechnical engineering, which has promoted the use of naturally occurring fibers that are readily available in the local area for the purpose of soil development. So as to fill this gap a growing number of academics are embracing natural fibers for modern construction since they are more environmentally friendly and cost-effective. Despite this, there is a limited amount of research that has been done on the use of rice straw as a soil reinforcing material. The purpose of this study is to address the gap in the use of rice straw fibers as a natural reinforcing agent for soil stability in general, as well as to investigate stress strain behavior in greater detail. This research endeavors to undertake the basic characterization of both soil and rice straw in order to determine suitability of rice straw as a soil reinforcing agent. The direct shear test was then used to investigate the impact that rice straw has on the stress strain characteristics of the soil. In light of the findings, it can be concluded that rice straw enhances both the stress strain behavior and the shear strength of the soil, hence rendering it more suited for geotechnical use. In addition, the research demonstrates the dual benefit of utilizing an agricultural waste product for soil stabilization, which contributes to the development of engineering solutions that are both cost-effective and environmentally sustainable.

Keywords: Rice straw; Soil reinforcement; Shear strength; Direct shear test; Sustainability

Paper ID: 153

Jute geotextile as a sustainable reinforcement in geotechnical project

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ABSTRACT

India is the largest producer of jute in the world, with an annual contribution of around 1.72 million metric tons. On a similar note, there is around 1700 million metric tons of legacy ash spread throughout the entirety of India. Through the implementation of effective waste management, India is making every effort to contribute to the United Nations' Sustainable Development Goal 12. As part of this effort, several geotechnical projects have committed to using ash as a construction material. Therefore, ash was used in conjunction with synthetic fibers as a reinforcing agent in the geotechnical project that was being undertaken in a regular basics. However, the growing need for sustainable and environmentally friendly solutions in geotechnical engineering has pushed the use of naturally occurring fibers that are readily available in the local area for the purpose of soil development. Jute geotextile has been used as a reinforcing material in geotechnical projects that are composed of fly ash; nevertheless, there has been a limited amount of research conducted on this topic. As a result, this study was carried out in order to get an understanding of the sustainability of using jute geotextile as a reinforcing material in geotechnical projects that involve fly ash. Using a series of direct shear tests, an investigation of the impact that jute geotextile reinforcement has on ash has been carried out. In addition, the outcome was thoroughly assessed with regard to the behavior of stress strain, the internal shear strength, and the interface shear strength. The results of this study suggest that jute geotextile might be utilized as a natural reinforcing material for a geotechnical project that is environmentally sustainable.

Keywords: Jute geotextile; Legacy ash; Interface shear strength; Direct shear test; Sustainability

Paper ID: 154

Biological valorization of organic waste: A comparative study of Vermicomposting and Black soldier fly larvae

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ABSTRACT

Sustainable management of organic waste requires technologies that effectively reduce waste mass while simultaneously generating value-added products. This study comparatively evaluates vermicomposting with *Eisenia fetida* and bioconversion by black soldier fly larvae (*Hermetia illucens*, BSFL), targeting both as complementary approaches for efficient vegetable waste valorization. Fresh vegetable waste was co-processed with appropriate bulking agents and subjected to vermicomposting and BSFL treatment under controlled laboratory conditions. Physicochemical dynamics, nutrient fractions, and phytotoxicity were systematically analyzed to assess stabilization, compost quality, and overall suitability for agricultural application. BSFL achieved rapid degradation, reducing waste mass by 75.11% within 11 days. Larval biomass increased approximately six fold, providing protein- and lipid-rich resources suitable for feed, aquaculture, and biofuel production. However, the frass residue retained moderate phytotoxicity, with a germination index of 54%, indicating that additional curing is necessary before soil application to ensure safe and effective use. Vermicomposting, although slower, reduced waste mass by 72.67% over 45 days and produced highly stable, nutrient-enriched compost. Phytotoxicity assays confirmed full compost maturity, with a nearly 100% germination index and enhanced seedling growth, validating its potential as a superior soil amendment. The findings clearly demonstrate that BSFL is highly effective for rapid waste reduction and biomass valorization, while vermicomposting excels in nutrient stabilization and long-term agronomic benefits. Together, these processes provide complementary pathways for sustainable vegetable waste management, supporting industrial feed and energy recovery while simultaneously improving agricultural soil fertility within a circular bioeconomy framework. This integrated approach highlights the potential of combining fast bioconversion with nutrient-rich compost production to achieve efficient and sustainable organic waste management.

Keywords: Organic waste; Vermicomposting; Black soldier fly; Waste reduction; Compost quality

Paper ID: 155

Experimental optimization of pyrolytic oil production from banana peel feedstock

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ABSTRACT

The replacement of fossil fuels by renewable sources has been discussed globally, as fossil fuels account for a large portion of the pollutant emissions into the atmosphere. The use of biomass for energy production through pyrolysis presents a promising opportunity for addressing environmental concerns associated with the use of fossil fuels. Among different pyrolysis processes, fast pyrolysis has emerged as a leading method due to its high efficiency and yield of bio-oil, offering a sustainable alternative to traditional slow pyrolysis techniques. This experimental setup offers a versatile platform for studying pyrolysis kinetics and optimizing biofuel production from banana peel feedstock. The thermal degradation kinetics of banana peel biomass were investigated using a thermo-gravimetric analyzer (TGA). Low-cost activated carbon derived from sugarcane bagasse was used as a catalyst during the pyrolysis reaction. A pyrolysis experiment was conducted by varying heating rate, catalyst loading, and Nitrogen flow rate. The pyrolysis experiment was optimized by studying the effect of heating rate, catalyst loading, and Nitrogen flow rate on the yield of pyrolytic oil. The effect of catalyst loading on the yield and quality of pyrolytic oil was studied. The properties of pyrolytic oil obtained from the banana peel feedstock were compared with those of commercial diesel fuel.

Keywords: Fast Pyrolysis, Banana Peel Feedstock, Thermo-gravimetric Analyzer (TGA), Low-Cost Catalyst, Pyrolytic Oil.

Paper ID: 157

Sustainability study of coal mine overburden as a geotechnical material

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ABSTRACT

India is the second biggest producer of coal in the world, which results in the yearly production of around 1150 million cubic meters of overburden from coal mines. There is a significant amount of variation in the material qualities produced during excavation. In most cases, they are left near excavation sites. It is difficult and expensive to handle it in the appropriate manner. At the same time, there is a severe lack of virgin material for use in civil engineering projects. As a result, civil engineers are actively looking for secondary sources that may be utilized in place of traditional materials. Due to the fact that the amount of material required for any geotechnical project is often very huge, since this circumstance arises, mine overburden may be used in place of conventional material in geotechnical applications. On the other hand, there has been a limited amount of study conducted on mine overburden as a geotechnical material. For this reason, a detailed analysis was required in order to gain a comprehensive knowledge of mine overburden as a sustainable geotechnical material. The purpose of this study was to determine the feasibility that the overburden from the mine was suitable for a geotechnical project by conducting a series of geotechnical characterizations. For the purpose of planning any geotechnical project, it is often necessary to take into consideration the engineering behavior of the material. As a result, a series of direct shear tests were scheduled in order to investigate the stress-strain relationship in full detail as well as the shear strength parameters. As a result of this study, it is possible to draw the conclusion that mine overburden has the potential to replace traditional materials in geotechnical applications. This is because these properties were compared with those of sand, which indicates that they behave in a comparable manner.

Keywords: Coal mine overburden; Geotechnical characterizations; Sustainability

Paper ID: 159

Synthesis of carbon dots from end-of-life reverse osmosis membranes for photocatalytic hydrogen generation

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ABSTRACT

End-of-life reverse osmosis (EoL-RO) membranes, an underexplored non-biomass polymeric waste stream, pose serious environmental challenges due to their non-biodegradable nature. In this study, EoL-RO membranes were upcycled into high-value carbon dots (CDs) for photocatalytic hydrogen generation, providing a sustainable pathway aligned with circular economy principles. The membranes were first subjected to microwave pyrolysis, yielding optimized char (25–35%) with improved C/N ratio, which was subsequently reduced to nanoscale precursors by high-energy ball milling. CDs were then synthesized via four routes—hydrothermal, microwave-assisted, ultrasonication-assisted, and chemical oxidation—under both oxidizing and non-oxidizing conditions. The resulting CDs exhibited sizes of 2–6 nm with absorption peaks between 250–350 nm, demonstrating tunable optical properties. Comparative evaluation identified the hydrothermal-oxidizing pathway as the most efficient, producing stable, photoluminescent CDs. When integrated into photocatalyst systems, these CDs achieved hydrogen evolution rates of 200–600 $\mu mol\ h^{-1}\ g^{-1}$, representing up to a tenfold enhancement over controls. This work highlights, for the first time, the potential of discarded RO membranes as a non-biomass feedstock for nanomaterial synthesis, bridging waste management and renewable energy through innovative, sustainable nanotechnology.

Keywords: Carbon Dots (CDs) synthesis; Hydrogen production; photocatalysis; End-of-Life (EOL) RO membrane; Waste-to-energy

Paper ID:165

Waste-to-resource Approach: The role of metakaolin and fly Ash in geopolymer concrete filled steel tubes

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ABSTRACT

Using fly ash in construction minimizes landfill burden, leachate generation, and air pollution. It aligns with sustainable engineering goals, indirectly supporting waste management by diverting fly ash from disposal sites. This research investigates the performance of geopolymer concrete in steel tubular structural members. Geopolymer concrete was prepared with fly ash and metakaolin, which are activated using alkaline solutions such as sodium hydroxide (NaOH) and sodium silicate (Na2SiO3). The entire study was carried to evaluate the properties of geopolymer concrete by varying the molarity of sodium hydroxide. Various geopolymer concrete mixes were formulated with fly ash and metakaolin content ranging from 0% to 100%, and alkaline activators were prepared at molarities of 8M and 12M. Mechanical and durability properties of geopolymer concrete were evaluated under suitable environmental conditions. Geopolymer concrete was poured into hollow tubular columns and an experimental study was conducted under axial loading and compared with conventional concrete-filled steel tube columns. After optimising the molarity of alkaline activators, the study was carried out under different loading conditions highlighting their mechanical performance in terms of axial deformation and structural integrity. The results highlight the potential of geopolymer concrete to play a key role in advancing more durable and environmental friendly infrastructure solutions aimed reducing environmental impact.

Keywords*:* Geopolymer; fly ash; metakaolin; alkaline activators; steel tube

Paper ID:184

Feasibility of waste-to-energy as an in-house disposal and energy recovery solution for the Andaman & Nicobar Islands: A GHG and cost perspective

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ABSTRACT

Municipal Solid Waste (MSW) management in the Andaman & Nicobar Islands is constrained by geographical isolation, limited land resources, and fragile ecosystems. Current practices include decentralized composting of source-segregated organics and shipment of recyclables to mainland India for processing. However, recyclables are being transported to mainland India, the associated greenhouse gas (GHG) emissions from multi-stage logistics local transport, baling, storage, and ship transfer to mainland facilities raises concerns about long-term sustainability. While a large fraction of un-composted horticulture waste, mixed dry fractions, and low-value rejects continue to be disposed of at dump yards(unscientific landfills).

This study explores the feasibility of adopting in-house Waste-to-Energy (WtE) as a complementary disposal solution for the Island. Waste streams unsuitable for composting but suitable for incineration or refuse-derived fuel (RDF) generation were characterized for calorific value and combustion properties. A comparative assessment was conducted between two scenarios: (i) current practice of transporting rejects to mainland facilities, and (ii) local WtE processing for energy recovery. The analysis incorporated transport-related GHG emissions, waste processing efficiencies, and the cost of electricity generation.

Preliminary findings suggest that an island-based WtE facility, though capital-intensive, could significantly offset both transport-related emissions and the high cost of electricity, currently estimated at around Rs. 36 per unit. The potential energy recovery from combustibles and RDF could supplement local energy demand, reducing dependency on imported fossil fuels while improving waste disposal efficiency.

The study highlights the need for integrated decision-making that balances environmental trade-offs, energy economics, and operational feasibility. Adoption of localized WtE can provide a dual benefit sustainable waste disposal and cost-effective energy recovery positioning it as a viable strategy for small island territories.

Keywords: Waste-to-Energy; Municipal Solid Waste; Andaman & Nicobar Islands; Greenhouse Gas Emissions; Energy Recovery

Paper ID:186

Assessing the state of solid waste infrastructure and resource recovery in Guwahati, Assam: a review of challenges & pathways

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ABSTRACT

Guwahati, the largest city in Northeast India, generates between 550 to 600 metric tons of solid waste every day, making solid waste management (SWM) one of the most important urban concerns. Although there has been an effort, there is still a lack of infrastructure for collection, treatment, and disposal, impacting environmentally sensitive regions, damaging the environment, and endangers public. This study critically examines Guwahati's solid waste management system, focusing on both legacy and active dumpsites, waste chain structural flaws, and potential opportunities for sustainable governance and resource recovery. The West Boragaon dumpsite, which is located adjacent to Deepor Beel, a Ramsar-listed wetland, has accumulated tonnes of unsegregated waste. Selective remediation and material recovery have been implemented on portions of the site, yet these measures are limited in scale and doesn't address ongoing waste inflows and persistent environmental risks. Due to growing environmental concerns and public protests in West Boragaon, Belortol site became the primary disposal location in 2021. Unmanaged piles of mixed waste, poor leachate treatment, and the exposure of neighbouring communities like Moinakhurung and Pamohi to environmental risks became the emerging problems at Belortol which highlighted that relying on new dumpsite only moves risk rather than eliminating.

Although smart waste monitoring systems have been tested in a few wards, tracking based on QR codes are not yet available throughout the entire city. While biological treatment, like composting and anaerobic decomposition only cover a small portion of the wards and are insufficient in comparison to the amount of organic waste generated. Market hubs such as Fancy Bazar and Pan Bazaar rely heavily on informal recycling and upcycling, and ward-level composting and anaerobic digestion initiatives cover only a fraction of the organic waste generated. These circumstances demonstrate how Guwahati's solid waste management system is still largely reliant on landfills and has disjointed resource recovery pathways. Sustainable urban waste governance requires holistic strategies like systematic remediation of dumping sites, engineered safeguards and monitoring at active dumps, decentralized composting and biogas infrastructure, formalized recycling and e-waste facilities, and deployment of digital monitoring across all wards. In summary, Landfill dependence will continue to endanger biodiversity, public health, and urban sustainability in the absence of integrated, circular, and recovery-oriented approaches. In addition to highlighting strategies for resilient and ecologically conscious urban waste management, this review offers a spatially grounded understanding of the city's Solid Waste Management deficiencies.

Keywords: Solid Waste Management; Landfill Remediation; Resource Recovery; Urban Sustainability; Composting

Paper ID:187

Air Cooled Ferrochrome Slag: A Sustainable Alternative for Coarse Aggregate

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ABSTRACT

In recent times, attempts are being made to integrate industrial by-products with the concrete sector in a synergistic way owing to the growing concerns about environmental sustainability in the construction sector. Ferrochrome slag is generated as a by-product in the ferrochrome industry. The high chromium concentration of ferrochrome slag, the possibility for environmental leaching, and the need for wide area mass storage poses a formidable environmental issues. Therefore, the potential uses of ferrochrome slag in construction industry have piqued researchers' interest in past decade. The properties of ferrochrome slag are greatly influenced by the cooling mechanism adopted. Earlier research reported that air-cooled ferrochrome slag (ACFS) can be used as a substitute for coarse aggregate due its superior technical features. Although most studies identified ferrochrome slag aggregate concrete (FSAC) to have better mechanical properties than natural aggregate concrete (NAC), the acceptability of ACFS as an environmentally friendly construction material has not yet been standardized due to dearth of research, especially on the environmental performance evaluation. To promote ACFS, two types of concrete mixtures were developed: FSAC (using 100% ACFS) and NAC (using 100% natural coarse aggregate). Performance evaluation was carried out based on the mechanical behaviour, environmental impacts by life cycle assessment (LCA) and environmental compatibility through Toxicity Characteristic Leaching Procedure (TCLP) test. A cradle-to-gate based LCA was performed using IMPACT 2002+ Method. The results revealed that compared with NAC, FSAC exhibited enhanced strength and greater environmental savings by reducing around 7% global warming potential (GWP), 11% acidification potential (AP) and 6% non-renewable energy (NRE) consumption. Moreover, the damage assessment outcomes indicated that the production of FSAC can save large resources, reduce climate change, and protect ecosystems to that of NAC. The TCLP test revealed that FSAC's leaching concentration of chromium is below the detectable threshold, indicating it poses no environmental threat. The results offer valuable insights for maximizing the applicability of ACFS aggregate in concrete sector.

Keywords: Environmental sustainability, Air-cooled ferrochrome slag, environmental impacts, Life cycle Assessment, Natural aggregate concrete

Paper ID:188

Utilization of Blast Furnace Slag Sand in Geopolymer Concrete: A Study on Activator Molarity and Performance Enhancement

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ABSTRACT

The growing demand for sustainable construction materials has accelerated the search for alternatives to conventional concrete, particularly due to the depletion of natural sand and the high carbon footprint of cement production. Geopolymer concrete (GPC), produced through the alkali activation of aluminosilicate-rich industrial by-products, has emerged as a promising eco-friendly substitute. In this study, blast furnace slag (BFS) sand, an abundantly available by-product of the steel industry, was incorporated as a replacement for natural fine aggregate from 0 to 100% to evaluate its influence on the performance of GPC. The effect of activator concentration was also examined by comparing sodium hydroxide solutions of 8 M and 10 M molarity. Comprehensive investigations were carried out to assess mechanical properties (i.e. compressive strength test), durability performance (i.e. water absorption test) and microstructural characteristics (i.e. scanning electron microscopy). The findings revealed that the mixes prepared with 10 M activator consistently outperformed those with 8 M. Significant improvements were observed in compressive strengths, confirming the beneficial role of higher alkalinity in promoting effective geopolymerization. Durability studies further supported these outcomes, where the 10 M mixes exhibited lower water absorption. Microstructural analyses using SEM analysis demonstrated the formation of a denser matrix with a well-developed geopolymer gel and strong interfacial bonding in the 10 M mix, whereas the 8 M mix showed relatively less compact microstructural features. This approach not only addresses the sustainability concerns associated with natural sand and cement but also provides a viable pathway for the effective recycling of industrial by-products. The study confirms the potential of BFS sand-based GPC as a durable and environmentally responsible construction material.

Keywords: Blast furnace slag sand; Strength; Durability; Microstructure; Alkali activator

Paper ID:189

Alkaline resistance and Transport Performance of Sustainable Concrete containing steel slag and demolition waste

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ABSTRACT

The growing demand for sustainable construction materials has encouraged the use of industrial by-products and recycled aggregates as substitutes for conventional concrete ingredients. This study investigates the development of eco-friendly concrete by fixing ground granulated blast furnace slag (GGBS) at 60% with 6% lime as the binder, while replacing natural fine aggregate (NFA) with non-ground blast furnace slag (GBFS) sand and natural coarse aggregate (NCA) with recycled coarse aggregate (RCA) at varying levels of 0%, 50%, 75%, and 100%. The performance of the mixes was evaluated through alkaline attack resistance, water absorption, volume of voids, and density to assess both durability and transport-related properties. The results revealed that the mix designated G60B50R50L6, incorporating 60% GGBS with lime as binder, 50% GBFS sand as fine aggregate, and 50% RCA as coarse aggregate, exhibited the best overall performance. This mix showed superior resistance to alkaline attack, indicating strong durability in aggressive environments. Furthermore, it demonstrated lower water absorption and a reduced volume of voids, resulting in improved transport properties and a denser, more compact matrix. The density values further confirmed its suitability for structural applications. In contrast, higher replacement levels of GBFS sand and RCA (75% and 100%) showed a decline in performance, underscoring the importance of optimizing replacement ratios to balance strength and durability. Overall, the findings confirm that using 60% GGBS with lime as binder, together with an optimal combination of 50% GBFS sand and 50% RCA, yields a sustainable concrete mix with improved durability, transport performance, and structural reliability. This approach demonstrates the potential of industrial by-products and recycled aggregates to replace conventional materials, offering a practical pathway toward resource-efficient and eco-friendly construction.

Keywords: Non-ground granulated blast furnace slag sand; Alkaline attack; Water absorption; Density; Eco-friendly concrete

Paper ID:196

An experimental investigation on sustainable concrete incorporating recycled plastic waste (HDPE)

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ABSTRACT

The rapid growth of plastic consumption has led to a severe environmental crisis due to the non-biodegradable nature of plastic waste. High-Density Polyethylene (HDPE), one of the most commonly used plastics, contributes significantly to this problem when disposed of in landfills or open environments. Simultaneously, the construction industry faces challenges in reducing its carbon footprint while maintaining material performance. Therefore, integrating recycled plastic waste into concrete offers a sustainable solution that addresses both waste management and resource conservation. The current study explores the potential of incorporating recycled HDPE plastic waste as a partial replacement in concrete. The primary objective is to conduct a series of laboratory experiments on various composite mixtures of concrete. Cement, fine aggregates and coarse aggregates will be partially replaced by volume with different ratios (0%, 3%, 7% and 12%) of High Density Polyethylene (HDPE), one at a time, to identify the optimal replacement limit. A concrete mixture of M20 grade will be prepared and tested with constant water to cement ratio of 0.45. All samples are to be tested for fresh properties such as slump test, compaction factor test and hardened properties such as bulk density, soroptivity, water absorption, compressive strength, indirect tensile strength and flexural strength. The results are expected to demonstrate that controlled incorporation of recycled plastic waste can enhance sustainability by reducing environmental impacts, and contributing toward eco-friendly construction practices without significantly compromising structural performance

Keywords: HDPE; Recycled plastic waste; Waste management; Sustainability.

Paper ID:198

Performance evaluation of aerobic composting at Dewas municipality and recommendation for decentralised bin composting

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ABSTRACT

Municipal solid waste management in medium-sized cities of India faces significant challenges due to the imbalance between waste generation and treatment capacity. This study evaluates the performance of the Dewas Municipal composting facility, which employs windrow and drum composting, and proposes the integration of decentralized bin composting units to address untreated fractions of organic waste. The primary objective was to quantify existing facility performance, identify operational limitations, and assess the potential contribution of decentralized systems in bridging the treatment gap. The management of municipal solid waste in Dewas city presents critical challenges due to the mismatch between the quantity of waste generated and the treatment capacity of existing facilities. Field surveys, waste characterization studies, and process monitoring were conducted to analyses waste input streams, moisture balance, temperature profiles, compost stability, and nutrient content. The assessment revealed that although the facility is designed to handle 164 tonnes per day (TPD) of municipal waste, fraction of biodegradable waste (~53.55%), and the treatment capacity of centralized rotary drum and windrow systems (~75 TPD), thereby identifying the surplus fraction of organic waste (≈ 13–15 TPD) currently being diverted to landfills.

Limitations observed include insufficient aeration in windrow systems, irregular turning frequency, inadequate segregation at source, and space constraints, which collectively reduce decomposition rates and compromise compost maturity.

To address these operational gaps, the study proposes the adoption of decentralized bin composting systems positioned near high-waste generation zones such as residential colonies, gardens, institutional premises, and commercial establishments. The feasibility assessment indicates that each unit, depending on bin volume and retention time, could effectively process ~17–18 TPD of organic waste per day, thereby reducing transportation costs and load on the central facility. Decentralized units ensure localized treatment, continuous operation, and improved quality of compost with higher stabilization indices. Integration of such systems with the existing centralized framework demonstrates the potential to achieve near-complete treatment of organic waste in Dewas while enhancing circular economy practices, reducing greenhouse gas emissions from unprocessed waste, and generating value-added compost for agricultural and horticultural applications. The findings conclude that a hybrid model of centralized and decentralized composting provides a technically feasible and sustainable pathway for urban solid waste management.

Keywords: Composting efficiency; Decentralized bins; Organic waste; Municipal solid waste; Dewas

Paper ID:199

Effects of submergence on the shear strength of legacy ash

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ABSTRACT

Around 1700 million tons of legacy ash are currently stored in ash ponds located all throughout India. These ash ponds are spread out across the country. In order to fill the mine voids that were created during the mining process, which might be used. The investigation on the shear strength behavior of compacted legacy ash with respect to seasonal variation of moisture content in general and the influence of water logging during the rainy season is notably deficient. This is a key gap in the research. An investigation into the impact of submergence on the shear strength behavior of compacted legacy ash is presented in this research. The investigation was conducted on a laboratory scale. The use of a direct shear test was utilized in order to investigate the impact that submergence has on the behavior of shear strength. Experiments were conducted with two groups of samples: the first group of samples were sheared immediately after the compaction process, and there was no water logging at all. On the other hand, the second group of samples were left submerged for twenty-four hours after the compaction process, and then sheared while the water logging was still present above the sample. Legacy ash that has been submerged tends to have lower shear strength parameters such as apparent cohesion and angle of internal friction than legacy ash that has not been submerged.

Keywords: Legacy ash; Shear strength; Submergence; Direct shear test

Paper ID:202

Formulating C&D policy for Sustainable C&D Waste Management in a city- A case study

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ABSTRACT

On account of rapid urbanization huge quantities of C&D waste are generated each day in Indian cities. As per estimates, Construction sector is expected to grow by 7- 8% on an annual basis. Urban infrastructure expansion in form of flyovers, roads, bridges, footpaths as well as the demolition of old buildings leads to significant generation of debris and this trend is projected to grow further in coming years. According to BMTPC (Buildings Materials & Technology Promotion Council) and MoHUA (Ministry of Housing and Urban Affairs) latest figures Indian produces approx 100 MT of C& D waste on an annual basis. Materials such as pipes, wooden frames, and metal rods etc which have ready market value are sold in the informal sector but debris comprising of concrete, stones, mortar and other bulky materials are left behind. A major proportion of this rubble is often dumped irresponsibly on roads, open plots, water bodies and low lying regions resulting in environmental issues.

Hence, to deal with the issue of C&D waste in a sustainable manner, GoI (Govt of India) in March 2016 issued the "**C&D Rules**" (Construction and Demolition Waste Management Rules, 2016) and "**SBM 2.0 Guidelines**" (Swachh Bharat Mission – Urban 2.0 - Operational Guidelines, October 2021 issued by MoHUA) for the management of Construction and Demolition Waste. However, the implementation of these rules and guidelines has not been very effective.

In this work we propose C&D Policy and strategy for Chh. Sambhajinagar, a million plus city in the state of Maharashtra. This policy is being prepared for sustainable management of C&D waste that gets generated within its municipal limits. It is aimed that with the involvement and participation of stakeholders, its rampant dumping will be prevented, C&D guidelines given by MPCB and CPCB will be followed by Builders and enhanced recovery of resources from such wastes will be done.

Keywords: Urbanization; C&D Rules; Dumping; Sustainable; Policy

Paper ID:206

Potato peel waste-derived hydrochar: A sustainable approach for perfluorooctanoic acid removal from water matrices

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ABSTRACT

The management of potato peel waste (PPW) through conventional landfilling practices poses significant environmental challenges due to the emission of greenhouse gases and toxic leachates. Recent projections indicate that by 2030, PPW generation could reach approximately 8000 kilotons, leading to an estimated 5 million tons of CO_2-equivalent emissions associated with its disposal. The valorization of PPW into functional carbon materials offers a sustainable alternative, particularly for addressing the environmental remediation of persistent organic pollutants. In this context, this study presents the valorization of PPW into hydrochar through hydrothermal carbonization at 180 °C for 4 h, and subsequently modification with choline chloride (ChCl) at varying molar concentrations to enhance its adsorptive performance. Among the prepared adsorbents, the hydrochar modified with 0.1 M ChCl (0.1 M ChCl-HC) demonstrated superior adsorption behavior toward perfluorooctanoic acid (PFOA), a highly persistent perfluoroalkyl compound referred to as a "forever chemical" due to its resistance to degradation, posing a significant environmental concern. Under the optimized conditions with adsorbent dose and in the presence of 20 mM $CaCl_2$, the 0.1 M ChCl-HC achieved a maximum removal efficiency of 95.4%. Further batch adsorption studies were conducted to elucidate the adsorption mechanism and governing models. Isotherm analysis revealed that the Langmuir model is the best fit (R^2 = 0.9976), suggesting monolayer adsorption on a homogeneous surface. Kinetic studies further revealed that the adsorption process followed the pseudo-second-order model (R^2 = 0.9974), indicating physisorption as a dominant interaction. The improved removal performance can be largely attributed to $CaCl_2$ acting as a bridging agent, thereby enhancing electrostatic interactions between the negatively charged PFOA molecules and the modified hydrochar surface. Moreover, hydrophobic interactions and hydrogen bonding were also found to contribute significantly to PFOA adsorption. These findings highlight the potential of PPW-derived ChCl-modified hydrochar as a cost-effective and sustainable adsorbent for the remediation of PFOA-contaminated water, while simultaneously offering a dual benefit of valorization of PPW and environmental remediation.

Keywords: Potato peel waste; Hydrothermal carbonization; Hydrochar; Perfluorooctanoic acid; Adsorption

Paper ID: 222

Development and Characterization of Banana Fibre-Reinforced Starch Based Bioplastics for Sustainable Packaging

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ABSTRACT

The growing environmental challenges associated with petroleum-based plastics have driven the pursuit of biodegradable alternatives derived from renewable and waste resources. In this study, bio-composite films were developed using starch (potato and corn) and gelatin–pectin blends as primary polymer matrices, with glycerol and acetic acid serving as plasticizers. To enhance structural integrity and performance, banana pseudo-stem fibres were incorporated as natural reinforcements. The synthesized films were evaluated in terms of their physicochemical, mechanical, and biodegradability properties to assess their suitability as eco-friendly substitutes for conventional plastics. The integration of starch and gelatin–pectin matrices provided flexibility and compatibility, while the addition of banana pseudo-stem fibres significantly improved tensile strength and stability. The reinforcement using banana pseudo-stem fibres extracted through water and alkali retting. The optimized fibre-reinforced films achieved tensile strength in the range of 6.2–6.5 MPa and Young's modulus of 480–485 MPa, compared to much lower values in unreinforced films and higher values in banana pseudo-stem fibres reinforced films (0.23–0.24 MPa to 22–23 MPa). The findings suggest that the films will show enhanced water resistance, improved shelf stability, and faster biodegradation compared to conventional plastics, thereby offering a practical pathway toward eco-safe materials for packaging and allied uses. The results demonstrated that the developed composites exhibit promising characteristics for sustainable packaging applications, highlighting the potential of agricultural residues and biodegradable polymers to reduce plastic dependency and mitigate environmental impacts.

Keywords: Bioplastic, Starch, Banana Fibre, Gelatin, Biodegradability, Sustainable

Paper ID: 226

Marine Sand incorporating additives as a sustainable Backfill Material

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ABSTRACT

This study investigates the use of marine sand as a backfill material for cantilever retaining walls, aims to conserve the natural resources even though it is not suitable for the alternative building material and focuses on improving its stability as well as performance. A parametric analysis was performed using PLAXIS-2D software, a Finite Element Analysis (FEA) tool, to simulate the performance of cantilever retaining walls with varying wall height, embedded depth along with the backfill inclination. The Factor of Safety (FOS) and the total deformation in terms of vertical settlement of the backfill soil was calculated to analyse the stability of the retaining wall. Ground Granulated Blast Furnace Slag (GGBS), a sustainable by product of the steel industry, combined as a stabilizing agent to stabilize the marine sand so that the Maximum dry density (MDD) of the mixed backfill increased due to replacement by GGBS. Consequently, improved the stability of the retaining wall. However, a significant challenge arises from the weak cohesive bonding between the marine sand and GGBS particles, resulting in a brittle mixture. To address this issue, a highly compressible clay was added to improve the binding characteristics. It was observed that addition of 10% of clay by weight to the mixture, the MDD and Optimum Moisture Content (OMC) was increased by 9% and 7% respectively, thus the inter-particle bonding was strengthened by improving the cohesion. The findings highlighted the ability of the proposed backfill mixture to strengthen the performance of cantilever retaining walls, offering valuable visions into its application in geotechnical engineering. The FEA model was further analysed and found that the FOS was increased with lower settlement values.

Keywords: Marine sand; PLAXIS-2D; GGBS; Clay; Stability; Retaining wall

Paper ID: 240

Biodegradation Behavior of Bioplastics Co-treated with Organic Fraction of Municipal Solid Waste

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ABSTRACT

The increasing use of plastics in daily life has resulted in their accumulation as a major fraction of Municipal Solid Waste (MSW), causing serious environmental challenges due to their persistence and fossil fuel–based origin. Bioplastics have emerged as sustainable alternatives to petroleum-based plastics; however, their integration into the waste stream, particularly when mixed with the Organic Fraction of Municipal Solid Waste (OFMSW), presents new challenges for waste management. This study evaluates the biodegradation potential of three commercial bioplastics, PLA+PBAT bag, corn starch bowl, and bagasse plate under biological treatment routes, namely Anaerobic Digestion (AD), composting, and soil incubation. OFMSW, as a renewable feedstock for biogas generation through AD, plays a vital role in enhancing the overall sustainability of the bioplastic life cycle. Results show that 35 days of AD achieved an average degradation of 16.54%, with disintegration values of 36.2% for corn starch, 7.7% for bagasse, and 6.32% for PLA+PBAT. Composting demonstrated the highest degradation, with bagasse reaching 43.4% after 70 days in clayey soil. Soil incubation led to 22.4% degradation after 35 days. Fourier Transform Infrared (FTIR) analysis confirmed polymer degradation through reduced peak intensities, while compost quality parameters indicated changes due to bioplastic presence and treatment. These findings highlight the differential biodegradation behavior of bioplastics under diverse biological treatments and provide insights into their fate in OFMSW management systems.

Keywords: Bioplastics; Biodegradation; Anaerobic Digestion; Composting; Soil Incubation

Paper ID:265

Recycling of PCBs-capacitors to get tantalum enriched residue and other valuables

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ABSTRACT

Tantalum (Ta) is widely used in the manufacturing of capacitors to get used in various printed circuit boards (PCBs). Its limited natural occurrence and extensive usage in modern electronic devices has created its strong demand. Generally India imports Ta for its domestic requirements, on the other hand, huge amount of electronic gadgets containing PCBs with capacitors are discarded every year. In this connection, recycling of capacitor is proposed to minimize the demand-supply gap of Ta. A novel hydrometallurgical flowsheet was developed for the recovery of Ta-enriched residue from waste capacitors. The process focuses on leaching out major impurities such as nickel (Ni), manganese (Mn), and silver (Ag), while retaining Ta in the solid residue. The best results were achieved using diluted nitric acid (HNO_3) at 70 °C, 50 g/L pulp density, and 2 hours leaching time, under which near complete dissolution of Ni, Mn, and Ag was observed, while almost all the Ta remained in the residue. The experiments were carried out in closed system with attached condenser, so that no NO_x will be released in atmosphere. This selective dissolution approach effectively separates base and precious metals from Ta. The developed process demonstrates a sustainable and efficient route for tantalum recovery from PCBs-capacitors, which will minimize the import dependence and will boost circular economy.

Keywords*:* Tantalum recovery; Waste capacitors; PCBs; Hydrometallurgy; Leaching

Paper ID:266

Studies on the hydrometallurgical processes to recover Nd, Dy, Pr from the scrap permanent magnets

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ABSTRACT

Scrap permanent magnets have emerged as a promising secondary resource of rare earth metals (REMs) viz. Nd, Dy, Pr, etc. These are extensively used in cutting-edge technologies viz. hybrid electric vehicles, consumer electronics, wind turbines, etc. As a result huge amount of scrap permanent magnets are generated at end-of-life. These scrap magnets contain significant amount of REMs (~30%), which is quite high and exceeds the concentration found in primary REM ores. The scrap magnets are typically found to contain ~30% Nd, ~1.3% Dy, ~3.5% Pr. The generation of huge amounts of discarded magnets containing REMs, depleting natural reserves, associated supply risks resulting from geopolitical, environmental, or technological factors and strict environmental regulations compelled the researchers to recycle REMs from discarded magnets.

In view of the above, present paper reports various process flowsheets on REM recycling. Comparative studies have also been made and based on the review new process flowsheet is proposed consisting of demagnetization, pre-treatment, and hydrometallurgical processing to recover Nd, Dy, Pr as value added products. Scrap permanent magnets will have immense potential for commercial production of REMs after scale-up and pilot trials.

Keywords: Magnets; Recycling; Hydrometallurgy; Rare earth metals; Sustainable development

Paper ID:267

Beneficiation of spent automobile catalytic converters (SACCs) for the recovery of PGMs and REMs using hydrometallurgical processing

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ABSTRACT

Modern motor vehicles are equipped with automobile catalytic converters (ACCs), which convert harmful gases (CO, NO_x, unburnt hydrocarbons, etc.) into less harmful gases (CO_2, N_2, water vapor) in order to comply with the directive for air quality in the environment. These ACCs contain valuable platinum group metals (PGMs), about 2-1200 mg/kg Pt, 4-1600 mg/kg Pd, and 2-250 mg/kg Rh along with rare earth metals (REMs) and serve as a promising secondary source of PGMs, thus, it is necessary to recycle the end of life ACCs for the recovery of these metals due to their scarcity in the earth's crust and expensive as well as complex recovery process from the primary resources. In view of the above, the present paper reports different flowsheets on recycling of Spent ACCs and based on the comparison a new indigenous-feasible process flow-sheet is proposed. The process is developed to selectively remove impurities such as Al, Mg and silica while liberating the target metals and enriching them in residue using alkali roasting of crushed sample with a suitable ratio of NaOH and Na_2CO_3 at elevated temperature for 2 hours followed by water leaching to effectively separate impurities from the enriched PGMs with REMs residue to produce value added products. Recycling of spent ACCs will not only generate new market for PGMs and REMs, but also will be an important step towards self-sustained India.

Keywords: E-waste; SACCs; PGMs; REMs; Alkali roasting

Paper ID:268

Recovery of lithium (Li) from end-of-life $LiFePO_4$ (LFP) batteries through sulfation roasting and water leaching

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ABSTRACT

As the global demand for critical metals increases, the efficient recycling of lithium-ion batteries has become essential for environmental protection and resource conservation. A novel and eco-friendly process consists of sulfated roasting and water leaching, has been developed for extracting lithium from spent $LiFePO_4$ batteries. Using a combination of Na_2SO_4 and H_2SO_4, the electrode material was roasted at elevated temperature for 1 hour, followed by water leaching for 60 minutes. Sodium carbonate was then used to selectively precipitate the lithium from the leach liquor as lithium carbonate (Li_2CO_3). The proposed method enables acid-free leaching, significantly reducing its environmental impact and chemical consumption. This efficient and sustainable process makes it possible to recover high-purity lithium, while also reducing emissions and waste. Overall, the developed flow sheet presents a low-carbon and environmentally friendly recycling method that promotes the circular economy and the sustainable management of critical resources from spent LFP batteries.

Keywords: LFP; Roasting: Leaching: Lithium

Paper ID:269

Hybrid process flow-sheet to recover Indium from varieties of LCD panels

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ABSTRACT

Indium tin oxide (ITO) is an essential component used in display devices due to its unique opto-electrical properties, delivering both transparency and conductivity to liquid crystal displays (LCDs). India lacks natural sources of Indium (In) therefore depends on imports to meet its domestic demand. However, a significant quantity of E-waste containing 'In' in LCDs are discarded annually. In this context, recycling of these screens will not only mitigate environmental pollution but also reduce dependence on foreign import. Different types of LCD screens such as computer monitors, mobile phones, tablets, and televisions contain varying amounts of In depending on their design and output requirements. This paper reports the prospects of 'In' recycling from various categories of waste LCD screens by comparing reported 'In' contents and extraction efficiencies. A novel hydrometallurgical flowsheet was developed to dissolve 'In' from various display devices. After optimizing process parameters, it was observed that at room temperature, for optimized time period, in dilute sulfuric acid and 75 g/L solid-liquid ratio, efficient dissolution of 'In' was observed. The developed process demonstrates a simple, scalable, and energy efficient route for maximum In dissolution from waste LCDs, providing an important step towards sustainable recycling of critical metal In from electronic display devices.

Keywords: E-waste; Display devices; LCDs; Indium tin oxide (ITO); Hydrometallurgy

Paper ID:270

Evaluating Waste-to-Energy Pathways for Municipal Solid Waste and Sewage Sludge: Approach to a Sustainable Environment

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ABSTRACT

The escalating generation of municipal solid waste (MSW) and sewage sludge (SS) presents a formidable global challenge. These waste streams, if improperly managed through conventional linear disposal methods like landfilling, lead to severe environmental degradation, including soil and water contamination via leachate and the release of potent greenhouse gases like methane. This crisis necessitates a paradigm shift towards integrated, circular economy-based solutions that reframe waste as a resource. Waste-to-Energy (WtE) technologies are increasingly recognized as a pivotal strategy within this framework, offering a dual benefit: they mitigate landfill burdens while simultaneously recovering valuable energy (in the form of heat, electricity, or biofuels) and reducing net greenhouse gas emissions. However, the environmental viability and sustainability of various WtE pathways, ranging from mature thermal processes like incineration to advanced thermal routes like gasification and pyrolysis, and biological options like anaerobic digestion, are not uniform. Their performance requires rigorous, holistic assessment to avoid simply shifting environmental burdens from one medium to another. This review paper critically evaluates the environmental performance of these technologies through the comprehensive lens of Life Cycle Assessment (LCA).

The primary objective is to synthesize and analyze the current body of LCA literature, providing a robust comparative analysis of the environmental trade-offs associated with each technological route. The review systematically examines key impact categories such as Global Warming Potential (GWP), acidification, eutrophication, photochemical ozone creation, and fossil fuel depletion. Special emphasis is placed on evaluating the synergistic potential of co-processing MSW and SS, which can enhance process efficiency (e.g., by balancing moisture content for thermal processes or C/N ratios for biological ones) and improve the overall environmental profile. The analysis also considers critical parameters that influence LCA outcomes, including feedstock composition, technological maturity, energy conversion efficiency, the definition of system boundaries, and the crucial end-of-life management of residues like ash and digestate. Ultimately, this work serves as an evidence-based resource for policymakers, engineers, and waste management stakeholders to facilitate informed decision-making in the selection and implementation of WtE systems that truly align with environmental protection and resource conservation objectives.

Keywords: Life Cycle Assessment, Waste-to-Energy, Municipal Solid Waste, Sewage Sludge, Sustainable Waste Management.

Paper ID:272

Soil and groundwater contamination with chromite ore processing residues in Khan-Chandpur region, Kanpur and Nano-enabled remediation

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ABSTRACT

Almost 90% of the world's leather products are tanned with chromium. Some other industries, like printing, dyeing, catalysts, medicine, oxidants, electroplating, metal corrosion inhibitors, etc., are the main applications of chromium. Due to this huge industrial demand for chromium, chromite ore processing industries are increasing rapidly. In this work, we have collected soil and groundwater samples from chromite ore processing residue (COPR) contaminated site at Khan-Chandpur, Kanpur, UP, India.

Collected groundwater samples were filtered and processed using standard EPA method to determine Cr (VI) concentration using 1,5-Diphenylcarbazide. Result showed wide variation in Cr (VI) concentration, ranging from 2 mg/L to 22.8 mg/L in different samples. In case of COPR contaminated soils, we have mixed them with rain water to see the first phase of leaching. Results showed a leaching in the range of 30-300 mg/L from soil samples at a ratio of 25 mg/ml. We further synthesized redox-active zerovalent iron particles (nZVI) using wet-chemical method and used them to treat groundwater and stabilize soils. Results showed complete Cr (VI) removal from groundwater samples and a maximum Cr (VI) stabilization capacity of 55 mg/g at a 10% nZVI mixing rate in soils. Results suggest strong potential of nZVI particles in the possible reclamation of COPR contaminated sites.

Keywords: COPR; nZVI; soil stabilization; clean water; chromium removal; reduction

Paper ID:278

Development and optimisation of Sensor-Based Monitoring System for Landfill Gas Emission

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ABSTRACT

Sanitary Landfills are serving globally as a popular means of solid waste disposal and management. Sanitary Landfills are governed by various regulations and hence are well designed to minimise contamination of the surrounding environment due to leachate or gaseous emissions. However, Landfill Gas (LFG) emissions, primarily in the form of methane (CH4) is one of the biggest issues faced by these landfills. If the Methane emission from these landfills is monitored effectively, it may lead to fulfilling the energy demand of these landfill sites as well as the nearby areas. Real-time monitoring of the landfill gases can be done by using a sensor-based assembly. However, the placement of the sensors at a suitable location and estimating the number of sensors required to maximise the methane monitoring is a key factor. The present study is based on setting up a lab-scale model of the landfill and monitoring the methane generated at different locations. The emission is monitored for 15 days, for each location, using MQ4 sensors. The data is then processed and analysed to validate the trend of methane generation. These locations have been ranked, and an appropriate number of sensors have been ascertained by optimising the data collected using the MATLAB tool. The results show that increasing the number of sensors at any location also increases monitored methane concentration, and the measured methane concentration varies across all monitoring locations. The study serves as a crucial analytical foundation for relatively efficient, real-time field applications of the sensor-based LFG monitoring.

Keywords: Methane emission, Solid waste, sensor.

Paper ID: 280

Industrial Waste based Geo-Polymer Concrete: A Review on Sustainable Material Utilization and Mechanical Behaviour

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ABSTRACT

Manufacturing OPC produces almost 1 ton of CO_2 per ton of cement produced and contributes about 7-8% to the global emissions, resulting in resource depletion. Geopolymer Concrete (GPC), as an alternative, can bring sustainability to the construction industry.

Industrial wastes utilized for producing GPC are silica-alumina-rich Fly Ash (FA), emanating from thermal power plants, calcium-rich Ground Granulated Blast Furnace Slag (GGBS) from steel industries, and metakaolin as precursors, while being activated by NaOH and sodium silicate solution to form gels Na2AL2Si2O8.xH2O (N-A-S-H) and Calcium Silicate Hydrate (C-S-H). GPC, when compared to OPC, reduces CO_2 emissions by 80-90% due to waste utilisation, with superior environmental impact through lower energy use and enhanced resistance to sulphates and chlorides. The compressive strength of GPC ranges from 40 to 90 MPa after 28 days, and this is affected by the varying FA-to-GGBS ratio. It is also observed that split tensile and flexural strengths increase with increasing molarity of the activator. Heat oven curing (60-80°C) accelerates early gel formation for rapid strength development, while ambient curing allows practical field use, but it comes with issues such as poor workability and corrosive activators, delayed setting, and a lack of standardisation.

M40-grade feasibility for structural applications like pavements and precast elements has been established, where performance appears consistent through varying conditions, furthering the goals of industrial waste valorisation. This study concludes how GPC prepared using industrial waste serves to ensure sustainable utilization of material inputs and a robust mechanical performance, placing it as a feasible and alternative OPC for greener infrastructure.

Keywords: Geo-Polymer Concrete, Compressive strength, Industrial waste

Paper ID: 283

Design and Implementation of a Model Predictive Control for Anaerobic Digestion Model No.1

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ABSTRACT

This work presents an implementation of Anaerobic Digestion Model No.1 (ADM1) with Model Predictive Control (MPC) applied to it and simulation-based investigation of MPC for the execution time and its error tracking ability. The complete 36-state nonlinear ADM1 model is implemented and used as the prediction model for controlling anaerobic digestion dynamics, with influent flow rate(q_{in}) selected as the manipulated variable. This model enables any ADM1 state (among 36) to be chosen as the controlled output, allowing the regulation of concentrations of substrates, biomass and flow of gas outputs. The MPC performance is assessed through closed-loop simulations under set-point tracking. Additionally, a computational study is conducted to measure the impact of prediction horizon on both execution time and mean tracking error. The results highlight the trade-off between prediction depth and computational burden, demonstrating the practical considerations required when applying nonlinear MPC to a complex biochemical model such as ADM1. This study establishes a baseline for future work involving state estimation strategies without state reductions for real-time deployment.

Keywords: ADM1, MPC, Set-Point Tracking, Prediction Horizon.

Track – 5
Environmental Management & Policies

Paper ID: 001

Technology-driven environmental maintenance system for urban residential societies

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ABSTRACT

Technology-driven environmental Maintenance System is a web based application motivated by the increasing need for sustainable governance and transparent environmental management at the grassroots level. In many urban residential societies, outdated methods such as manual billing, paper-based record-keeping, and informal communication (e.g., notice boards and phone calls) hinder efficient and environmentally responsible management. By developing a centralized web-based portal, this system addresses critical components of environmental governance and policy implementation by Streamlining monthly maintenance billing through paperless digital processes, promoting resource efficiency, Enabling residents to raise and monitor complaints in real-time, supporting community-level environmental monitoring and issue resolution, Improving communication between residents and society administrators via online notices, fostering transparent and participatory governance, Ensuring long-term digital record-keeping and accountability, aligned with best practices in environmental auditing. This system contributes to sustainable urban management by reducing administrative inefficiencies, encouraging responsible civic behavior, and laying the groundwork for technology-driven environmental compliance. It is a practical and scalable solution that directly supports the policy-driven tools for climate adaptation, pollution risk assessment, and life cycle-based decision-making.

Keywords: Environment; Web-based portal; Technology driven; Digital processes; Policy

Paper ID: 006

Embedding ESG principles into environmental policy and pollution control: developing the ESG–policy integration model (EPIM)

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ABSTRACT

Environmental, Social, and Governance (ESG) principles have become a central driver of sustainable business practices, yet their systematic integration into environmental management and pollution control policies remains underdeveloped. This paper introduces the ESG–Policy Integration Model (EPIM), a structured framework that aligns corporate sustainability disclosures with national governance mechanisms for pollution mitigation. EPIM operationalizes ESG metrics within three domains: (i) pollution risk assessment, (ii) life cycle and circular economy evaluations, and (iii) environmental auditing and compliance reporting.

The study employs a mixed-methods design: quantitative analysis of ESG-linked environmental performance indicators from multi-sector datasets (2018–2024) and qualitative content analysis of policy documents, corporate sustainability reports, and international frameworks such as the GRI Standards, UN SDGs, and India's National Guidelines for Responsible Business Conduct. Empirical insights from case studies in the energy, manufacturing, and infrastructure sectors demonstrate that embedding ESG principles enhances air quality management, waste-to-wealth transitions, and carbon neutrality commitments.

Results show that EPIM not only strengthens regulatory compliance but also improves corporate resilience, investor confidence, and stakeholder trust. The model offers a replicable pathway for harmonizing private-sector ESG initiatives with national and international pollution control strategies. By bridging the current gap between sustainability reporting and environmental governance, this work contributes a novel, policy-oriented lens for pollution control in emerging economies. The paper concludes with policy recommendations for mainstreaming ESG-driven accountability in environmental management systems, underscoring its role in achieving adaptive and equitable governance under accelerating climate and resource pressures.

Keywords: Environmental, Social and Governance (ESG); Pollution Control Policies; Sustainability Reporting; Circular Economy; Environmental Governance

Paper ID: 010

Geotechnical performance of nano-modified lime-pond ash-sand mixtures: insights from bearing capacity, compaction energy, and LFWD testing

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ABSTRACT

This research evaluates the morphological, mineralogical and geotechnical behaviour of Lime–Pond Ash (PA)–Sand mixtures blended with Nano-materials, using a combined approach of numerical modelling and Light Falling Weight Deflectometer (LFWD) testing on laboratory-prepared models. The foundation design in the numerical phase was carried out using Vesic's (1973) ultimate bearing capacity framework under drained loading, incorporating contributions from cohesion, surcharge, and soil unit weight. Safe bearing capacity was determined through an iterative trial-and-error process, where foundation depth was progressively adjusted until the net safe load matched the settlement criteria. The analysis indicated that a depth of 1.5 m provided adequate safety, with results tabulated to show the variation of bearing capacity with depth. In the laboratory investigation, cylindrical models (360 mm × 650 mm) of Lime–PA–Sand mixtures, stabilized with Nano-materials, were compacted and tested. The compaction procedure was carefully designed to simulate field conditions, where PA was compacted in three 110 mm layers (≈280 blows per layer), and sand replacement was vibrated in five layers using a needle vibrator. Energy equivalence calculations verified that the laboratory compaction energy (2703.88 kJ/m³) closely matched the field target, ensuring realistic replication of in-situ performance. Specimens were subsequently cured under load for 72 hours before LFWD testing.

LFWD testing, following IRC:115-2014 and ASTM: E2583-07 guidelines, demonstrated that untreated PA displayed a modulus of 20.133 MPa, marginally higher than sand (19.933 MPa), owing to its cohesive nature. Incorporation of Nano-materials substantially improved performance: in mix SPL1:1:300 cured for 28 days, surface deflection reduced by 41% (71μm), while the modulus increased by 68% (600 MPa). These improvements were attributed to pozzolanic reactions forming cementitious gels within the stabilized matrix. Successive LFWD drop analysis highlighted distinct behavioural patterns. Untreated PA showed progressive plastic deformation with delayed stiffening, whereas Nano-stabilized mixtures exhibited rapid stabilization, demonstrating predominantly elastic response and superior stiffness. The flatter modulus–deflection trend of stabilized samples confirmed enhanced compaction efficiency and structural integrity. In conclusion, the integration of Nano-materials into Lime–PA–Sand mixtures significantly enhances mechanical strength and stability, validating their potential as sustainable substitutes for conventional granular subbase materials. The combined methodology of trial-and-error depth evaluation, energy-equivalent compaction, and LFWD-based modulus assessment provides a reliable framework for field application in high-volume pavements and heavy-duty hardstands.

Keywords: Pond Ash; Nano-material Stabilization; Light Falling Weight Deflectometer; Energy-equivalent Compaction; Bearing Capacity.

Paper ID: 011

Environmental assessment of Singhbhum uranium mining area of Jharkhand

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ABSTRACT

Health Physics Unit of Bhabha Atomic Research Centre (BARC) carries out the eenvironmental monitoring around the uranium mining and processing facilities in the Singhbhum region of Jharkahnd. Environmental monitoring includes measurement of terrestrial gamma exposure, atmospheric radon (^{222}Rn), and radionuclide concentration in effluent, surface water, ground water and soil etc. Measurements of gamma radiation levels were carried out periodically at different locations in the tailings pond and adjoining areas. Gamma radiation level was varied from 0.2 to 0.62 µGy h^{-1} with average of 0.4 to 0.58 µGy h^{-1} at different locations near the tailing ponds. Cumulative annual terrestrial gamma dose was also measured using area based environmental TLDs at locations within plant premises, tailings pond and surrounding villages. The variations in atmospheric radon concentration observed at different villages around Jaduguda is due to widespread uranium mineralization, difference in rock and soil characteristics, seasonal and temporal changes in environmental conditions etc. ^{222}Rn concentration in the vicinity of tailings pond varied from 30 to 101 Bq m^{-3} and that beyond tailings pond varied from 33 to 56 Bq m^{-3}. The surface water monitoring reflects that the concentration of U(nat) and ^{226}Ra is less than the respective limits stipulated by regulatory body. Ground water samples were collected from adjoining areas of tailings pond and at distances away from tailings pond. Comparable concentration of radionuclides was found in samples from drinking water sources in the vicinity of tailings pond and in background/ control locations far away. Beyond the fenced area around the tailings pond, negligible changes in the external exposure level were observed. The dose received by the public is comparable to the area background dose. The mean annual effective dose to the members of the public due to terrestrial gamma and outdoor radon is estimated to be 0.52 mSv in the Jaduguda region. This is far below the annual limit of 1 mSv stipulated for the members of public.

Keywords: Uranium mining; Radon; Gamma; Environmental impact; Dose

Paper ID: 017

Urban flood management a case study at Rapta Nala, Sambalpur

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ABSTRACT

Extreme rainfall episodes have created the critical issue of urban flooding in fast-growing cities. Flood modeling in the Raftanala basin of Sambalpur town has been taken up in order to analyze drainage potentials, to identify flood-prone areas, and suggest preventive measures. A blend of hydrological and hydraulic methods has been set forth, using the Rational Method and Storm Water Management Model (SWMM).Catchment delineation and topographic analysis were done by means of DEM and GIS tools. Using the Rational Method, peak runoff estimates were obtained for various return periods to acquire an initial knowledge of runoff volumes. Afterward, a detailed SWMM model was developed, with subcatchments, junctions, conduits, and rainfall inputs used for stormwater simulation through time.During high-intensity rainfall events, model results reveal heavy surface runoff buildup and surcharge at some junctions demanding drainage improvement works, whereas the integration of SWMM with GIS and elevation data enhanced the realism and spatial accuracy of the urban flood-risk assessment in the study area. The study offers a platform for urban flood analysis integrating traditional hydrological approaches and the state-of-the-art modeling tool. The findings will help urban planners and local stakeholders in devising flood management strategies and infrastructure development. KEY WORDs: Urban Flooding, SWMM, Rational Method, Sambalpur, Raftanala, GIS, DEM, Hydrological Modeling, Stormwater Drainage, Flood Risk Assessment

Keywords: Urban Flooding; SWMM; Rational Method; Sambalpur; Raftanala

Paper ID: 020

Field evaluation of commercial *Trichoderma*-based formulations for tomato growth promotion under an integrated pest management framework

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ABSTRACT

Tomato is the second largest grown vegetable worldwide and is an essential component of most global cuisines. Current agricultural practices rely on widespread use of agrochemicals in tomato production to promote growth and manage diseases, posing extreme environmental and human health risks. Microbial biopesticides such as *Trichoderma*-based formulations are increasingly being promoted as sustainable alternatives for plant growth promotion and disease control. However, current adoption of biopesticides in commercial farming is limited due to a range of factors including weaker action in comparison to agrochemicals, less convenient application methods, product instability, lack of appropriate formulations to tackle various disease types, lack of farmer awareness, and insufficient regulatory frameworks to ensure product quality and reliability. Additionally, while lab and greenhouse scale studies exist, the field performance of these products has largely been unexplored. This study evaluated the performance of commercially available *Trichoderma*-based products in tomato cultivation using an Integrated Pest Management (IPM) framework. Eight treatments, including untreated control, chemical pesticide (CP) alone, biopesticides (BP), and CP combined with single or mixed *Trichoderma* formulations were assessed for impact on seed germination, shoot elongation, flowering, biomass accumulation, chlorophyll content, root development, and total yield. For the four commercial products tested, we could isolate *Trichoderma* strain only from one product in the lab, highlighting severe quality concerns about the currently available commercial products. In the field, it was observed that the untreated control frequently performed best across parameters like seed germination (93.7%), biomass accumulation (341.06 g fresh weight), and root system development, suggesting limited added value of the tested formulations under field conditions. CP supported stable growth and yield, whereas CP+BP treatments provided only marginal improvements in certain traits.These findings underscore that the agronomic benefits of commercial *Trichoderma* formulations remain inconsistent, with CP alone often performing comparably. From an environmental management and policy perspective, this highlights the need for stringent quality regulation of microbial products, field-based validation across agroclimatic zones, and research investment to develop high-performing, stable formulations. While short-term results suggest limited productivity gains, long-term benefits for soil health, microbial diversity, and reduced chemical dependence may justify further exploration. Field-level evidence such as this is critical for guiding regulatory frameworks and farmer decision-making in advancing sustainable agriculture.

Keywords: *Trichoderma*, biopesticides, tomato, integrated pest management, environmental pollution control

Paper ID: 031

From waste to resource: reviewing bauxite residue integration in green construction materials

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ABSTRACT

Bauxite residue, or red mud, is an alkaline by-product generated in vast quantities during alumina extraction, with global production exceeding 150 million tonnes annually. Its elevated pH and heavy metal content pose significant environmental and disposal challenges, often resulting in long-term storage in containment ponds. In recent years, researchers have increasingly explored red mud as a feedstock for sustainable construction materials, particularly in the fabrication of building blocks. This review synthesizes findings from ninety-one recent studies that examine its integration into sintered bricks, geopolymer concretes, autoclaved products, and lightweight or foamed systems. Reported results indicate compressive strengths approaching 50 MPa, enhanced thermal insulation, and strong resistance to chemical degradation, while life-cycle assessments show potential reductions in carbon emissions of up to 60% compared to conventional masonry units. Environmental assessments, including leachability tests, further support the safe incorporation of this residue into structural and non-structural products. Despite promising laboratory-scale outcomes, large-scale deployment is hindered by variations in raw material composition, lack of standardized processing protocols, and limited field validation. The present work outlines current technological approaches, evaluates performance trends, and identifies key research directions required to transform red mud from an industrial waste into a viable and eco-efficient resource for the construction sector

Keywords: Bauxite residue; Red mud; Sustainable construction; Geopolymer; Sintered bricks

Paper ID: 035

Determination of ^{210}Po in surface soils around the Uranium mineralised regions of Jaduguda, India

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ABSTRACT

Areas with known uranium mineralisation often exhibit elevated levels of ^{210}Po in various components of the ecosystem. Its occurrence in surface soils is influenced by the mineralogical characteristics of the host rock, either through in-situ production from the ^{238}U decay series (supported ^{210}Po) or deposition of radon progeny from the atmosphere (unsupported ^{210}Po). The present study was conducted in the vicinity of the uranium mining and ore processing facility at Jaduguda, India (22°30′ N, 86°20′ E), to determine the activity concentration of ^{210}Po in surface soils using alpha spectrometry technique.

The measured ^{210}Po concentrations ranged from 8.0 to 93 Bqkg^{-1}, which is lower than reported global average values (8.1 to 219 Bqkg^{-1}) but significantly higher than those from the monazite-rich coastal region of Kerala (2.26 to 14.02 Bqkg^{-1}, with mean of 6.43 Bqkg^{-1}). The results are comparable with soils from southwest Syria (1.2–110 Bqkg^{-1}). Regression analysis revealed a significant correlation ($p = 0.02$) between silt content and ^{210}Po activity, highlighting the strong role of silt in polonium adsorption. Conversely, no significant association was observed with soil organic matter, clay, or organic carbon, which contrasts with findings from other ecosystems where ^{210}Po correlates with organic content and clay minerals. This discrepancy may be attributed to the pyrite-rich geological formations of the Singhbhum region, which can lower soil pH and alter ^{210}Po distribution in soil matrix.

Furthermore, no systematic variation in ^{210}Po activity was observed with increasing distance from the mining complex, suggesting localized geochemical controls. The study emphasizes that silt content is the dominant factor influencing ^{210}Po retention in Jaduguda soils, whereas acidic conditions linked to pyrite formations may reduce the association of ^{210}Po with organic matter. These findings contribute to the understanding of radionuclide behavior in uranium mineralised regions and provide comparative insights with other global ecosystems.

Keywords: Uranium mining; Soil; Polonium

Paper ID: 054

Green human resource management (GHRM): integrating environmental policies into HR practices

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ABSTRACT

This study explores the extent to which Green Human Resource Management (GHRM) practices are applied in India and proposes a framework for embedding environmental considerations into HR policies and processes. The focus is on building a comprehensive approach where sustainability principles are consistently reflected across recruitment, training, appraisal, and employee engagement functions. The paper also establishes key theoretical and methodological foundations for examining GHRM, positioning it as a strategic instrument for advancing corporate social responsibility initiatives that address environmental challenges. The results reveal that although GHRM encourages environmentally responsible behaviour and supports innovative employee-driven green practices, its application in India remains limited. Evidence from job postings on leading employment platforms shows that environmental aspects are rarely prioritized in HR requirements. At the same time, the study underscores the growing importance of green issues and the development of a sustainable economy within the country. To strengthen the adoption of GHRM, the paper recommends several measures, including the integration of GHRM-focused courses in higher education, the introduction of certification and training modules, and the organization of professional forums, workshops, and conferences. These actions can increase awareness among managers, HR professionals, and business leaders, ultimately fostering greater alignment between HR functions and environmental sustainability goals.

Keywords: Green Human Resource Management (GHRM); Environmental Policy Integration; Sustainable Workforce Practices; Human Resource Development; Eco-friendly Organisational Strategies

Paper ID: 061

Life cycle assessment of plastic waste-integrated concrete mixtures as a pollution control strategy for sustainable construction

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ABSTRACT

The integration of plastic waste into concrete mixtures represents a promising pollution control technology aimed at mitigating the environmental impact of both construction materials and plastic disposal. This study conducts a comprehensive Life Cycle Assessment (LCA) to evaluate the environmental performance of concrete mixtures incorporating varying proportions of recycled plastic waste as partial substitutes for conventional aggregates. The LCA methodology considers all stages from raw material acquisition, material processing, transportation, construction, use phase, and end-of-life disposal or recycling. Results demonstrate that using plastic waste in concrete significantly reduces the consumption of natural aggregates and landfill burden by diverting plastic from waste streams. The substitution results in lower carbon dioxide emissions, reduced energy demand, and decreased ecological footprints compared to traditional concrete manufacturing. Additionally, waste-incorporated concrete exhibits favorable durability and mechanical properties, making it viable for sustainable construction applications. However, the assessment highlights potential trade-offs such as microplastic release during wear and challenges in material recycling at the end-of-life stage. This study emphasizes the importance of optimizing plastic content proportions and improving recycling techniques to maximize environmental benefits. Overall, the LCA underscores the role of plastic waste-concrete mixtures as an effective pollution control technology contributing to circular economy goals and sustainable infrastructure development. The findings support policy frameworks encouraging innovation in construction materials to reduce pollution impacts and promote resource efficiency.

Keywords: Life cycle assessment; Pollution control; Plastic waste; Concrete mixtures; Sustainable construction.

Paper ID: 064

Governance and policy frameworks for environmental sustainability

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ABSTRACT

This paper investigates the effectiveness of governance structures and policy frameworks in shaping environmental management in India. The objective is to critically assess why, despite the presence of extensive laws and regulations, implementation remains weak and outcomes inconsistent.

A qualitative and analytical approach is adopted, drawing on case studies of policy execution across multiple sectors, including air pollution control, watershed management and forest conservation. The study applies a governance framework focusing on two dimensions: institutional coordination across Central, State and local levels and policy coherence between environmental objectives and socio-economic development priorities. Data sources include government reports, policy documents, judicial interventions and secondary academic literature.

The findings reveal that fragmented institutional mandates, overlapping jurisdictions and weak enforcement capacity create significant barriers to effective environmental governance. Similarly, incoherence between economic growth agendas and environmental priorities often results in trade-offs that compromise ecological sustainability. These structural weaknesses explain the persistent gap between policy intent and environmental outcomes in India. The discussion emphasizes that effective governance requires streamlining institutional responsibilities, improving vertical and horizontal coordination and integrating sustainability into mainstream development planning. It also underscores the role of accountability and monitoring mechanisms in bridging the gap between regulation and practice.

The paper concludes that strengthening institutional coordination and achieving policy coherence are essential for advancing India's environmental management capacity. The analysis contributes to governance scholarship by providing an India-specific perspective on how structural reforms in governance can drive more sustainable and implementable environmental policies.

Keywords: Environmental governance; Institutional coordination; Policy coherence; Sustainable development; Environmental policy

Paper ID: 079

Smart cities or eco-cities: which direction should India take in the era of artificial intelligence?

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ABSTRACT

One of the major goals of modern India is to transform into a developed nation by 2047. To achieve this objective in 2015, India has launched Smart City Mission (SCM) aimed at transforming over hundred cities into smart cities. These cities leverage technology, infrastructure development, and data management to enhance urban service efficiency, improve quality of life, and drive economic growth. Unfortunately this growth comes at the cost of increase in air and water pollution, deforestation, and loss of biodiversity. The Environmental Performance Index (EPI) ranked India 176th among 180 countries (2024) in environment sustainability which indicates we need to think differently without hampering our major objective of development.

The best possible way out is to convert these smart cities into smart-eco cities. While improving lifestyle comfort is a major goal of smart cities, the central concept of eco-cities is derived from minimizing the environmental impact from technology uses. The urban eco-cities (smart-eco cities) are designed with a primary focus on sustainability and environmental wellbeing. These cities integrate green technologies, practice sustainability and brainstorm innovative solutions at every aspect of urban life to minimize ecological footprint. This may include energy-efficient buildings, extensive green spaces, and sustainable transportation systems, such as electric public transit and bike-sharing programs.

In the present paper the authors proposed an Artificial Intelligence of things (AIOT) driven model to transform the smart cities into sustainable smart-eco cities. AIOT is the integration of Artificial Intelligence (AI) into Internet of Things (IoT). Here, IoT devices are the physical objects which with the help of sensors extract enormous data. By integrating AI algorithms, these devices can derive meaningful insights from the huge data they generate, leading to improved efficiency, predictive maintenance, and innovative solutions. AIOT technology if use in smart cities can optimize energy and material flows, improve air and water quality, reduce waste, monitor and conserve forest areas, educate the public on environmental management, and help build sustainable eco-cities for a promising future.

Keywords: SCM; Smart cities; Smart-eco cities; AI, AIOT

Paper ID: 082

Experimental Study on the use of tire-derived aggregates for soil stabilization

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ABSTRACT

Expansive soils like black cotton soil pose serious challenges for infrastructure due to their high swelling and shrinkage potential. This study explores the effectiveness of tire-derived aggregates (TDA) as a sustainable stabilizer. These soils, which are widely distributed throughout India, require stabilization since they are inappropriate for direct use in subgrades and foundations without first undergoing treatment. The purpose of this research is to determine whether tire-derived aggregate (TDA) can enhance the geotechnical behavior of black cotton soil as a sustainable stabilizing supplement. TDA provides the combined benefits of trash utilization and soil development, which is beneficial given the growing environmental burden of disposing of scrap tires. Using three distinct size grades, experimental work was conducted in expansive soil with TDA levels of 5%, 10%, and 15% (by dry mass). The blended soils' compaction, swelling, and strength properties were evaluated by using a battery of laboratory tests, such as the California Bearing Ratio (CBR), free swell index, and standard Proctor compaction. The results show that TDA significantly reduces swelling and plasticity while improving strength characteristics. Due to its low weight and water-repellent properties, the study demonstrates that the addition of TDA decreases the swelling and plasticity of black cotton soil. 10% medium to coarse TDA produced the best effects, improving strength and reducing soil expansivity from high to moderate. All things considered, TDA offers a practical, cost-effective, and environmentally sustainable method of stabilizing expansive soils for foundations and pavements.

Keywords: Black cotton soil; Tire-derived aggregate (TDA); Swelling potential; CBR.

Paper ID: 091

Addressing the urban heat challenge in Delhi: mitigation, economic benefits, and policy pathways

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ABSTRACT

Delhi's rapid urbanization has intensified the Urban Heat Island (UHI) effect, resulting in elevated surface and air temperatures, deteriorating air quality, and surging energy demand. These environmental stressors exacerbate public health risks, increase cooling-related energy consumption, and strain critical infrastructure. Ultimately threatening the city's economic competitiveness and long-term sustainability. While economic growth and infrastructure expansion remain vital for India's development agenda. Failure to integrate UHI mitigation into urban planning could undermine national climate commitments, sustainable development goals, and social equity objectives.

This study adopts a policy-oriented, multi-dimensional lens to examine Delhi's UHI challenge. Analyzing technological interventions, their economic feasibility, and governance frameworks for effective implementation. Proposed mitigation strategies include mandatory adoption of reflective roofing and permeable pavements, large-scale green infrastructure development (urban forests, vertical gardens), energy-efficient building codes, and integration of renewable energy in urban cooling systems.

The research emphasizes the need for institutional coordination between municipal authorities, state agencies, and central ministries. Also, a multi-level governance models for mainstreaming UHI mitigation into land-use planning, building regulations, and transport policies. Economic assessments indicate that targeted investments in heat mitigation yield substantial co-benefits—reducing cooling energy costs by up to 20%. Thereby, enhancing workforce productivity, and cutting healthcare expenditures linked to heat stress. Policy recommendations include fiscal incentives for cool roofs and reflective surfaces. Mandatory urban greening norms in building approvals, climate-resilient zoning guidelines, and public-private partnership (PPP) frameworks for large-scale retrofitting projects. By aligning technology, economics, and governance, this research presents a practical policy roadmap for transforming Delhi into a climate-resilient metropolis while sustaining its economic growth trajectory and fulfilling national and international climate obligations.

Keywords: Urban heat island; Urban planning, Green infrastructure policy; Energy-efficient building; Public-private partnerships

Paper ID: 104

Evaluation of lime-stabilized compressed earth blocks as a sustainable alternative to cement-based masonry units

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ABSTRACT

Compressed Earth blocks (CEBs) are increasingly being used as a sustainable eco-friendly alternative to conventional burnt bricks masonry units due to their low embodied energy and use of locally available soils. Conventionally, cement has been used as the primary binding material in the production of CEBs; however, this approach raises concerns regarding cost and environmental factors. In the present study, lime is used as an alternative binder to cement to evaluate its feasibility as a stabilizing material, with a water to binder ratio of 1.2. The developed blocks are evaluated for their mechanical properties through compressive strength and splitting tensile strength tests, while physical properties such as density and dimensional stability, along with durability properties such as water absorption and material pH are also determined. In addition, the environmental impact is analyzed by estimating the embodied energy and CO_2 emissions of lime-stabilized blocks and comparing them with conventional cement-stabilized blocks. In contrast to the earlier investigations that mostly concentrated on the cultivable soils, this study focuses on the lateritic soil, which is generally non-cultivable, thereby promoting land use. The results are compared with the conventional CEBs developed using cement to assess the impacts in mechanical and environmental performance.

Keywords: CEBs; Lateritic soil; Cement; Lime; Mechanical properties

Paper ID: 105

Psychological and perceptual feature engineering for electric vehicle purchase willingness; a principal component and explainable AI approach

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ABSTRACT

Electric vehicles (EVs) offer an essential solution towards energy security and reducing the impact of environmental degradation. Nevertheless, adoption remains slow in many places, not only due to infrastructural or financial constraints, but also because of people's perceptions and mental calculations about the necessity of change. This study considers psychological and perceptual determinants that affect the readiness of people to purchase EVs within the framework of interpretable machine learning. Principal Component Analysis (PCA) was conducted on twenty perception-driven variables, resulting in four latent constructs: "Environmental and Pro-EV Attitude," "Tech Trust and Social Influence," "Perceived Usability and Range Assurance," and "Cost Sensitivity and Financial Risk." Socio-demographic characteristics and these components were included in training an XGBoost classifier, which achieved a predictive accuracy of 86.7%. The SHapley Additive exPlanations (SHAP) approach secured model interpretability by showing the relative preference of factors in prediction outcomes. Compared to other components, "Tech Trust and Social Influence" had the strongest positive effect on purchase intention, while "Cost Sensitivity and Financial Risk" was the most significant deterrent. "Environmental and Pro-EV Attitude" and "Perceived Usability and Range Assurance" also contributed meaningfully. These results emphasise the multidimensionality of EV adoption choices and illustrate the value of psychological and perceptual feature engineering in behavioural forecasting practices. By combining dimensionality reduction with explainable artificial intelligence (XAI), the study contributes methodological advances and offers practical implications to policymakers interested in accelerating EV adoption through trust building and targeted awareness campaigns.

Keywords: Electric vehicle adoption; Psychological and perceptual modelling; Explainable AI; Principal component analysis; Sustainable urban mobility

Paper ID: 108

Effect of nitric acid polluted water on Atterberg limits of bentonite

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ABSTRACT

Construction of the structural foundation in expansive and sensitive soil, such as bentonite, may be necessary in the near future because the amount of land with suitable stronger soil is rapidly decreasing owing to the global population growth. The shrinkage and swelling characteristics of bentonite become very complicated when it interacts with acidic polluted water, which can occasionally happen due to industrial gas emissions, such as oxides of principally sulphur and nitrogen resulting in acid formation. Numerous scientific investigations have been carried out worldwide to examine the impacts of different chemical and mineral additives on the various geotechnical features of expansive soils like bentonite. However, the effect of acid contaminated water on Atterberg limits of bentonite has rarely been studied. The main objective of the current study is to investigate the impact of nitric acid (HNO_3) on the Atterberg limits of bentonite clay. The study analyzed the test results of liquid limit (LL), plastic limit (PL) and shrinkage limit (SL) of bentonite treated with ten different concentrations of HNO_3. The study found that the LL and PL of the bentonite considerably reduce while the HNO_3 concentration rises. Whereas the SL of the bentonite increases with the rise in the concentration of HNO_3. As a result, both the plasticity index (PI) and shrinkage index (SI) of the bentonite are interestingly found to fall significantly. These findings clearly indicate the efficiency of HNO_3 in mitigating the volume change behavior and shrinkage cracking potential of the bentonite. The study thus advocates the resulting soil to have a tendency in reduction of swelling, shrinkage, and sticky properties, plausibly improving its suitability for construction in the expansive soil after interacting with nitric acid polluted water.

Keywords: Expansive soil; Bentonite; Nitric acid; Acid polluted water; Atterberg limit

Paper ID: 109

Utilization of fly ash in reduction of plasticity and compression indices of silty clay loam

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ABSTRACT

Different geotechnical characteristics of different kinds of soil materials can be improved by reusing fly ash (FA) which is a widely available waste material in India, for its ecologic and economic benefits. In an effort to find the best places to utilize this waste material for a variety of useful applications, numerous research studies have recently been carried out all over the world for improving various engineering and geotechnical properties of different types of nation specific indigenous native soils. However, the impacts of FA on the plastic behavior and compression properties of silty clay loam (SCL) have hardly been studied. The influence of fly ash on the plastic properties and compression characteristics of SCL is considered as the principal objective of the current investigation. The current study analyzed the experimental results of two consistency limits i.e. liquid limit (LL) and plastic limit (PL) as well as two indices i.e. plasticity index (PI) and compression index (CI) of SCL blended with six distinct incremental percentages of 5%, 10%, 15%, 20%, 25%, and 30% of FA. The study reveals a consistent fall in both LL and PL of SCL. The LL reduces to 28% from 43% whereas the PL decreases to 13% from 18% when the % FA reaches from 0 to 30%. Evidently, it indicates a mitigation in plastic and compression behavior of the SCL as the PI and CI reduces by 40% and 45% respectively. This study thus advocates that the fly ash might be utilized as an additive with silty clay loam to minimize its plastic and compression potential.

Keywords: Plasticity index; Compression index; Fly ash; Silty clay loam

Paper ID: 113

Impact of urea-polluted water on consistency of black cotton soil

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ABSTRACT

The global population is growing exponentially, which is causing the amount of habitable land with soil suitable for geotechnical construction to diminish daily. As a result, it is now necessary to build structural foundations on cultivated land with expansive and sensitive soil, like black cotton soil (BCS). In particular, when BCS interacts with nitrogen-based fertilizers over several years during its farming lifetime, its sensitivity and expansiveness become extremely critical. Many research has recently been conducted to look into these kinds of soils for appropriate uses by altering their varied properties in the presence of different substances. However, the influence of nitrogen-based fertilizers on the consistency and plasticity of expansive soil has rarely been studied. This study mainly focuses on the investigation of the consistency of BCS affected by water polluted by urea, which is the most widely used nitrogen-based fertilizer. Two consistency limits, the liquid limit (LL) and the plastic limit (PL), of BCS treated with eight distinct urea solutions with progressive molarities of 0.2 M, 0.4 M, 0.6 M, 0.8 M, 1.0 M, 1.2 M, 1.4 M, and 1.6 M are evaluated experimentally in this work. The study shows a steady increase in LL and PL of BCS. When the molarity of the urea solution rises from 0.2M to 1.6M, the LL rises from 64% to 84% and the PL rises from 32% to 39%. The study also found that the plasticity index (PI) and compression index (Cc) increase by 10% and 21%, respectively, which clearly showed that the plasticity and consistency behavior of the BCS has been aggravated. This might be because of changes in physicochemical properties such as molecular polarity, adsorption, and adhesion of BCS due to interaction with the urea-polluted water. This study thus advocates the necessity to examine the influence of urea in the cultivated soil to understand its plasticity and consistency before constructing a foundation.

Keywords: Black cotton soil; Urea-polluted water; Consistency; Plasticity

Paper ID: 123

A comparative analysis of global e-waste policies: evaluating the effectiveness of legislation in the EU, North America, and Asia

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ABSTRACT

This paper presents a systematic comparative analysis of electronic waste (e-waste) management policies across three major regions: the European Union, North America, and Asia. With global e-waste generation reaching 62 million tonnes in 2022 and only 22.3 percent being properly recycled, effective policy frameworks are critical for sustainable technology management. This study evaluates policy effectiveness using standardized metrics including collection rates, recycling performance, Extended Producer Responsibility (EPR) implementation, and enforcement mechanisms. The analysis reveals significant variations in approaches and outcomes: the EU achieves 42.8 percent collection rates through mandatory EPR and harmonized targets, North America demonstrates fragmented state-level governance with 30 percent collection rates, while Asian countries show diverse national systems averaging 11.8 percent collection rates. The EU's comprehensive WEEE Directive shows superior performance in formal recycling infrastructure, though falls short of 65 percent collection targets. North American fragmentation creates compliance challenges and inconsistent outcomes across states. Asian systems demonstrate innovation in digital tracking and EPR certificate trading but face enforcement and informal sector integration challenges. The study identifies key success factors including mandatory EPR implementation, clear producer responsibilities, adequate enforcement mechanisms, and stakeholder coordination. Results provide evidence-based recommendations for policy harmonization and effectiveness improvement across regions.

Keywords: Green computing; E-waste policy; Electronic waste management; Circular economy; Sustainable development.

Paper ID: 143

Synergistic application of Ag/TiO_2 as an anode catalyst in the single chamber microbial electrosynthesis to enhance bioconversion of CO_2 to volatile fatty acids

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ABSTRACT

The ever-increasing global warming concerns and the urgent demand for sustainable energy production have stimulated innovation in technologies that can convert CO_2 into valuables. Microbial electrosynthesis (MES) is a promising approach that harness electrotrophs to transform CO_2 into sustainable products, thereby offsetting greenhouse gas emissions. Nevertheless, several obstacles hinder the efficiency of MES, including corrosion of electrodes, slow electron transfer, reliance on expensive catalysts and inefficient reactor designs, limiting its widespread applications. To overcome these limitations, researchers have explored cost-effective single-chamber MES with different catalysts, leading to the development of matured biofilm on the cathode. While single chamber designs are simple and affordable, their lack of product separation makes them vulnerable to accumulating inhibitory products and the consumption of valuable volatile fatty acids (VFAs) by anodic microbes. To address this, this study explored the application of a silver-titanium dioxide (Ag/TiO_2) nanoparticle as an anode catalyst for a single chamber MES (MES-AgT), for its antimicrobial and conductive properties. This captivating technique aims to boost the overall performance of MES, achieving higher yields in CO_2 valorization. The overall performance of MES-AgT was also compared to a control MES (MES-C) operated without any anode catalyst. Among all VFA products, acetate and propionate were found to be the most prevalent in both MES systems. The maximum 35.12 mg/L/day and 53.05 mg/L/day of acetate and propionate, were produced after fourth day of operation with a carbon consumption efficiency of 85.2 %, through MES-AgT, which were 1.3 and 1.4 times higher compared to MES-C, respectively. After 10 days of operation, VFAs in the MES-C system were completely degraded, while the MES-AgT system still contained 30% of the total VFA concentration. Moreover, MES-AgT also attained a 1.5 times higher current density in comparison to control MES-C due to more stable and mature biofilm growth on the cathode. The improved performance of MES-AgT can be attributed to the dual effects of the highly conductive $AgTiO_2$ anode catalyst. Also, the Ag component's antimicrobial property prevents the growth of competing microbes, which helps to reduce the consumption of VFAs at the anode. Meanwhile, semiconductor TiO_2 can directly catalyze oxidation reactions, potentially enhanced water splitting and active sites for higher electron transfer, boosting the overall performance of MES. Therefore, this research pioneers the application of Ag/TiO_2 as a potent anode catalyst of MES, intending to guide researchers in realizing the feasibility of this technology by presenting a sustainable and less energy-intensive strategy.

Keywords: Anode catalyst; Anti-biofouling; Carbon capture; Microbial electrosynthesis; Volatile fatty acids

Paper ID: 152

Environment protection need: sustainable approach for soil conservation and use of beneficial microbes for managing plant soil interaction

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ABSTRACT

Its need of hour to protect mother earth (soil) from chemical and pesticide attack. It's not only uniformity that can save humanity, that everyone should follow the same methodology of farming it's not like that, as diversity is rule of nature everything in nature is diverse this made to study the soil in that direction. Beyond diversity there is something which connects and has interaction between the soil and crops. With the use of chemicals it confined the yield of crops but single interpretation is not at all eternal truth. This has turned as cancerous casualty today. Significance of study of sustainable approach for soil conservation is accounting circular economy in environmental management of soil with experimental study of soil parameters developing three fields with alikeness soil type with average 5000sft. area at one location only, in which one field microbes implanted, second field nothing implanted field kept natural and in third field chemical fertilizers implanted. Objective to study the soil parameter, consumption of water for each field, microbial count and study plant-soil interaction. Results of soil parameters after one year of work have proven increase by 30% in count of Electrical conductivity, increase by 27.55% in count of Organic carbon, increase by 23.33% in count of Nitrogen, increase by 22.4% in count of Phosphorus in the field were the microbes where implanted, compared with chemical fertilizers implanted field. It may be concluded with continuous use of beneficial microbes it is possible to sustain the soil to it natural parameter also study of sustainable approach for soil conservation and environmental management of soil to get sustainable crops and maintain the good health of soil.

Keywords: Microbes field; Natural field; Chemical field; Electrical conductivity; Organic carbon

Paper ID: 164

Advancing circular economy through iso 59000: a strategic framework for pollution control and a clean environment

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ABSTRACT

Moving toward a circular economy is one of the most significant changes in the way society and industry change the way they use and dispose of resources and their effects on the environment. The culmination of this change will be the management standard ISO 59000 series, which offers global guidelines on the strategic management of resources, the reduction of waste, and the sustainable achievement of circular economies. This paper offers, in relation to the international community's sustainable development goals, a seven-pillar framework to implement ISO 59000 in structured and quantifiable manners.

The first pillar, Circular Integration, focuses on the incorporation of circular governance, systems, and decision-making processes. Resource Optimization focuses on the more efficient use of materials, energy, and water in productive activities to minimize diversionary waste and excess use, maximizing productive achievement. Waste Valorization focuses more on the recovery and recycling of waste to become resources to be used again. Systemic Circularity focuses on closed loop systems and the life-cycle evolution of systems to maintain a flow of resources in a circular economy. The fifth pillar, Innovation and Collaboration, drives the use of new strategies to bring technology and new partnerships to facilitate knowledge transfer and accelerate circular systems. Measurement and Accountability consists of standardized metrics and indicators to track improvement and facilitate ongoing enhancements. Lastly, Policy and Compliance Alignment completes the cycle by guaranteeing that activities are aligned with regulatory requisites and overarching sustainability goals. All seven pillars together comprise an executable framework that combines science, technology, and policy. ISO 59000 serves as a pragmatic enabler and a policy driver by uniforming highly efficient, waste-free, and closed-loop system approaches. It also shows the positive impact of strategic circularity on environmental, economic, and social value and on resilience, innovation, and enduring sustainability.

Keywords: Resource Optimization; Waste Valorization; Systemic Circularity; Innovation and Collaboration; Measurement and Accountability

Paper ID: 166

Integrating spatial and machine learning algorithms for mapping of urban green spaces of Chh. Sambhajinagar

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ABSTRACT

Urban green spaces (UGS) which include the green lands, water bodies and wetlands are essential for the cities for the provision of ecosystem services as well as health benefits for their residents. These green spaces act as city's lungs and also play an important role in mitigating the impacts of climate change and air pollution. Therefore, the mapping of these UGS holds immense value for urban planning, ecological monitoring and implementing initiatives for environmental conservation. This approach not only aligns with environmental goals but also offers significant economic benefits. High levels of air pollutants especially the PM 10 and 2.5 (Particulate matter) in Indian cities is a significant cause of concern. For achieving a substantial improvement in air quality the Government of India in 2019 launched the NCAP (National Clean Air Programme) covering 130 cities, targeting 40% reduction in PM 10 levels by the year 2025-26. City of Chh. Sambhajinagar (formerly Aurangabad) is also included within the Non-Attainment cities list of the country. This implies that the city must focus on measures such as enhancing the green cover for reducing PM 10 levels. The Government of India has launched various policy initiatives to increase the urban green spaces such as AMRUT 1.0 (Atal Mission for Rejuvenation and Urban Transformation) this scheme launched in 2015 strived for improving the green spaces in addition to water supply, sewerage, non-motorized transport. The recently launched Nagar Van Yojana intends to develop 600 Nagar Vans and 400 Nagar vatikas till 2026-27 for enhancing the green cover, biodiversity and mitigating the adverse impacts of air pollution as well as climate change.

This research work is centered on Chhatrapati Sambhajinagar city and seeks to provide a thorough evaluation of trends in green cover. The study is to be carried out in two phases: (1) a decade-wise analysis of trend in the green cover (2) zone-wise comparison within the Smart City limit, emphasizing differences in green cover between zones (3) and measuring the success of interventions planned (urban forests, plantation). With the integration of spatial analysis, and machine learning algorithms, significant insights will be obtained in the trends of green infrastructure in the city. These results would assist in urban planning driven by data and focused greening strategies for improving climate resilience and high air pollutant levels.

Keywords: Machine learning; Mapping; Urban; Green spaces; Chh. Sambhajinagar

Paper ID: 172

Development of a CNG-powered tractor

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ABSTRACT

Air pollution from traditional fossil fuel-based engines has become a critical environmental and public health concern, contributing to respiratory diseases, cardiovascular problems, and environmental degradation. In India, tractors play a vital role in agriculture, with millions of units operating across diverse farming landscapes. However, most of these tractors run on diesel, which emits significant amounts of pollutants such as particulate matter and nitrogen oxides. Compressed Natural Gas (CNG) offers a cleaner alternative fuel with lower emissions of harmful pollutants, making it an attractive option for reducing the environmental footprint of agricultural machinery. This paper presents the development of a tractor powered by CNG, highlighting its multiple advantages such as significant reduction in pollution and noise levels, along with enhanced cost efficiency. The CNG tractor is particularly well-suited for low horsepower (HP) tractor operations commonly used in agricultural settings. The engine's performance has been rigorously evaluated using advanced simulation software, including ANSYS, demonstrating excellent operational results. The study concludes that CNG-powered tractors provide an environmentally friendly and economical alternative to conventional diesel-powered tractors, supporting sustainable agricultural practices in India.

Keywords: CNG tractor; Alternative fuel; Emission reduction; Sustainable agriculture; Simulation analysis

Paper ID: 177

Assessing thermal stability of forest fire derived pyro-char carbon: Implications for long term soil carbon persistence in relation to climate change

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ABSTRACT

Wildfires are frequent hazard in dry deciduous forests of Odisha and play a major role in shaping forest ecosystems. Incomplete combustion produces pyrogenic carbon (PyC) and due to its aromatic as well as condensed structures, it is highly recalcitrant, resisting microbial decomposition and thermal breakdown. Consequently, it persists in soils for millennia, influencing carbon sequestration, nutrient cycling, and ecosystem resilience. To assess these dynamics, PyC samples were collected from burned and control soils (0–5 cm depth) in the Sulia reserve forest, Nayagarh district, Odisha. Thermogravimetric analysis (TGA) determined the TG-T_{50} index (50% thermogravimetric mass loss) for thermal stability; Carbon Nitrogen ratio (C:N) reflected carbon stability; Fourier transform Infrared Spectroscopy (FTIR) characterized aromatic and structural stability; X-ray diffraction (XRD) assessed clay mineral stability; organic carbon estimation provided oxidative stability; and Field emission scanning electron microscope-Energy dispersive X ray spectroscopy (FESEM-EDX) revealed surface topography as well as organo–mineral associations. TGA showed higher combustion-related mass loss in control soils than in PyC soils, as most of organic matter residue were consumed during combustion. The TG-T_{50} index indicated PyC thermal stability at 399 °C with 89.59% mass loss, compared to 360 °C with 96.09% in control soils. The C:N ratio was lower in PyC (0.34%) than in control soils (14.36%), confirming chemical alteration. FTIR spectra revealed phenolic residues and aromatic hydrocarbons in PyC, while XRD peaks showed destruction of kaolinite, feldspar, and hematite. Organic carbon content ranged from 7.16% in PyC to 6.38% in control soils. FESEM revealed porous structures, while EDX confirmed carbon-bound organo–mineral complexes. As PyC is inherently resistant, studying its thermal stability and fate is critical to predicting its longevity, mobility, as well as role in soil carbon stabilization along with long-term carbon cycling. High energy density and aromatic stability of PYC can be useful for bioenergy source that might be used to connect carbon-neutral energy generation.

Keywords: Incomplete combustion; Black carbon; Carbon sequestration; Forest resilience; Recalcitrant carbon

Paper ID: 178

Synergistic role of plant growth–promoting rhizobacteria (PGPR) and biochar in enhancing chromium phytoremediation

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ABSTRACT

Chromium (Cr) contamination, largely originating from mining, tannery, and metallurgical activities, poses serious risks to ecosystems and human health due to its toxicity, persistence, and mobility in soils. Phytoremediation using perennial grasses has emerged as a cost-effective, sustainable alternative for remediation; however, limitations in metal bioavailability and plant tolerance often restrict its efficiency. The present study evaluates the synergistic potential of biochar and plant growth–promoting rhizobacteria (PGPR) as soil amendments for enhancing Cr phytoremediation with two resilient grasses: vetiver (*Chrysopogon zizanioides*) and lemongrass (*Cymbopogon flexuosus*). Biochar, derived from lignocellulosic biomass, improves soil structure, increases cation exchange capacity and modulates the mobility of Cr(VI) to plant-available forms, while also reducing toxicity hotspots through surface sorption and redox reactions. PGPR strains, particularly chromium-resistant and stress-tolerant species, play complementary roles by reducing Cr(VI) to the less toxic Cr(III), enhancing root growth, producing siderophores and phytohormones, and activating plant antioxidant defenses.

Preliminary findings indicate that the combined application of biochar and PGPR results in improved seedling establishment, greater root and shoot biomass, and enhanced chromium accumulation and translocation in both vetiver and lemongrass compared to individual treatments. Vetiver demonstrated higher root accumulation and stabilization capacity, while lemongrass showed stronger shoot translocation potential, suggesting species-specific phytoremediation strategies. The integrated amendment also improved soil pH and microbial activity, contributing to long-term ecosystem recovery.

This study highlights the synergistic role of biochar and PGPR in addressing the dual challenge of reducing chromium bioavailability and enhancing plant uptake efficiency. The findings support the use of these amendments as eco-friendly, low-cost solutions to augment phytoremediation potential of vetiver and lemongrass, with significant implications for the reclamation of chromium-contaminated mine spoils, industrial effluents, and marginal lands.

Keywords: Chromium; Biochar; PGPR; Vetiver; Lemongrass; Bioavailability.

Paper ID: 191

Survey of consumer perceptions for electronic waste management: A Case study of Chh. Sambhajinagar city

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ABSTRACT

Electronic waste (e-waste) comprises discarded electrical and electronic equipment, either in whole or in parts, and has emerged as a major environmental challenge due to the rapidly decreasing lifespan of electronic products. Globally, e-waste generation reached nearly 60 million metric tonnes in 2023, with China, the United States, and India being the leading contributors, while recycling rates remain critically low. In India, Maharashtra ranks among the highest e-waste-generating states, with cities such as Mumbai, Pune, Nagpur, and Chhatrapati Sambhajinagar contributing significantly. Consumer perception and awareness remain key factors influencing the effectiveness of e-waste management systems. In the present study, consumer awareness, perception, and disposal practices related to e-waste management were assessed among residents of Chhatrapati Sambhajinagar city, Maharashtra. A cross-sectional survey was conducted using a structured questionnaire administered to 620 respondents representing students, households, shopkeepers, industry personnel, and street vendors. The findings reveal a moderate level of awareness, with 60% of respondents aware of the concept of e-waste, 27% partially aware, and 13% unaware. Statistical analysis using the chi-square test indicated a significant association ($p < 0.05$) between awareness level and e-waste disposal practices, suggesting that awareness influences disposal behaviour. Correlation analysis further showed a positive relationship between awareness and perceived environmental and health risks, although this awareness did not consistently translate into environmentally sound disposal practices. The study highlights that despite moderate awareness, improper disposal of e-waste remains prevalent due to limited knowledge of formal collection systems and inadequate infrastructure. Awareness alone is therefore insufficient to ensure sustainable e-waste management unless supported by accessible collection facilities, incentive-based mechanisms, and effective enforcement of regulatory frameworks. Enhanced stakeholder awareness combined with strengthened formal recycling systems can play a crucial role in improving e-waste recycling and processing outcomes in rapidly urbanizing cities such as Chhatrapati Sambhajinagar.

Keywords: E-waste; Heavy metals; Hazards; Consumer Awareness; Processing

Paper ID: 192

Environmental impact of vehicle coolants in emerging indian cities: risks and sustainable alternatives

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ABSTRACT

Coolants—mainly made from chemicals like ethylene glycol and propylene glycol—are needed to keep car engines from overheating. But when coolants leak or are discarded improperly by garages or service centres, they can pollute soil and water. This short study focuses on Chhatrapati Sambhajinagar, Maharashtra, where vehicle use is rising, making coolant pollution a local concern. To understand the scale, we first looked at the number of garages and service centres. There are about 100 cashless garages listed for the city on Zurich Kotak General Insurance, and at least 20 more are listed by PolicyBazaar. From this, we assume around 120 garages and service centres are actively handling coolants. If each garage handles about 50 liters per week, the city may be using or changing about 6,000 liters weekly and over 312,000 liters yearly. Even if 10% is thrown away improperly, that is still more than 30,000 liters of coolant entering the local environment each year. During simple field checks near garages and drains, we found small but detectable signs of coolant chemicals. Rainwater during monsoon reduces concentration but can spread pollutants further. Groundwater tests showed that glycols usually break down fast in nature, but pollution was worse in places where coolant was mixed with oil or other waste. This suggests that disposal practices are the main problem, not only the coolant itself. Sustainable alternatives like 1) Nano-coolants: Better cooling (10–30%) but costly. Additive type is affordable, full nanofluid is very expensive 2) Bio-coolants: Eco-friendly, safe, slightly costlier than normal coolant 3) Conventional coolant: Cheapest and widely used. In India, bio-coolants are more practical, while nano-coolants are suitable mainly for EVs or special systems. help reduce this impact and also Recycling old coolant at garages and setting up local collection or treatment systems will also lower risks. Along with this, mechanics and vehicle owners should be made aware of safe disposal practices. If such steps are taken, Chhatrapati Sambhajinagar can control coolant-related pollution and protect both soil and water resources.

Paper ID: 204

Designing AI assisted low emission zones in a city – a case study

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ABSTRACT

A Low Emission Zone (LEZ) is an area where entry of highly polluting vehicles is restricted to reduce air pollution. Many international cities such as Berlin, London, and Paris have successfully implemented LEZs to encourage cleaner transport and sustainable living. In India, similar initiatives are seen in places like Chandni Chowk (Delhi) and proposed projects in Pune and Pimpri-Chinchwad. Creating LEZs in cities like Chh. Sambhajinagar can play a key role in developing a sustainable smart city and improving the public health. Such initiatives not only protect the environment but also improve quality of life, promote green mobility, and create a modern urban ecosystem for future generations. The use of Artificial Intelligence and Machine Learning tools can analyze traffic flow, predict pollution peaks, suggest alternative routes, and even recommend city planning strategies to minimize emissions. And manage such zones by analyzing traffic, pollution levels, and leading to more efficient solutions.

Keywords: Air Quality; City; Pollution; Low emission zone; AI assisted

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Empirical insights into global green economy dynamics: drivers and developmental outcomes

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ABSTRACT

The evolution of the green economy is inherently multidimensional, encompassing the dynamic interplay of environmental health, governance quality, technological innovation, and social development. Over the past few decades, the convergence of environmental sustainability and economic growth has given rise to the concept of the green economy, a transformative framework aimed at harmonizing ecological preservation, inclusive social progress, and sustained economic advancement.

This study explores the determinants and developmental outcomes of the green economy using a comprehensive panel datasets of several countries spanning from 2000 to 2023. A multifaceted Green Economy Index (GEI) was constructed to capture the multidimensional nature of green growth. The index integrates indicators across four core dimensions, environmental health (air pollutants, forest area, greenhouse gas emissions), innovation and governance (R&D spending, regulatory quality, government efficacy), resource efficiency (energy intensity, renewable energy adoption, water and land use), and socioeconomic well-being (GDP growth, poverty rate, life expectancy).The key forces driving green economy transitions are identified, and their impacts on major development outcomes are assessed using dynamic panel regression models and fixed effects on balanced multi-year country data.

The empirical findings highlight that countries investing in innovation, regulatory quality, and renewable resource efficiency tend to achieve higher sustainable development outcomes and reduced environmental degradation. The results emphasize the crucial role of governance and technological advancement in shaping long-term ecological and economic resilience. The study offers valuable insights for policymakers aiming to balance environmental priorities with growth imperatives and on sustainable transition strategies in modern era.

Keywords: Green Economy; Panel Data Analysis; Sustainable Development; Renewable Energy; Regression Model

Paper ID: 253

Evaluating urban RF radiation levels using the NARDA SRM-3006: a case study of Bhubaneswar, India

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ABSTRACT

With the rapid expansion of wireless communication networks, especially 4G and 5G, urban areas are increasingly exposed to radiofrequency (RF) electromagnetic fields. Although RF radiation is non-ionizing, its continuous presence in densely populated regions has raised environmental and public health concerns. Assessing these exposure levels is therefore essential for effective urban environmental management and policy formulation.

This study investigates the levels of ambient RF radiation across different parts of Bhubaneswar, Odisha, using the NARDA SRM-3006 selective radiation meter. Measurements were taken in diverse environments, like commercial centers, residential neighborhoods, and institutional areas, covering the frequency range from 100 kHz to 6 GHz. Key parameters such as electric field strength (V/m), power density (W/m^2), and dominant frequency sources were recorded. The collected data were analyzed to identify spatial and temporal variations in exposure and compared with the safety limits recommended by the international commission on non-Ionizing radiation protection (ICNIRP) and India's department of telecommunications (DoT).

Findings reveal that RF exposure levels across Bhubaneswar are well within international safety guidelines. However, slightly higher values were observed near clusters of mobile base stations and busy commercial zones, particularly during peak network usage periods. The results highlight the need to include RF radiation assessment within broader environmental monitoring and smart city planning frameworks. Establishing regular RF audits and adopting global best practices can help ensure that technological growth continues in a safe and sustainable manner.

Keywords: RF radiation; Electromagnetic exposure; Bhubaneswar; NARDA SRM-3006; Environmental monitoring

Paper ID: 257

Impact of the implementation of business responsibility and sustainable reporting (BRSR) framework on net zero target

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ABSTRACT

The pursuit of net-zero emissions has become a defining goal for corporate sustainability globally, and India's introduction of the Business Responsibility and Sustainability Reporting (BRSR) framework marks a pivotal regulatory shift in aligning business practices with climate targets. This study examines the impact of the BRSR framework's implementation on the progress toward corporate net-zero commitments among Indian companies. By adopting a mixed-method approach—combining quantitative analysis of sustainability disclosures from top-listed firms and qualitative insights from industry case studies—the research evaluates how BRSR-aligned reporting has influenced environmental governance, carbon accounting accuracy, and strategic climate investments. Findings suggest that the mandatory structure of BRSR has significantly improved transparency and accountability, enabling better integration of emission reduction metrics into organizational decision-making. The framework facilitates the harmonization of corporate climate disclosures with global standards such as GRI and TCFD, thereby enhancing comparability and investor confidence. However, challenges remain in capacity-building and data consistency, particularly among mid-sized enterprises. The study concludes that the BRSR framework, while still evolving, has accelerated momentum toward India's national net-zero goals by embedding climate-risk management within business operations and capital allocation. Future recommendations emphasize the need for enhanced policy coherence, improved sector-specific guidance, and digital infrastructure for sustainability data to maximize BRSR's role in achieving measurable decarbonization outcomes

Keywords: Net Zero; Sustainability Framework; Environmental disclosures; Climate disclosures; decarbonization.

Paper ID: 258

Integrating economic valuation, Indian knowledge systems, and institutional sustainability indicators for a circular environmental management framework: evidence from NIRF–SDG 2025 data

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ABSTRACT

Sustainability transitions in India demand an integrative framework that bridges economic, ecological, and cultural dimensions of environmental management. This study develops a hybrid analytical model combining economic valuation of ecosystem services, Indian Knowledge Systems (IKS), and institutional sustainability performance data to support evidence-based pollution control and circular resource management. Using secondary data from the National Institutional Ranking Framework (NIRF) Sustainable Development Goals (SDG) 2025 submissions, sustainability indicators from ten leading Indian institutions including IIT Madras, IIT Roorkee, Banaras Hindu University, NIT Rourkela, SRM Institute of Science and Technology (SRMIST) and Indian Agricultural Research Institute (IARI) were analyzed to assess the extent and balance of institutional green practices.

Findings indicate a heterogeneous landscape of sustainability performance. Green area ratios ranged from 11% (NIT Rourkela) to 100% (Jamia Millia Islamia), while renewable energy generation varied widely, with SRMIST (57%) and IARI (9%) leading the spectrum. Wastewater reuse efficiency was highest at Manipal Academy of Higher Education (77%) and SRMIST (70%), whereas waste recycling rates peaked at IARI (99%), but remained below 50% for most technical institutions. Tree density data up to 471,703 trees at NIT Rourkela highlight significant biodiversity commitments. These patterns suggest that while institutional initiatives align with the National Mission for a Green India and Circular Economy frameworks, measurable disparities persist in renewable energy adoption and integrated waste management. The study situates these quantitative insights within the philosophical and ethical dimensions of IKS, referencing environmental stewardship principles from Prithvi Sukta and Vriksha Ayurveda. This fusion of data analytics and traditional ecological ethics underlines the importance of value-based governance, where sustainability is viewed not only as a technical goal but also as a moral and cultural responsibility. The paper proposes a Composite Sustainability Index model integrating environmental performance indicators and non-market valuation metrics to guide institutional and policy-level decision-making. By synthesizing indigenous environmental thought with data-driven metrics, the study contributes a replicable framework for advancing sustainable development and pollution control strategies in higher education and beyond.

Keywords: Sustainability Indicators; Circular Economy; Indian Knowledge Systems; Ecosystem Valuation; Institutional Data Analytics

About ICPCCE 2025

The Indian Institute of Technology Bhubaneswar in Odisha, India, will host the 2nd International Conference on Pollution Control for Clean Environment (ICPCCE-2025). With the newly created control methods, ICPCCE-2025 seeks to give with an understanding of the pollutants present in air, water environments, and in solid waste. In addition to providing details on efficient monitoring, detection, sustainable practices, cleaner, and cutting-edge treatment technologies, ICPCCE-2025 aims to discuss the occurrence of various pollutants, emerging contaminants, micropollutants in water, wastewater, and aquatic environments, pathways, and risk and impact assessments of pollution. In addition to a thorough discussion of carbon capture and storage, ICPCCE-2025 will also cover a number of innovative approaches to solid waste management and the interactions of pollutants in the atmosphere. This will provide a platform for researchers, academicians, policy makers and agencies to share their knowledge on solving environmental pollution. The abstracts of accepted papers are published in the book of abstracts. The accepted full papers will be published as Springer book series Lecture Notes in Civil Engineering.

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