3RD IWA-YWP CANADA CONFERENCE 2025

“Bridging Communities, Shaping the Future of Water Together”

EDMONTON, ALBERTA

JUNE 18- 20, 2025

CONFERENCE PROCEEDINGS

the international water association

YOUNG WATER PROFESSIONALS CANADA

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WELCOME

Hadi Mokarizadeh
Chair

On behalf of the organizing committee, it is my great pleasure to welcome you to the 3rd IWA Young Water Professionals (YWP) Canada Conference and the beautiful city of Edmonton, Alberta. As we work toward achieving the UN Sustainable Development Goal 6 (SDG 6) to ensure access to water and sanitation for all, I recognize the vital role of collaboration and the contributions of YWPs. I believe the success of this goal depends on the collective commitment of all stakeholders, engaging with diverse communities, and working more closely around the world.

This year's conference brings together emerging leaders, students, and professionals from across Canada and beyond to share knowledge, inspire innovation, and foster meaningful collaboration in the water sector. Under the theme "Bridging Communities, Shaping the Future of Water Together," we aim to highlight the critical role young professionals play in shaping the future of our most precious resource, water, through research, innovation, leadership, and inclusive dialogue.

At this conference, you will engage with technical presentations, inspiring keynotes, hands-on workshops, and vibrant networking sessions. Whether this is your first time attending or you are a returning participant at the IWA YWP Canada conference, we hope this event offers valuable opportunities to learn, connect, and grow.

I would like to thank all those who contributed to the success of this event, particularly the organizing and program committees, our passionate volunteers, and our valued partners and sponsors. Your dedication, effort, and support have been vital in making this conference possible.

Thank you for being part of this community and for your commitment to a sustainable and resilient water future. We are excited to see the impact you will make, not only during this event, but throughout your careers.

Regards,
Hadi Mokarizadeh
Chair, 3rd IWA YWP Canada Conference

YOUNG WATER PROFESSIONALS CANADA

3RD IWA-YWP CANADA CONFERENCE 2025

WELCOME

Kala Vairavamoorthy
IWA Executive Director

It's a great pleasure to welcome everyone to the 3rd IWA Young Water Professionals Canada Chapter Conference, taking place in the vibrant city of Edmonton. This gathering is more than just a conference —it is a powerful reminder of the passion, energy, and creativity that young water professionals bring to the global water sector.

Across the world, we are witnessing growing pressures on water systems —resulting from climate change and urbanisation to ageing infrastructure and increasing social inequities. These are challenges that no single institution, government or discipline can solve alone. The future of water depends on collaboration, innovation, and most importantly, on this new generation of leaders who are equipped to think systemically and act boldly.

This is why the IWA YWP community is so vital. You are not only the future of the water sector—you are also the present. Through your research, professional work, engagement and advocacy, you are already driving meaningful change. Conferences like this one play a crucial role in providing a space where young professionals, academics, and industry leaders come together to exchange ideas, forge partnerships, and advance solutions to shared challenges.

The international and interdisciplinary nature of this event—highlighted by a range of participants from across Canada, the United States, Africa, and Asia—reflects the global spirit of IWA. I am especially pleased to see the inclusion of the second international hackathon, where finalists will present innovative solutions to real-world water issues. This speaks directly to the kind of practical, impact-driven engagement that we at IWA deeply value and support.

On behalf of the IWA, I extend my sincere thanks to the organising team, our partners at CAWQ, CWWA, and Water Canada, and all the sponsors who have made this conference possible. I encourage you all to make the most of these days: connect widely, learn openly, and contribute confidently. Together, we are building a water-wise future.

Warm regards,
Kala Vairavamoorthy
Executive Director of the International Water Association

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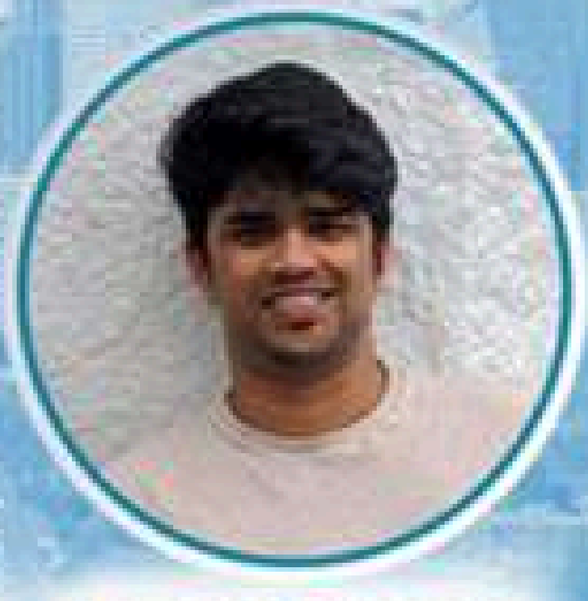

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KEYNOTE SPEAKERS

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Vice President, Regional Growth Leader, Water

Stantec

Dr. Norman Neumann

Professor, School of Public Health

University of Alberta

INVITED SPEAKERS

The Prospects of Membrane Technology for Treating Oil Sands Produced Water

Dr. Mohtada Sadrzadeh, PhD, P.Eng

Professor, University of Alberta

Integration of a Photo-electrochemical Advanced Oxidation Process with a Forward Osmosis Membrane Sewage Treatment System

Dr. Youhei Nomura, PhD

Assistant Professor, Kyoto University

Intensification of Anaerobic Digestion: Role of Pretreatment

Dr. Elsayed Elbeshbishy, PhD

Professor, Toronto Metropolitan University

Biorefinery Possibilities in Wastewater Treatment Plants: The Path to Water Resource Recovery Facilities

Dr. Oliver Iorhemen, PhD, P. Eng

Assistant Professor, University of Northern British Columbia (UNBC)

CAREER PATHS FOR WATER PROFESSIONALS: ACADEMIA, INDUSTRY & PUBLIC/PRIVATE SECTORS

June 18, 2025 | 10:30 AM- 12:15 PM | ECERF W2-090, University of Alberta

Steve Craik, PhD, P. Eng.
Director, Alberta Environment and Protected Areas (EPA)

Morna Hussey
Freshwater Directorate, Canada Water Agency

Cindy Shepel, P. Eng.
Wastewater Treatment Director, EPCOR

Dr. Olubukola Alimi
Asst. Professor, University of Alberta

CONFERENCE WORKSHOP

NAVIGATING CAREER GROWTH IN THE WATER INDUSTRY: FROM EARLY CAREER TO LEADERSHIP

June 19, 2025 | 10:15 AM- 12:00 PM | ECERF W2-090, University of Alberta

Sanaz Mohebali

Researcher | Veolia WTS

Sheila Fyfe

Researcher | Veolia WTS

Presentation 1: YWP's Perspective

Abubakar Waraich, M.Eng, P. Eng., PMP

Project Manager | Associated Engineering

Presentation 2: Senior Engineer's Perspective

YOUNG WATER PROFESSIONALS CANADA

3RD IWA-YWP CANADA CONFERENCE 2025

YOUNG WATER PROFESSIONALS International Hackathon

Water is the cornerstone of life, connecting people, communities, and ecosystems in countless ways. The theme of this conference Bridging Communities, Shaping the Future of Water Together" emphasizes the collaborative power needed to tackle the pressing water challenges of our time.

Global trends such as climate change, urban expansion, and inequitable resource distribution have exacerbated the water crisis worldwide. Scientists warn that most people will experience climate change through its impacts on water—whether through droughts, floods, or contamination. Overuse, pollution, and the uneven distribution of water resources have strained both natural systems and human settlements.

Regions that were once water-rich are now experiencing shortages, while water-scarce areas face increasingly severe droughts. Conversely, some communities are enduring frequent floods, threatening their safety, infrastructure, and livelihoods. These challenges go beyond regional boundaries, underscoring the interconnected nature of water systems. The ripple effects of water scarcity, pollution, and climate variability are already manifesting as migration, economic instability, and social inequities.

A report by the United Nations predicts that by 2050, one in every four people will live in areas affected by chronic water shortages. This stark reality calls for immediate and innovative action.

The second edition of the IWA Young Water Professionals International Hackathon challenges Young Water Professionals to create sustainable solutions to address these challenges within their region. The goal is to harness innovation and collaboration to design impactful strategies that strengthen community resilience and ensure water security for future generations.

In this year's edition, teams from **South Africa, Mexico, Nigeria, Peru and Ghana** have reached the finals.

ABSTRACTS

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For more information contact us at: **conference@iwa-ywp.ca**

Abstract # : TIWW-008

Nature-Inspired Approach for Treating Mine-Impacted Water in Cold Climates

Daria Popugaeva*, Ethan Allen, Konstantin Kreyman, Lars Rehmann
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Abstract:
The remediation of contaminated mine sites and access to safe water has been an ongoing challenge for the regions in Northern Canada. The current project focuses on freeze concentration (cryopurification) as a nature-inspired water treatment approach. The results of laboratory experiments revealed contaminant removal of up to 94% through cryopurification. The outcomes of laboratory experiments were applied to develop a mathematical model describing the cryopurification process. The proposed water treatment approach is anticipated to offer a more sustainable water treatment solution at the contaminated mine sites in the Arctic and Subarctic regions, such as the Yukon Territory.

Keywords: cryopurification; freeze concentration; Faro Mine

The cryopurification of the mine-impacted water is proposed and tested in the current research work. The cryopurification process is a chemical-free method of treating contaminated water and could be 2–10 times cheaper compared to reverse osmosis, evaporation, etc. (Youssef et al. 2014; Kaviani et al. 2024). The industrial application of cryopurification at or near the polar regions (e.g. Finland, Canada) adds an additional advantage to this process as cold climates' low temperatures are in effect (John et al. 2020; Najim and Krishnan 2022).

In the current study, the water samples used as a feed solution for a set of laboratory experiments on cryopurification were received from the Faro Mine site, Yukon, Canada. These water samples are characterized by elevated zinc concentrations that exceed by almost 25–30 times the corresponding effluent quality standard of 0.5 mg/L (The Government of Canada 2022). The objectives of current research work are to: (a) remove zinc from the mine-impacted water through cryopurification, and (b) numerically investigate the effect of initial and boundary conditions corresponding to the physics of cryopurification process. The detailed description of the materials and methods used in current study are described in our previous publications (Popugaeva et al. 2023; Allen et al., 2024). Numerical experiments were performed using computational fluid dynamics software, ANSYS Fluent. Three major modules were enabled in the simulation: energy, species transport and solidification-melting.

The results of laboratory experiments revealed zinc removal of up to 94% using just one cycle of freezing. Major parameters influencing the efficiency of cryopurification were identified and quantitatively described, those include freezing temperature, water stirring, and the direction of ice front propagation. Based on the obtained results of laboratory experiments, zinc concentration in the mine-impacted water could be reduced by cryopurification close to the effluent quality standard of 0.5 mg/L under optimal experimental conditions that were identified. The data collected during laboratory experiments were applied to develop a mathematical model that describes cryopurification process. The developed model allows a user to investigate the effect of initial and boundary conditions corresponding to the physics of cryopurification process.

The results achieved up to date formed a foundation for the pilot-scale reactor design and testing (currently ongoing). Based on the outcomes obtained in the current research work, the application of cryopurification process at the Faro Mine site could be effective considering the cold climate conditions of Yukon.

ACKNOWLEDGMENTS
We would like to acknowledge Lee Johnson of LC Design, a team of Core Geoscience Services Inc. including Eri Boye, Natashia Drage, Jessica Pandya and other colleagues for their support and discussions.

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Abstract # : TTT-005

Adsorptive Removal of Carbaryl from Water Using Sodium Palmitate-Modified Layered Double Hydroxide

Mariana Acosta-Lopez*, Robert Hausler
* École de Technologie Supérieure, Canada, mariana.acosta-lopez.1@ens.etsmtl.ca

Abstract

Water pollution by insecticides poses significant risks to ecosystems, pollinators, and human health. In this study, a surfactant modified layered double hydroxide (CaAl-PS-LDH) was synthesized using the co- precipitation method and evaluated as an adsorbent for removing carbaryl from water. The material consists of Ca and Al in the main layers, with sodium palmitate as the interlayer anion. This combination of cations and a natural, food-grade surfactant ensures environmental compatibility and minimizes toxicity risks. The modified LDH demonstrated a significantly higher adsorption capacity than the inorganic LDH, highlighting its superior performance. These findings suggest that CaAl-PS-LDH is a safe and effective option for water treatment applications. The ease of preparation, cost-effectiveness and capacity for targeted pollutant removal of LDHs make them suitable materials for water treatment in rural, remote, and vulnerable communities with specific water treatment needs.

Keywords: carbaryl; adsorption; layered double hydroxide

Background and nature of the problem: Pesticides, including insecticides, are widely used in agriculture to improve crop yields; however, they often disperse into the environment through mechanisms, such as filtration, volatilization and runoff. Along with their excessive use, this has led to the contamination of water sources resulting in negative impacts on both the environment and human health (Rad et al., 2022). Carbaryl, in particular, has been detected in numerous water sources worldwide. Prolonged exposure to
this compound in drinking water can lead to both acute and chronic health problems. Additionally, carbaryl is highly toxic to bees and other essential pollinators (Gunasekara et al., 2008).

Layered double hydroxides (LDHs) offer potential applications as adsorbents in water treatment due to their properties such as low toxicity, high surface area, anion exchange capacity, ease of preparation, cost-effectiveness and adjustable structures through variations of metal types, interlayer anions, and synthesis methods (Johnston et al., 2021). LDHs can be modified by incorporating organic anions, such as surfactants, into their structure to enhance their capacity to adsorb organic, low polarity pollutants (Zhang et al., 2019).

Most research on the adsorption of emerging pollutants, such as pesticides, onto surfactantmodified LDHs has primarily focused on Mg-Al cations with syntheticnsurfactants as interlayer anions (Moldes et al., 2021). However, as scientific and technological advancements increasingly prioritize green and sustainable chemistry, there is a growing demand for safer, more environmentally friendly alternatives. In this context, biosurfactants are a bio-based alternative in several industrial and environmental applications, due to their low toxicity, biodegradability, chemical stability, and environmental compatibility. These compounds are derived from natural sources such as plants, microbes, and agro-industrial waste (Begum et al., 2023).

In this study an adsorbent material was developed by synthesizing an LDH structure composed of Ca-Al cations and the naturally derived, food-grade surfactant sodium palmitate as the interlayer anion for carbaryl removal from water. This combination of cations, which has been less explored, and a natural surfactant, reduces the toxicity and environmental risks associated with the adsorbent material, making it a safer option for water treatment applications. The modified LDH demonstrated significantly enhanced adsorption capabilities compared to the unmodified LDH.

Results and discussions:

The adsorption rates of carbaryl by the inorganic LDH (CaAl-LDH) and CaAl-PS-LDH were compared by measuring the amounts of pesticide removed from a solution with an initial carbaryl concentration of 50 mg L -1 at various time intervals. As shown in Figure 1a, the carbaryl uptake by the modified LDH was significantly higher than that of the inorganic form of the material, with values of 6.96 mg g -1 for CaAl-PS-LDH and 1.83 mg g -1 for CaAl-LDH; equilibrium was reached at 1.5 h and 12 h, respectively. The effects of pH, temperature, initial pesticide concentration and adsorbent dosage on the adsorption of carbaryl onto CaAl-PS-LDH were also investigated. The adsorption mechanisms were best described by the pseudo-second-order kinetic model, while the adsorption isotherm was best represented by the Freundlich model.

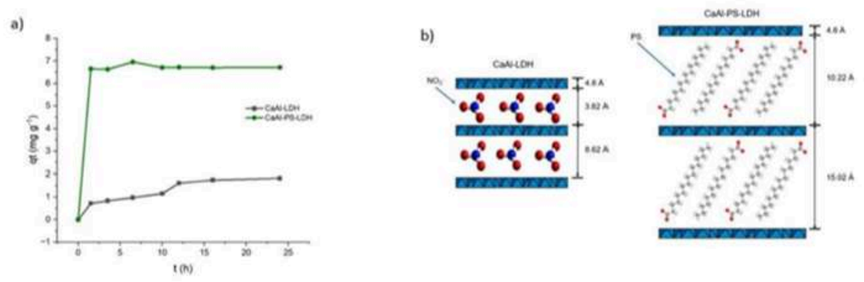

Figure 1. a) Adsorption kinetics of carbaryl by CaAl-LDH and CaAl-PS-LDH, and b) schematic representation of CaAl-LDH and CaAl-PS-LDH.

Abstract # : TTT-005

Adsorptive Removal of Carbaryl from Water Using Sodium Palmitate-Modified Layered Double Hydroxide

Mariana Acosta-Lopez*, Robert Hausler
* École de Technologie Supérieure, Canada, mariana.acosta-lopez.1@ens.etsmtl.ca

The LDH materials were characterized by X-ray diffraction, which revealed a change in the basal spacing from 8.62 Å in the inorganic LDH to 15.02 Å after surfactant modification.
Particle morphology was analysed by field emission scanning electron microscopy. The elemental composition of the samples was determined by energy dispersive spectroscopy and the compositional analysis was conducted using Fourier transform infrared spectroscopy. A structural arrangement for the LDH materials, including the possible orientation of sodium palmitate anions within the novel adsorbent structure, was proposed, as shown in Figure 1b. Comparisons with other clay and mineral adsorbents (Table 1) indicate that CaAl-PS-LDH is a suitable and safe option for water treatment applications.

Table 1 Comparison of the adsorption capacities of different clay and mineral adsorbents for carbaryl removal.

Absorbent	Polluant	Adsorption capacity	Reference
CaAl-PS-LDH	Carbaryl	15.99	This work
Montmorillonite	Carbaryl	3.7	Chen et al., 2009
Kaolinite	Carbaryl	1.6	Chen et al., 2009
Bentonite	Carbaryl	0.145	Eldurini et al., 2010
Natural Clay	Carbaryl	3.25	Ouardi et al., 2013
Smectite	Carbaryl	3	Arroyo et al., 2004
Indian Soil	Carbaryl	0.6	Singh et al., 2011

Impact and contributions of the work:
This research contributes to the advancement of sustainable and safe technologies for the removal of emerging pollutants from water, aiming to safeguard public health and preserve the environment. The ease of preparation, costeffectiveness and capacity for targeted pollutant removal of LDHs make them suitable materials for water treatment in rural, remote, and vulnerable communities with specific water treatment needs. The removal of insecticides is particularly important due to their toxicity, stability, persistence and potential for bioaccumulation. Of special concern is their high toxicity to bees and other essential pollinators, as well as their negative impacts in human health.

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Abstract # : TUWM-012

Electrochemical Activation of PMS for Efficient Plasticizer Degradation Using a Novel Fe-C Catalyst

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Abstract

Plasticizers, particularly phthalates, are widely used in industrial applications but pose significant environmental and health risks due to their carcinogenic and endocrine-disrupting properties. Conventional treatment methods often suffer from high energy consumption and low efficiency. In this study, we propose a novel Fe-C-based catalyst/cathode, synthesized from red mud and stone coal, to enhance peroxymonosulfate (PMS) activation for plasticizer degradation in a 3D electrochemical oxidation (3D-EO) system. The Fe(III)/Fe(II) cycles are effectively sustained under weak electrical current, promoting electron transfer and enhancing radical generation. Electrochemical degradation experiments were conducted to investigate the catalytic performance, influencing parameters, and degradation mechanisms of diethyl phthalate (DEP). The system's efficiency was evaluated using EPR, LC-MS, TOF-MS, and HPLC, revealing three primary degradation pathways involving nucleophilic, electrophilic, and free radical attacks. The proposed system demonstrated superior degradation efficiency, sustainability, and cost-effectiveness, making it a promising solution for plasticizer-contaminated wastewater treatment.

Keywords: Electrocatalytic oxidation; Fe-C catalyst; plasticizer degradation

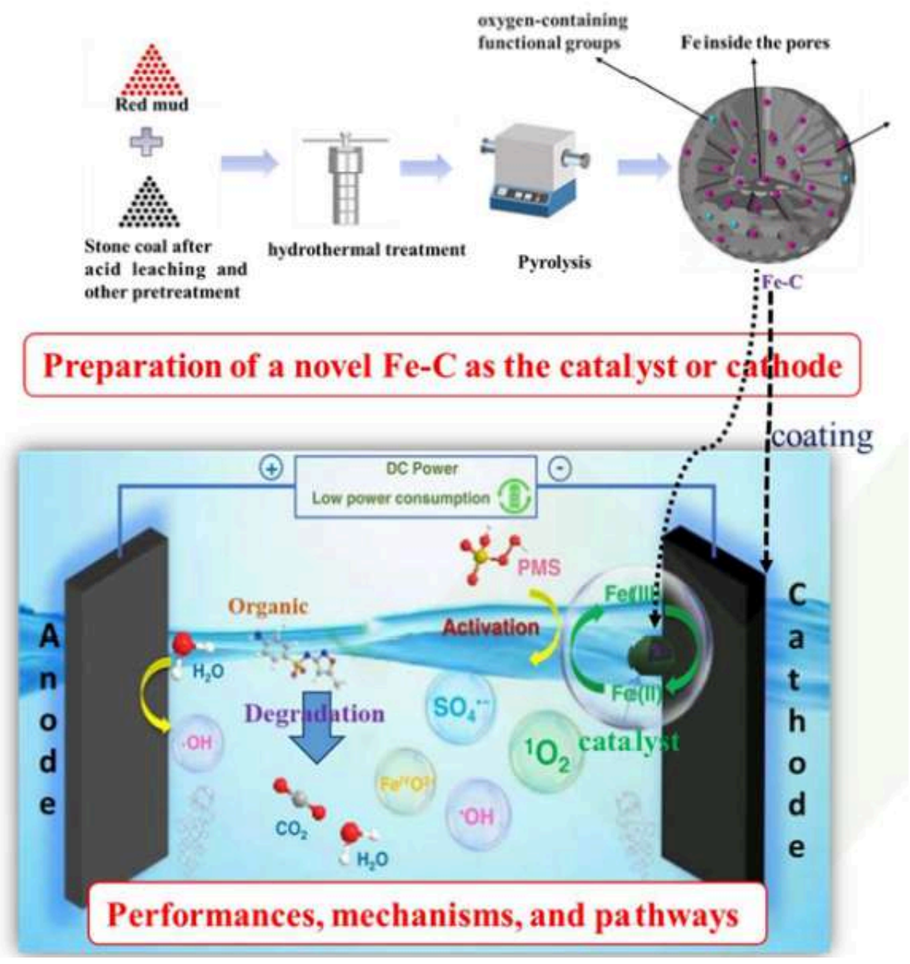

Fig. 1 Schematic diagram of the 3D electrochemical oxidation (3D-EO) system with Fe-C catalyst

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Abstract # : TUWM-001

Accelerated Weathering of Polyethylene Microplastics in Water

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Abstract

The extensive production and consumption of plastic goods has led to the widespread presence of microplastics (MPs) and nanoplastics (NPs) in the environment, particularly in aquatic systems. Plastics in aquatic environments undergo weathering processes that alter their physical and chemical properties. A common plastic found in environmental samples is polyethylene (PE), with the types distinguished by the density of the molecules. The two main types, high-density polyethylene (HDPE) and low-density polyethylene (LDPE), differ in their molecular structures due to varying degrees of branching, which impacts their susceptibility to weathering. This study investigates the photooxidative degradation of four PE MPs (two HDPE and two LDPE formulations) exposed to UV irradiation in distilled water under accelerated weathering conditions. FTIR and SEM analyses were used to track changes in functional groups associated with plastic weathering. Results confirmed that HDPE MPs were more resistant to photooxidation than LDPE MPs, and consumer plastics with chemical additives weathered differently from pristine samples. Ongoing experiments explore the influence of natural organic matter (NOM) on the weathering behavior of these plastics. These findings highlight the complexity of plastic weathering and the importance of considering polymer additives within water matrices.

Keywords: contaminant; microplastics; photooxidation

The diversity and intensity of synthetic polymer production has resulted in the dispersal of plastic particles throughout the biosphere, in every environmental compartment tested (Thompson et. al, 2024) from soils and sediment to waters, airs, and animals (Nizetto et. al, 2016)(Dubaish et. al, 2013)(Thompson et. al, 2004). Alarmingly, micro- and nano-plastics are considered to be ubiquitous with water. Microplastic (MP) particles are less than 5 mm in at least one dimension and must be considered as a diverse chemical contaminant suite rather than a uniform entity (Rochman et. al, 2019). MPs and other plastics in the environment are subjected to natural weathering processes that are known to cause physical and chemical transformations in MPs (Alimi et. al, 2018). Both the MPs and the weathering processes they undergo are diverse and complex, resulting in increasingly complex water systems (Jahnke et. al, 2017). To navigate and manage these complexities, further understanding of the particle transformations and their environmental implications is needed.

Polyethylene (PE), as the name indicates, is made from repeated ethylene -(C 2 H 4)- units that form its carbon backbone. These carbon chains can be arranged with a variety of branching patterns, imparted through specific production conditions. These branching patterns affect the polymer's molecular structure while maintaining the chemical composition. High density polyethylene (HDPE) is characterized by minimal branching along the carbon chain, allowing for a tightly packed molecular structure. Alternatively, low density polyethylene (LDPE) has a high degree of branching of both long and short chain lengths. This branching pattern prevents LDPE's molecules from packing closely together, resulting in a material with a less dense structure.

One of the most commonly used synthetic plastics is PE, and it is frequently identified in high proportions within mixed environmental MP samples (Yang et. al, 2024). Characterization is often accomplished through Fourier transform infrared spectroscopy (FTIR) analysis, with the PE absorption spectra having a distinct couplet peak. However, this characterization alone does not necessarily indicate the effects of weathering on the particles. In most aquatic environments, MPs are exposed to sunlight, and UV irradiation has been shown to oxidize PE surfaces (Garvey et. al, 2020). Within the types of PE, the structural differences result in more severe oxidation effects in LDPE than HPDE (Craig et. al, 2005). These chemical changes are impacted by the mechanical stresses on particles in aquatic environments, and the mechanical changes are impacted by the chemical changes. Thus, the photooxidative effects of PE products may not be directly applicable to PE MPs. In particular, the effects of sunlight on PE MPs resulting from commercial products are not well understood.

To investigate the photooxidative degradation of aquatic PE MPs, four different PE MPs were exposed to UV irradiation in DI water; two high density PE and two low density PE formulations. For each PE type (HDPE, LDPE), one consumer plastic (purchased from a grocery store) and one pristine plastic (selected and ordered to minimize additives) were obtained. All plastics except the spherical HDPE pellets were cut to MP size before creating samples of deionized (DI) water and PE MPs.

The four PE MPs were each tested in triplicate under accelerated weathering conditions over four months. The accelerated weathering conditions were created by attaching the samples to the surface of a shaker table located beneath an array of UV bulbs. Irradiance was measured and tracked for each sample, such that each timestep is related to each sample's cumulative irradiance (UV dose). Each month, sacrificial particles were obtained for characterization tests using FTIR and SEM analysis. The FTIR spectral data was processed in Matlab to integrate specific areas of absorption peaks in order to obtain information about select functional groups (e.g., carbonyl, vinyl) associated with PE's photooxidative degradation.

Abstract # : TUWM-001

Accelerated Weathering of Polyethylene Microplastics in Water

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The carbonyl index (CI) trends of the plastics confirmed that the HDPE MPs were more resistant to photooxidation than the LDPE MPs. This was reflected in the vinyl index (VI) trends. Comparing the consumer plastics to their pristine counterparts highlighted the ability of chemical additives to modify a polymer's behaviour. Indeed, the physicochemical properties imparted to a polymer resin upstream (in petrochemical processes) contribute significantly to behaviour exhibited by a MP downstream (in environmental surface waters). Additionally, weathering index data suggested that an individual index alone cannot be used to quantify the extent of weathering, especially in highly modified blends such as those in consumer products.

This investigation contributes to a growing understanding of the fate and form of the MP contaminant suite in vital environmental compartments such as surface waters. If water treatment systems are to effectively treat contaminants, engineers must have a comprehensive understanding of the behaviours and impacts of emerging contaminants. Ongoing experiments expand the water matrix to include natural organic matter (NOM), to further investigate the response of consumer and pristine LDPE MPs to accelerated weathering.

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Biological Processes

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Abstract # : TTT-001

Application of Biofiltration for the Treatment of Wildfire-Impacted Raw Water

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Abstract

This study examined the effectiveness of biofiltration in degrading dissolved organic carbon (DOC) in wildfire-impacted raw water, using three bench-scale biofilters with different media: sand, granular activated carbon (GAC), and a combination of sand and GAC. The wildfire-impacted raw water was pre-treated using aeration and a roughing filter. With an influent DOC concentration of 20 mg/L, the biofilters operated at an empty bed contact time of 15 mins, a hydraulic loading rate (HLR) of 2.8 m/h, a pH in the range 6.5 – 8.5, and temperature ranging from 19 to 22°C. The biofilters achieved DOC removal efficiencies of up to 76% (sand), 92% (GAC), and 97% (sand and GAC). The biofilters also effectively removed turbidity with sand achieving effluent turbidity of 0.42 – 0.88 NTU, GAC 0.61 – 0.84 NTU, and sand and GAC 0.5 – 0.6 NTU. The results of this investigation demonstrate that combining sand and GAC media in a biofilter more effectively removes pollutants.

Keywords: Biofiltration; climate change; water treatment.

Introduction

Climate change has resulted in more frequent extreme events such wildfires, rising temperatures, and changes in precipitation patterns. These events threaten drinking water production and availability, with wildfires causing runoff of ashes and unburnt carbon into surface water bodies that increases turbidity and dissolved organic matter (DOM) concentration in water (Paul et al., 2022; Ali et al., 2025). Water treatment plants (WTPs) in low-resource areas struggle to manage these challenges, leading to higher costs and reduced efficiency (Ali et al., 2025). Additionally, climate change increases ultraviolet radiation (UVR) exposure and contaminant transport into water sources. Biofiltration is a sustainable and cost-effective water treatment technology that can remove DOM, but more research is needed to understand its adaptability to extreme weather events and emerging contaminants. This study aims to address this gap, focusing on biofiltration resilience to extreme weather events such as wildfires.

Materials and methods

Three bench-scale biofilters with different media (sand, granular activated carbon (GAC), and a combination of sand and GAC) were setup to treat wildfire-impacted raw water. Raw water was collected from the shore of West Lake in Prince George, British Columbia and amended with sodium acetate and sodium propionate to achieve the test concentrations for dissolved organic carbon (DOC). This water was pretreated by aeration for oxidation of certain organic matter, followed by rouging filtration to reduce the suspended solids. The biofilters operated with a hydraulic loading rate of 2.8 m/h, an empty bed contact time of 15 minutes, pH range 6.5 – 8.5, and temperatures from 19 – 22°C. After acclimation for 116 days, the experimental period lasted 73 days, evaluating turbidity, pH, alkalinity, and DOC concentration (measured as COD).

Results and discussion

The biofilters effectively removed turbidity with sand achieving effluent turbidity of 0.42 – 0.88 NTU, GAC achieving 0.61 – 0.84 NTU, and sand and GAC achieving 0.5 – 0.6 NTU. Throughout the experimental period, pH and temperature remained stable, while alkalinity and DOC removal varied. The biofilters achieved DOC removal efficiencies of up to 76% (sand), 92% (GAC), and 97% (sand and GAC) as shown in Figure 1.1 below.

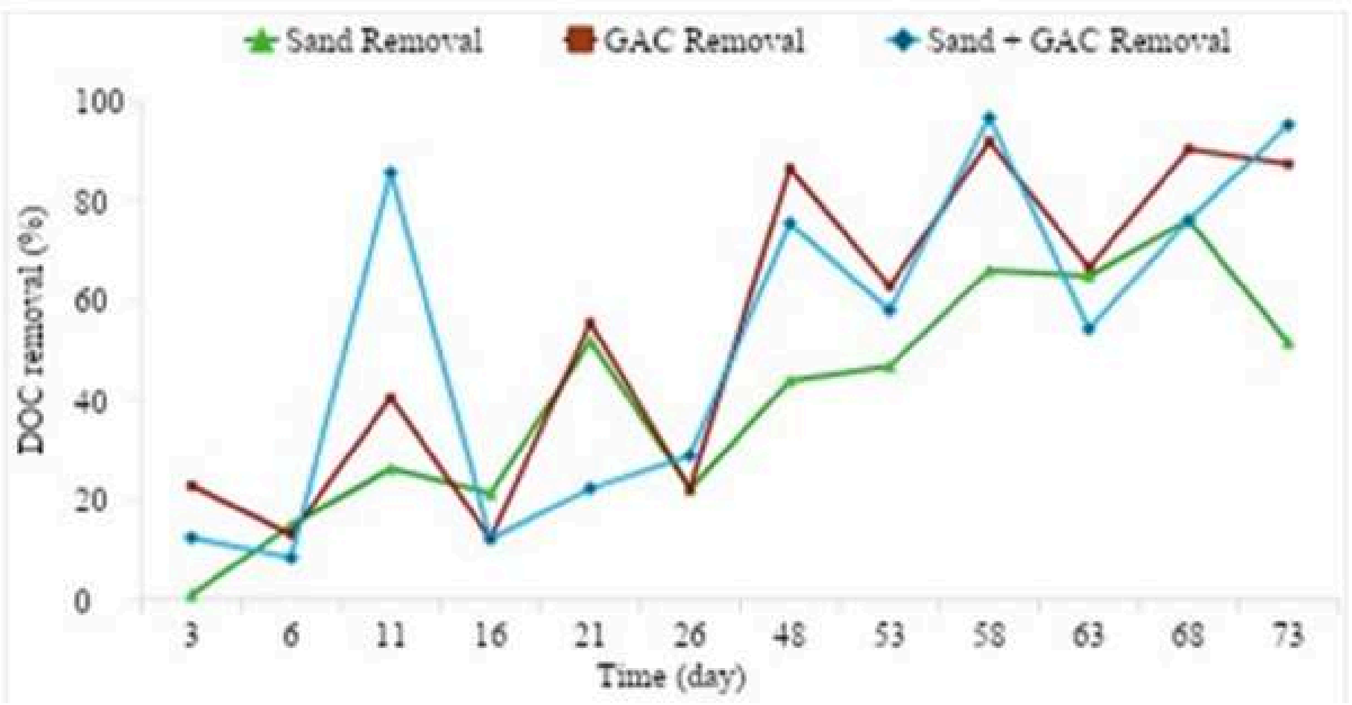

Figure 1.1: Daily Difference in the DOC removal (%)

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Application of Biofiltration for the Treatment of Wildfire-Impacted Raw Water

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These results underscore the superior effectiveness of using a combined media approach in biofilters for pollutant removal, compared to using each media type separately. The study's findings highlight the potential of biofiltration, particularly with a combined media approach, to significantly enhance water treatment processes.

Conclusion

The increasing threats to drinking water posed by extreme events such as wildfires makes it a necessity to find a resilient drinking water treatment technology. Biofiltration, using sand and GAC as media, proved to be a sustainable and effective method to reduce DOC and turbidity in wildfire-impacted raw water. The combination of sand and GAC media in the biofilters was especially effective, achieving the highest DOC removal efficiency and demonstrating strong potential for water treatment in the face of a changing climate.

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Abstract # : TWS-002

Application of Multiple Criteria Analysis to Select the Best Biofilter Media Material for Pollutant Removal via Wastewater Biofiltration

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Abstract

Biofiltration has seen significant innovation in recent years, making it an essential and versatile technology for wastewater treatment across the globe. Wastewater biofiltration involves the use of microorganisms attached to the media to remove contaminants as the wastewater passes through the filter media. This study applied multiple criteria analysis on a broad data set of biofilter media materials to ascertain which biofilter media is the best for either organic matter (measured as chemical oxygen demand (COD)) or nutrient removal from wastewater. The results indicated that converter slag/coal cinder and plant-based wastes were most suitable for nutrient removal while synthetic-plastic and ceramic filter media were the most efficient for COD removal.

Keywords: Biofilter media; multiple criteria analysis; wastewater treatment;

Background and nature of the problem:

Although several lab- and pilot-scale studies have shown the feasibility of applying biofiltration in advanced wastewater treatment resulting in high-quality effluent, fullscale application of biofiltration as an advanced wastewater treatment using various organic and inorganic filter media materials is still scarce. Moreover, most reviews on wastewater biofiltration discussed a few aspects of biofilters such as the use of a single filter media in biological wastewater filtration (Deng et al., 2021), hotspots, trends, and challenges of biological filtration (Jin et al., 2023; Vikrant et al., 2018), microbial immobilization (Cohen, 2000), and comparative studies of different biofiltration processes (Malakar et al., 2017). On the other hand, the application of multiple criteria analysis (MCA) on varying filter media materials using broad data sets from literature to give clear recommendations of which filter media is suitable for organic or nutrient removal from wastewater has not been done, which is the novelty of the current study.

Methods:

MCA executed in the current study was based on the Technique for Order Preference by Similarity Ideal Solution (TOPSIS) method (Yoon and Hwang, 2011). The biofilter media were the alternatives while the attributes included, COD removal, phosphorus removal, and nitrogen removal assigned a weight between 0 to 1 matching their importance in which the total weight of all the attributes was equal to 1.

Findings and results:

Table 1.1 summarizes MCA results based on the TOPSIS method. Giving more importance to nutrient removal from wastewater, converter slag/coal cinder and gravel were the best and worst biofilter media, respectively for the data considered in the current study (Table 1.1). On the other hand, focusing on organics removal (in terms of COD) as the most important task, synthetic-plastic biofilter media materials such as plastic balls were the best while ferric carbon micro electrolysis filter media was the worst (Table 1.1).

Table 1.1: Results for best and worst filter media based on multi-criteria analysis

Filter media	Nutrient (P and N) removal		Organics (COD) removal	
	Scores	Rank	Scores	Rank
Biochar	0.296381	8	0.667873	6
Ceramic	0.515793	6	0.829636	2
Converter slag/coal	0.928865	1	0.790568	4
Earthworms	0.497328	7	0.812815	3
Ferric carbon micro	0.614527	4	0.108886	10
Gravel	0.156373	10	0.489857	8
Oyster shells	0.570205	5	0.734284	5
Plant-based waste	0.707424	2	0.438554	9
Synthetic-plastic	0.617323	3	0.93404	1
Wetland plants	0.193327	9	0.535741	7

Abstract # : TWS-002

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Significance and impact:

Based on the results of the current study, wastewater treatment plants should use filter media such as synthetic plastic balls and ceramics during the secondary treatment of wastewater using biofilter technologies like trickling filters to maximize COD removal. For maximum nutrient (phosphorus and nitrogen) removal, however, treatment plants should use filter media materials such as a combination of converter slag/coal cinder and plant- based waste materials (e.g., rice husks, wood chips, wheat straws, peat, potato peels, agave fibre, sawdust, etc.) during tertiary treatment of wastewater. The results from the current study may serve as a guide for wastewater treatment plants aiming at embracing and optimizing biofiltration for maximum organic or nutrient removal from wastewater.

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Abstract # :TWS-009

Exploring the Addition of Algal Bacterial Granular Sludge on Aerobic Granular Sludge Systems

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Abstract

Aerobic Granular Sludge (AGS) systems have become an innovative alternative to conventional Activated Sludge (CAS) systems due to their use of granulation to form dense, self-aggregated microbial granules. The AGS system provides a higher rate of removal of organic matter (85%), nitrogen (59%), ammonia (99%), and phosphorus (80%) to happen simultaneously throughout a multistage cycle of aerobic, anoxic, and anaerobic zones. Although AGS has high removal rates and is more efficient than the traditional CAS system, it requires a superficial air velocity (SAV) of typically 1.2-3.2 cm/s 150 minutes in a sequencing batch reactor (SBR) with a volume of 5.4L on a lab scale during the anaerobic zone to provide the necessary oxygen and shear force to the microbes in the granules to grow and remove the pollutants and maintain their structure (Devlin, di Biase, Kowalski, & Oleszkiewicz, 2016). This causes the system to require a large amount of air flow and energy consumption when applied in wastewater treatment plants.

Keywords: algae bacterial granular sludge; wastewater treatment; environmental stability

Integrating algae into Aerobic Granular Sludge (AGS) forms an Algal-Bacterial Granular Sludge (ABGS) system, presenting opportunities for energy savings and fostering a symbiotic relationship, thereby enhancing the functionality of AGS. By using the algae less air flow and oxygen is required in the system as the algae produces oxygen through photosynthesis that the microbial bacteria in the granules are able to use to grow while capturing the carbon dioxide created by the bacteria. There are three primary methods for incorporating algae into an AGS system: Adding algae in with the seed sludge on day one, adding in algae into an existing AGS system once the granules have matured, and using the effects of flocculation of fungi on algae and bacteria. This research investigates the impact of adding algae to an existing AGS system with mature granules. AGS was cultivated in a Plexiglas column-type sequencing batch reactor (SBR) with a working volume of 4.8 L, a volumetric exchange ratio (VER) of 50%, resulting in an 8-h hydraulic retention time (HRT). The operational cycle length was four hours (six cycles per day).

Each cycle consisted of five sequential phases: influent addition (10 minutes), anaerobic reaction (30 minutes), aerobic reaction (150 minutes), settling (30 minutes), effluent discharge (10 minutes), and idle time (10 minutes). The air (during the aeration phase) was introduced into the reactor from the bottom of the reactor through a fine air bubble diffuser using an air pump. An air flow meter was used to control the air flow at about 23 SCFH, corresponding to a superficial air velocity (SAV) of 2.3 cm/s. The dissolved oxygen (DO) level was in the range of 6-8 mg O2 L -1 .

The reactor was fed a synthetic acetate-based wastewater containing the requirements for growth of microorganisms. After maturation, two algal species; namely, Chlorella and Scenedesmus were added. LED lights were used to create a light to dark ratio of 12 hours on, 12 hours off giving the algae environment it needs to thrive and grow through attachment to the outer layers of the granules. Analysis was conduced weekly to examine the biomass characteristics Mixed Liquor Suspended Solids (MLSS), Mixed Liquor Volatile Suspended Solids (MLVSS), Sludge Volume Index (SVI),) in accordance with the (APHA, 2012). System performance was assessed for Chemical oxygen demand (COD), ammonia, phosphorus, nitrate and nitrite using HACH kits. both the influent and effluent, as well as the soluble organics, Nitrate, Total Suspended Solids (TSS) and Volatile Suspended Solids (VSS) in the effluent. Particle Size Distribution (PSD), and DNA samples were taken weekly from the reactor to examine the growth, size and microbial dynamics during the formation of the AGS as well as after the algae was added into the system. Extracellular polymeric substance (EPS) testing was done to monitor the binding of the algae and the granules to each other. Preliminary results after 5 weeks of operation have shown that the use of an ABGS system can enhance the removal of pollutants much more than the use of AGS alone with an aeration rate of 0.007 cm/s (Wang, et al., 2024). The removal of organic matter (95%), nitrogen (77%), ammonia (99%), and phosphorus (95%) all increase due to the O 2 generated by the algae itself. Further analysis will focus on the long-term performance, bacterial-algal interactions, and impact on treatment efficiency.

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Abstract # :TTT-004

Effects of Nanosecond Pulse Electric Fields for Enhanced Activated Sludge Performance

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Abstract

This study proposes a novel method to induce reversible electroporation in activated sludge while minimizing lethal cell lysis by applying nanosecond pulsed electric fields. This approach might temporarily trigger oxidative stress, enhance cellular activity, and improve the degradation of organic pollutants. Experimental results demonstrate that nanosecond pulse treatment significantly enhances the removal of soluble chemical oxygen demand (sCOD) and nitrogenous compounds under tested conditions (40 V/cm to 10 kV/cm, 100 Hz, 500 ns pulse width), with a clear time-voltage dependency. Predictive modeling for achieving 60% sCOD removal under hypoxic static conditions aligns with experimental findings, showing that even low-intensity fields (40 V/cm) achieved a 70% reduction in treatment time compared to untreated samples. These findings highlight nanosecond pulse electric fields as a promising non-destructive technique to enhance wastewater treatments efficiency.

Keywords: Nanosecond pulse; activated sludge; electroporation.

Introduction

Conventional activated sludge (CAS) and membrane bioreactor (MBR) systems are extensively employed in wastewater treatment, where minimizing energy consumption remains a critical priority in alignment with sustainability objectives. In both systems, aeration, mixing, and filtration constitute the primary sources of energy expenditure, and these processes are significantly affected by the characteristics of activated sludge (AS). This study explores the application of nanosecond pulse NSP electric fields (NSPEF) using inert carbon electrodes to enhance the performance of activated sludge. The introduction of NSP-EF enhances filterability, dewaterability, and oxygen accessibility, contributing to a reduction in energy consumption required for aeration and mixing. Additionally, the potential to induce reversible electroporation was examined, aiming to minimize the risk of cell lysis while facilitating nutrient intake.

Experimental method

Return Activated Sludge (RAS) samples were collected from Nagaoka Central Purge Centre and aerated at a constant rate of 1L/min for same-day experimental use. A 200mL portion of RAS was transferred from the main batch to a glass beaker, which functioned as an electrochemical reactor without aeration, and stirred at a constant speed of 500rpm. Two inert carbon electrodes, positioned 10mm apart and fixed using a 3D-printed jig, were connected to a nanosecond pulse (NSP) power supply to generate an electric field upon voltage application. Prior to voltage application, a soluble starch solution was added to the sample to adjust the soluble COD (sCOD) concentration to 500mg/L. Electric fields of 40V/cm, 100V/cm, and 1kV/cm were applied at a frequency of 100Hz with a pulse width of 500ns for durations of 30s, 1min, 3 min, and 5 min. sCOD measurements were conducted immediately after voltage application, as well as at 10, 30-, 60-, 90-, and 120-minutes while conducting aeration post-experiment. Furthermore, live/dead cell analysis and particle size distribution measurements were performed to verify non-lethal lysis and assess reversible electroporation.

Results and discussion

Experimental results demonstrate that nanosecond pulse treatment significantly enhances the removal of soluble COD (sCOD). A clear dependency on treatment time and applied voltage was observed. Notably, even low-intensity electric fields (40V/cm) resulted in a significant reduction in treatment time compared to untreated samples. A quick decrease in sCOD levels in NSP-EF-treated samples suggests that nanosecond pulse electric fields (NSP-EF) enhance the biological activity of activated sludge. Additionally, the application of NSP-EF temporarily induces oxidative stress, enhancing cellular activity and resulting in reduced COD (sCOD) levels in the effluent. Furthermore, a non-lethal lysis effect (reversible electroporation) was observed, which may promote and facilitate nutrient uptake.

Conclusions

Results highlight nanosecond pulse electric fields (NSP-EF) as a promising nondestructive technique for enhancing pollutant removal in wastewater treatment processes. Additionally, the ability to induce non-lethal lysis through the application of NSP-EF has been demonstrated. The electrochemical reactions triggered by NSP-EF are also believed to be effective in breaking down non-soluble organic matter and extracellular polymeric substances (EPS), such as humic acid, in real sewage, suggesting potential applicability in membrane bioreactor (MBR) systems.

Abstract # :TTT-004

Effects of Nanosecond Pulse Electric Fields for Enhanced Activated Sludge Performance

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Conclusions

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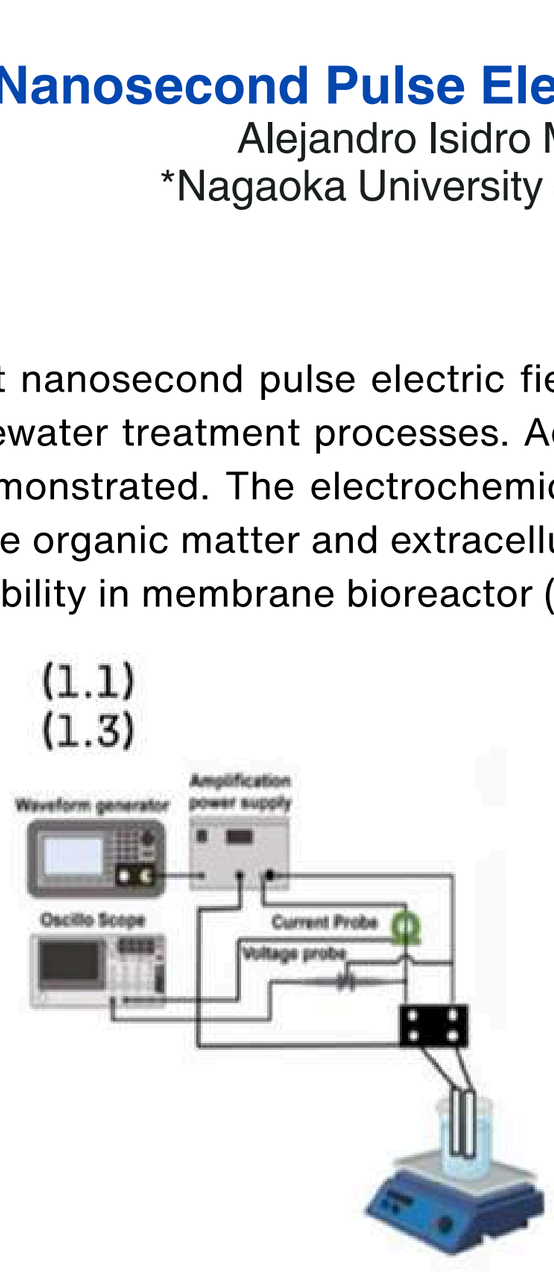

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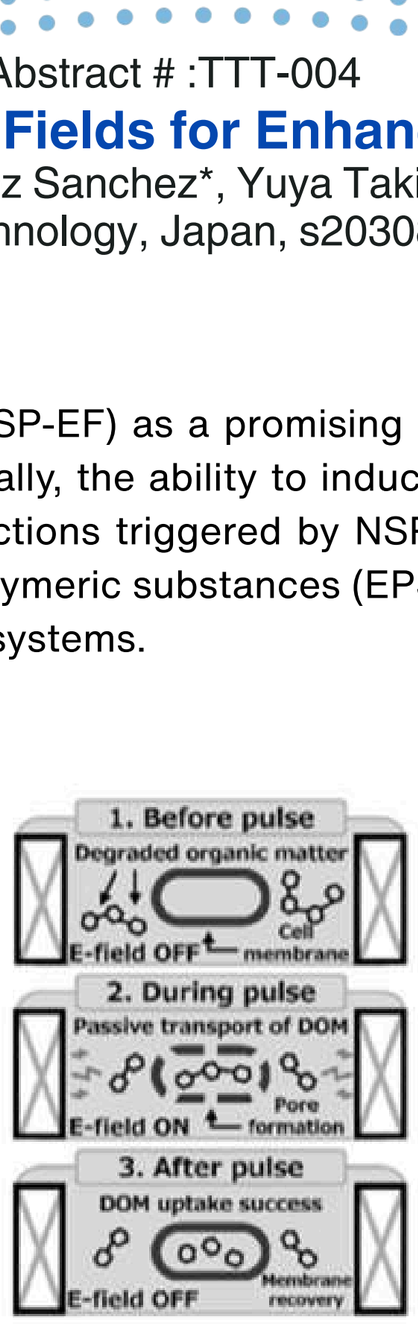

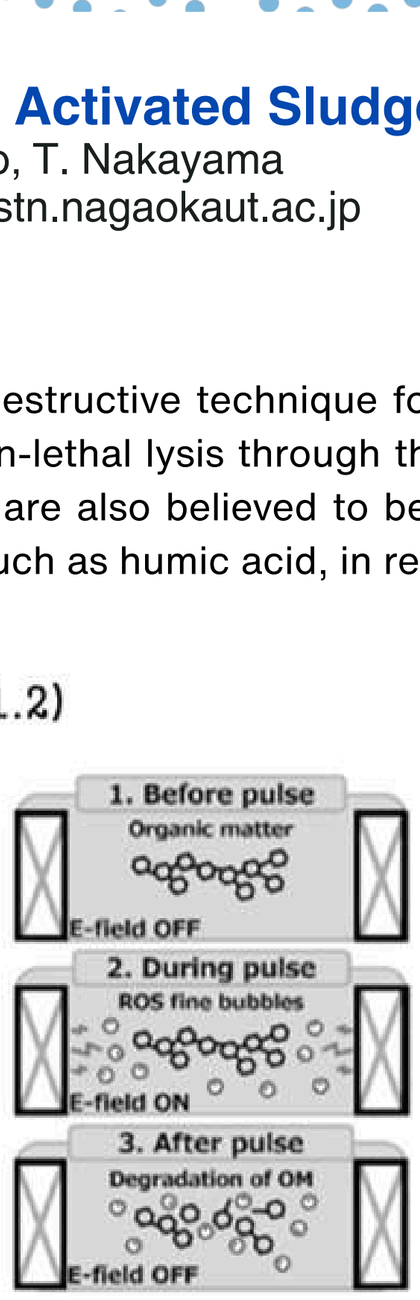

Figure 1.1 Schematic diagram of the experimental apparatus
Figure 1.2 Hypothetical reaction for decomposition of organic matter by nanosecond pulse electric field application.
Figure 1.3 Hypothetical microbial reaction by nanosecond pulse electric field application.

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Abstract # :TTT-002

Wastewater Treatment in Resource-Limited Northern Canada Communities: Lagos Limitations and MBR-HIX Innovations

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Abstract

This study assesses wastewater treatment lagoon efficiency in a northern Canadian community, focusing on physicochemical parameters, human enteric viruses, and PFAS micropollutants. To explore alternative solutions, a treatment train composed of an anoxic-aerobic membrane bioreactor (MBR) using two different membranes combined with a hybrid anion exchange (HIX) nanotechnology resin column was operated under simulated northern conditions. Results showed that the treatment train effectively reduced COD, TSS, NH^{4+} , NO_3-N, TN and PO_4^{3-}-P, while nanofiber membranes had better fouling resistance and lower maintenance requirements than commercial PVDF membranes. This study revealed that a combined MBR-HIX treatment train has great potential for sustainable wastewater treatment in remote northern regions.

Keywords: Decentralized treatment; membrane bioreactor; northern communities

Wastewater lagoons are widely used in northern decentralized communities, yet their treatment efficiency and environmental safety require further evaluation. The present study deals with the efficiency of the wastewater treatment lagoons in Kangiqsualujjuaq, an Inuit community in northern Canada. Physicochemical parameters, human enteric viruses, and PFAS micropollutants in raw wastewater, lagoons, and natural wetlands were assessed. The results obtained regarding lagoon removal efficiencies showed 94.1% for TSS, 91.3% for COD, and 65.85% for PO_4^{3-} , which was not sufficient to meet acceptable discharge levels. In addition, Noroviruses GI and GII enteric viruses have continuously been detected in lagoons and wetlands, indicating environmental and public health risks. Also, eight PFAS components have been detected so far, both in wastewater and environmental samples, with the most frequently detected being 6:2 FTS, PFHxA, and PFNA.

To improve wastewater treatment, a novel MBR featuring an anoxic-aerobic configuration integrated with a hybrid anion exchange resin (HIX) column impregnated with iron oxide nanoparticles was designed and tested under simulated northern conditions. Results from the MBR indicated removal efficiencies of over 90% for COD, TSS, NH^{4+} and NO_3-N at 4 °C. The nanofiber membrane exhibited higher resistance to fouling and less maintenance requirements compared to a commercial PVDF membrane. The HIX column further improved the performance by enhancing phosphate and nitrate removal. These results confirm the feasibility of a combined MBR-HIX system as a viable decentralized wastewater treatment option in remote northern communities. Key benefits include its strong performance, low maintenance requirements, and possibilities of water reuse and nutrient recovery.

Bioelectrochemical Systems and Wetlands

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Abstract # :TRRR-005

Boosting CO2 Electro-methanogenesis in Microbial Electrosynthesis Systems via Electrode Modification

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Abstract

Microbial electrosynthesis (MES) systems have emerged as a potential alternative for CO_2 conversion to CH_4 , facilitating the use of biogas as an alternative to limited fossil fuels. However, selecting appropriate electrode material is critical for efficient methanogenesis in MES systems. In this study, we investigated the impact of different applied potentials on CH_4 production in SS-equipped MES and accordingly poised the modified electrodes to achieve maximum CO_2 to CH_4 conversion. It was observed that MES-1 fabricated with MgO/CuO/SS cathode facilitated CH_4 generation in a shorter time compared to SS mesh and consumed less energy. The high catalytic activity of the composite electrode could be attributed to the basicity of the MgO surface and the uniform deposition of CuO nanoparticles on the SS mesh surface.

Keywords: microbial electrosynthesis; CO_2 -reduction-to-methane; electrodes modifications

Background

Biogas generated from carbon waste is a promising alternative to conventional fossil fuels. However, a major challenge lies in removing the CO_2 and increasing the CH_4 in biogas before its practical utilization. MES systems harness the metabolic energy of microbes to catalyse CO_2 reduction to CH 4 with simultaneous water splitting reaction on the anode for harvesting protons and electrons. The methanogenic archaea in the cathode biofilm utilize electrons, protons, and CO2 to produce CH4, via direct (CO_2 + 8H + + 8e– → CH_4 + 2H_2O, E 0 = −0.45 V vs. Ag/AgCl/3M NaCl) or indirect (2H + + 2e – → H_2 , E 0 = −0.62V vs. Ag/AgCl/3M NaCl, CO_2 +4H_2 → CH_4 + 2H_2O) pathway [1]. However, more negative potentials are generally applied to overcome the existing overpotentials. This energy consumption could be reduced by electrode materials that catalyze hydrogen evolution reactions at lower cathode potentials and facilitate direct CO 2 methanogenesis as well [2].

Key challenges and research gap

For MES, stainless steel (SS) based electrodes have been widely used due to their abundance, low cost, good mechanical strength, and electrical conductivity [3]. However, SS electrodes have relatively high charge transfer resistance and exhibit poor biocompatibility, compared to metal-composites, limiting the biocathode performance.

Findings

For the first time, this work explores an easy and green electrodeposition approach to modify the surface and electrocatalytic properties of SS mesh electrode. Herein, we developed a bimetallic composite cathode by in-situ fabrication of CuO nanoparticles decorated on SS mesh, anchored with 3-dimensional flower-like MgO structures for efficient CO_2 methanogenesis in MES. After 2 weeks of continuous operation, 100% CO 2 was observed. Composite electrode-based MES-1 started producing CH_4 by day 25, while SS-based MES-2 detected CH_4 production after 43 days of operation. As the experiment continued, MES-1 recorded more negative currents, which favoured H_2 gas generation over CO_2 reduction. As such, the applied potentials were reduced to -0.9V vs Ag/AgCl for the modified SS electrode only for the remaining cycles.

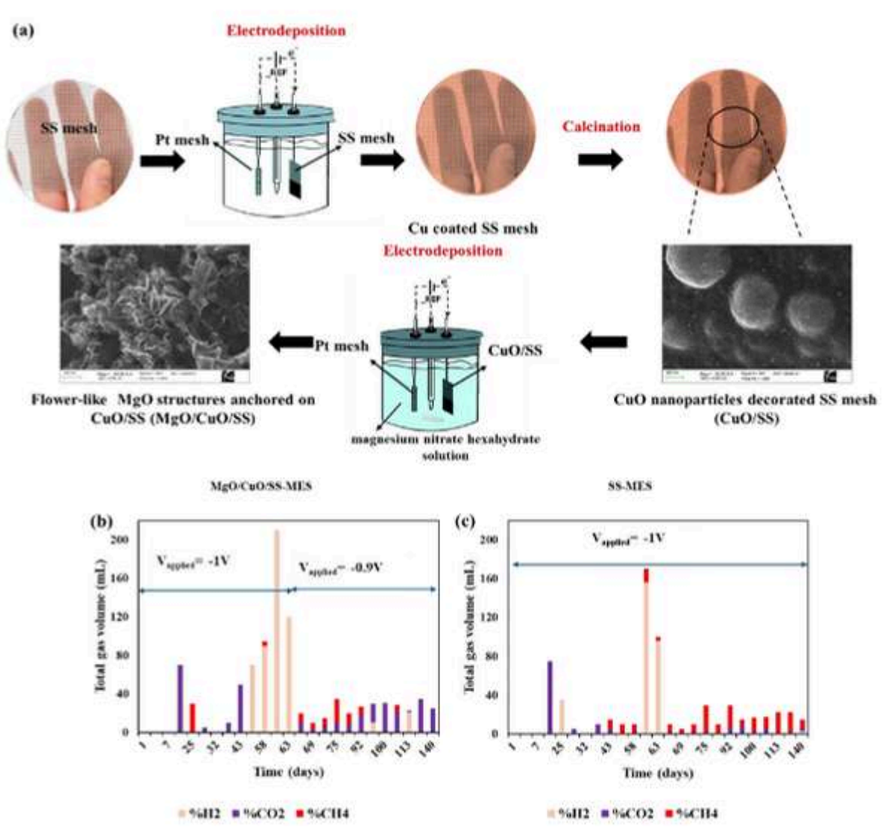

Fig. 1 (a) Schematics of the MgO/CuO/SS composite cathode synthesis procedure; gas composition in MES with (b) MgO/CuO/SS (MES-1) and (c) SS cathode (MES-2), respectively.

Abstract # :TRRR-005

Boosting CO2 Electro-methanogenesis in Microbial Electrosynthesis Systems via Electrode Modification

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Interestingly, MES-1 not only produced higher volumes of gases but also demonstrated better energy efficiency by outperforming MES-2 in terms of CH 4 production at the lower applied potential. This could be attributed to the synergistic effect of CuO nanostructures that enhances the conductivity and charge transfer capability of the electrode, while MgO improved CO_2 adsorption under bicarbonate formation, leading to efficient electro-methanogenesis via CO_2 reduction compared to SS electrodes [4,5]. However, more studies are needed to overcome the stability and metal leaching challenges that could deteriorate the MES performance in long-term applications.

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Abstract # :TWS-006

Rice-washing Wastewater Treatment in Microbial Fuel Cell with Ethanol Supplementation

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Abstract

Microbial fuel cell (MFC) could effectively treat rice-washing wastewater (RWW); however, high COD levels reduce its performance, which can be mitigated with ethanol supplementation. This study assessed RWW treatment in six single-chamber air-cathode MFCs supplemented with ethanol at 0% (R1, R4), 0.07% (R2, R5), and 0.15% (v/v) (R3, R6), corresponding to initial COD of 2900 mg L -1 (R1-R3) and 8000 mg L -1 (R4-R6). Results demonstrated that 0.07% ethanol enhanced COD removal efficiency and power density (R2: 89%, 480.5 mW m -2 ; R5: 80%, 654.4 mW m -2), while 0.15% ethanol impaired MFC performance. R5 exhibited delayed improvements, peaking after 12 d. Microbial analysis revealed that Clostridium sensu stricto 1 growth was promoted in R2, while Methanosaeta proliferated in R5, suggesting that methanogens competing for ethanol contributed to ethanol's delayed efficacy. Controlling initial COD is suggested to mitigate methanogens and optimize MFC performance.

Keywords: Ethanol; microbial fuel cells; rice-washing wastewater

Background

Rice-washing wastewater (RWW), with an estimated global volume of 504 billion litres annually, represents a major environmental challenge (Nabayi, 2021). Microbial fuel cells (MFCs), particularly single-chamber air-cathode (SCAC) MFCs, offer a promising solution for RWW treatment owing to their high efficiency, reduced manufacturing costs, and low environmental impacts (Lóránt, 2021). Ethanol has strong potential to enhance exoelectrogenic bacteria, leading to faster degradation and higher power output (Pan, 2023). This study investigated the novel impacts of ethanol concentrations on SCAC- MFCs, advancing both RWW treatment and bioelectricity production.

Materials and methods

Batch RWW treatments were performed using six SCAC-MFCs (R1-R6). R1, R2, and R3 were performed at an average COD of 2900 mg L-1 and selected ethanol concentrations of 0%, 0.07%, and 0.15% (v/v), respectively. Meanwhile, R4, R5, and R6 were performed at a higher COD of 8000 mg L-1 and similar ethanol levels of 0%, 0.07%, and 0.15% (v/v), respectively. All experiments were performed in duplicate over 34 d under a controlled temperature of 25°C and a resistance of 1000 Ω. Prior to experiments, 100 mL of anaerobic sludge was incubated with 100 mL of RWW in each SCAC-MFC for 30 d. Samples were collected every 2–3 d for COD and volatile acids measurement using COD Digestion Vials and Volatile Acids TNTplus Vial Test. Voltage and methane gas were monitored using a midi LOGGER GL240 and a Biogas 500, respectively. Microbial community was analysed via 16S rRNA gene sequencing.

Results and discussions

Over the course of 34 d, ethanol concentration significantly impacted SCAC-MFC performance in RWW treatment, with 0.07% proving most effective (Fig. 1a, b). R2 (0.07% ethanol) achieved the highest COD removal efficiency (89%) (Fig. 1a), consistent with Pan (2023). In contrast, R3 (0.15% ethanol) exhibited a reduced efficiency at 63% (Fig. 1a), suggesting a threshold ethanol concentration for optimal SCAC-MFC performance (Paz-Mireles, 2019). R5, also containing 0.07% ethanol yet with a higher initial COD than R2, exhibited delayed improvement, reaching 72% efficiency after approximately 12 d (Fig. 1b), indicating a time-lagged ethanol effect at higher COD levels. Methane formation of 6.0 mg COD.g COD removed-1 was detected in R5 on day 19 (Fig. 3), suggesting that methanogen growth interfered with ethanol efficacy. Microbial analysis revealed that at high COD levels, methanogens outcompeted exoelectrogens for ethanol as a carbon source, resulting to faster degradation of ethanol into volatile acids, such as acetate (Fig. 4, 5). A 2.5-fold increase in Clostridium sensu stricto 1 (exoelectrogens) in R2 likely contributed to the improved performance (Fig. 4), while R5 exhibited a 2.3-fold increase in Methanosaeta (methanogens). Notably, at the end of the experiments, the highest power density was achieved in R5 (879.05 mW m-2) (Fig. 2), highlighting the potential of 0.07% ethanol supplementation to enhance both organic removal and power generation from RWW.

Abstract # :TWS-006

Rice-washing Wastewater Treatment in Microbial Fuel Cell with Ethanol Supplementation

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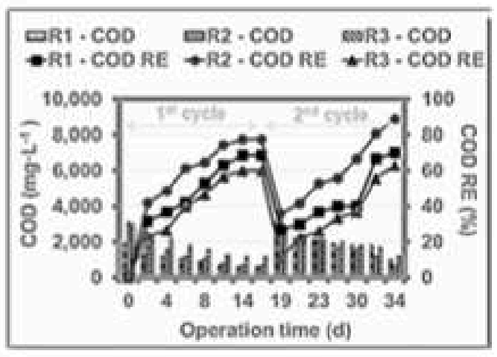

Fig. 1a COD removal in R1, R2, R3

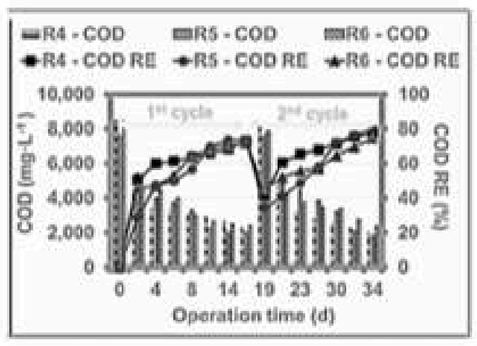

Fig. 1b COD removal in R4, R5, R6

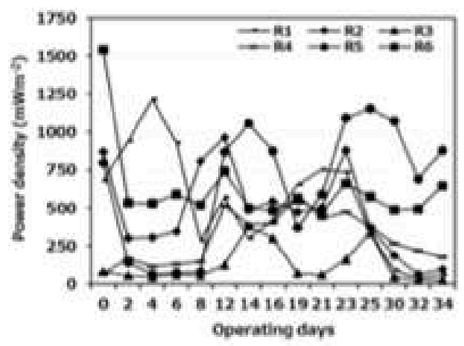

Fig. 2 Power density in all MFCs

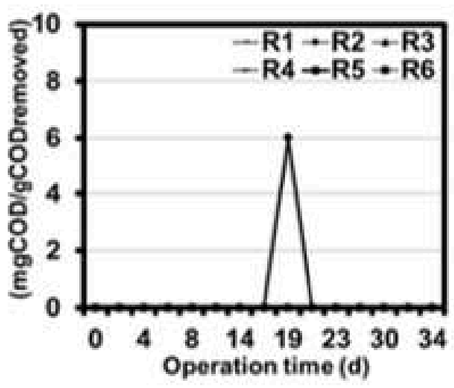

Fig. 3 Methane gas analysis

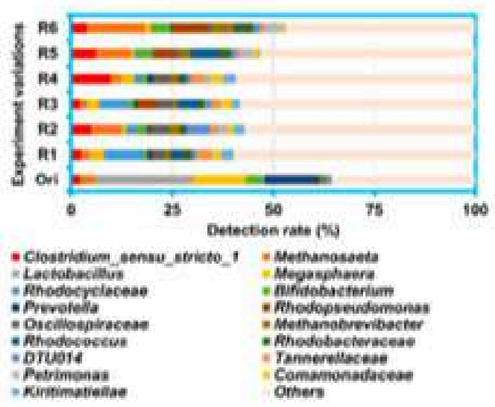

Fig. 4 Microbial community analysis

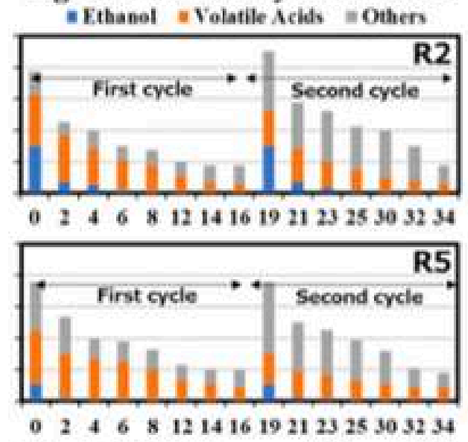

Fig. 5 COD balance of R2 and R5

Conclusions

Ethanol at 0.07% effectively enhanced RWW treatment in SCAC-MFCs, with controlling the initial COD to <3000 mg L-1 being crucial for optimizing performance.

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Abstract # :TUWM-004

Modelling Nutrient Fate and Transport in a Constructed Wetland in Calgary using the EFDC Water Quality Model

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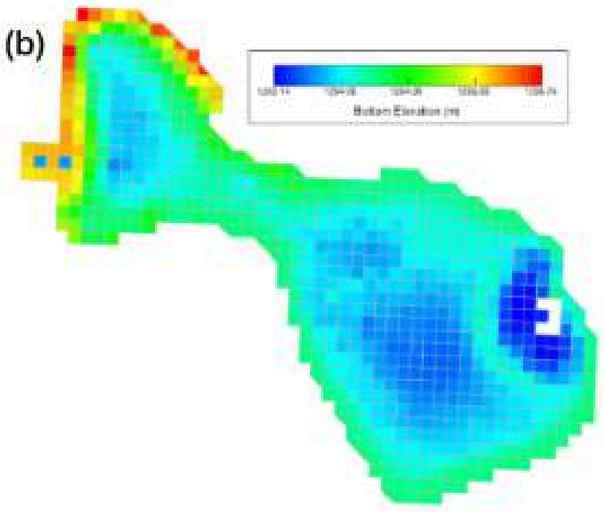
Abstract

This study applies EFDC to assess nutrient fate and transport in the Royal Oak wetland, Calgary. The model, calibrated and validated with two years of data, captured nutrient dynamics and algal interactions. Results showed spatially uniform nutrient levels, except during rainfall, which temporarily increased concentrations. Dry periods enhanced sedimentation, while algal growth was phosphorus-limited. High inflows reducednitrogen removal, while temperature had minimal impact. Raising the outlet height improved nutrient retention, whereas vegetation adjustments and dredging had limited effects. Findings confirm EFDC's suitability for small urban wetlands and its value in understanding nutrient processes.

Keywords: EFDC; water quality model; Constructed wetland

Constructed wetlands play a key role in urban stormwater management by mitigating flood risks and improving water quality through nutrient and total suspended solids (TSS) removal (Mitsch & Gosselink, 2015). However, their efficiency varies due to internal loading and eutrophication, necessitating a better understanding of nutrient cycling for optimal performance (Troitsky et al., 2019). Numerical models offer an efficient alternative to field monitoring. The Environmental Fluid Dynamics Code (EFDC) is a widely used three-dimensional model for simulating hydrodynamics and water quality (Hamrick, 1996).

This study applies EFDC to model nutrient dynamics in the Royal Oak (RO) wetland in Calgary, Alberta. The RO wetland, covering 4,375 m2, receives inflow from a 15.2-hectare catchment (51% impervious surfaces) and consists of a sediment forebay, a narrow channel, and a tail pond (Figure 1a). Field data were collected over two ice-free periods (2018–2019), with bi-weekly water sampling and flow monitoring at the inlet and outlet. The EFDC model domain (6,984 m2) used a 3 × 3 m grid with three vertical layers and incorporated 15 water quality parameters, focusing on nutrient cycling and algal dynamics (Figure 1b). Calibration and validation used four performance metrics: relative mean error (RME), relative root mean square error (RRMSE), Nash-Sutcliffe efficiency (NSE), and correlation coefficient (R) (Figure 1c).



(c)

	RME(%)	RRMSE	NSE	R
Calibration				
TN	-7.36	0.20	-0.28	0.28
TP	0.60	0.43	0.16	0.61
TOC	-8.51	0.21	0.27	0.60
Validation				
TN	-11.10	0.25	-3.36	0.45
TP	-0.58	0.34	-1.41	0.44
TOC	1.03	0.10	0.54	0.78

Figure 1 Aerial view of the RO wetland (a) and bottom elevation plot (b) of the RO wetland represented in the EFDC model. Inlet and outlet locations are shown in the figure with arrow and sampling locations (A, B,and C) are marked as cross stars.

Abstract # :TUWM-004

Modelling Nutrient Fate and Transport in a Constructed Wetland in Calgary using the EFDC Water Quality Model

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Calibration results showed good agreement for TP and TOC (NSE: 0.16 and 0.27), though TN had a slightly negative NSE (-0.28), indicating nitrogen modelling challenges. Validation results were slightly less accurate but maintained reasonable RME (<10%). Rainfall events caused transient nutrient spikes, particularly in the sediment forebay, while dry periods promoted sedimentation and sequestration. Vertical water quality remained stable, with minor stratification during hydrologic shifts. Algal growth was phosphorus-limited, as reflected in chlorophyll-a trends. Simulations assessed external nutrient inputs, climate change, and hydrodynamic modifications (Figure 2a). Increased inflow nutrients led to TN concentration spikes, emphasizing the wetland sensitivity to external loading. Temperature changes had minimal impact, while wind speed variations influenced mixing and TN accumulation. The drought scenario reduced TN inflow but did not account for potential internal loading.

Mitigation strategies had mixed results (Figure 2b). Raising the outlet height improved TN retention by increasing hydraulic retention time, while vegetation density and sediment interception had minimal effects. Dredging was limited by fixed internal loading parameters in the model.

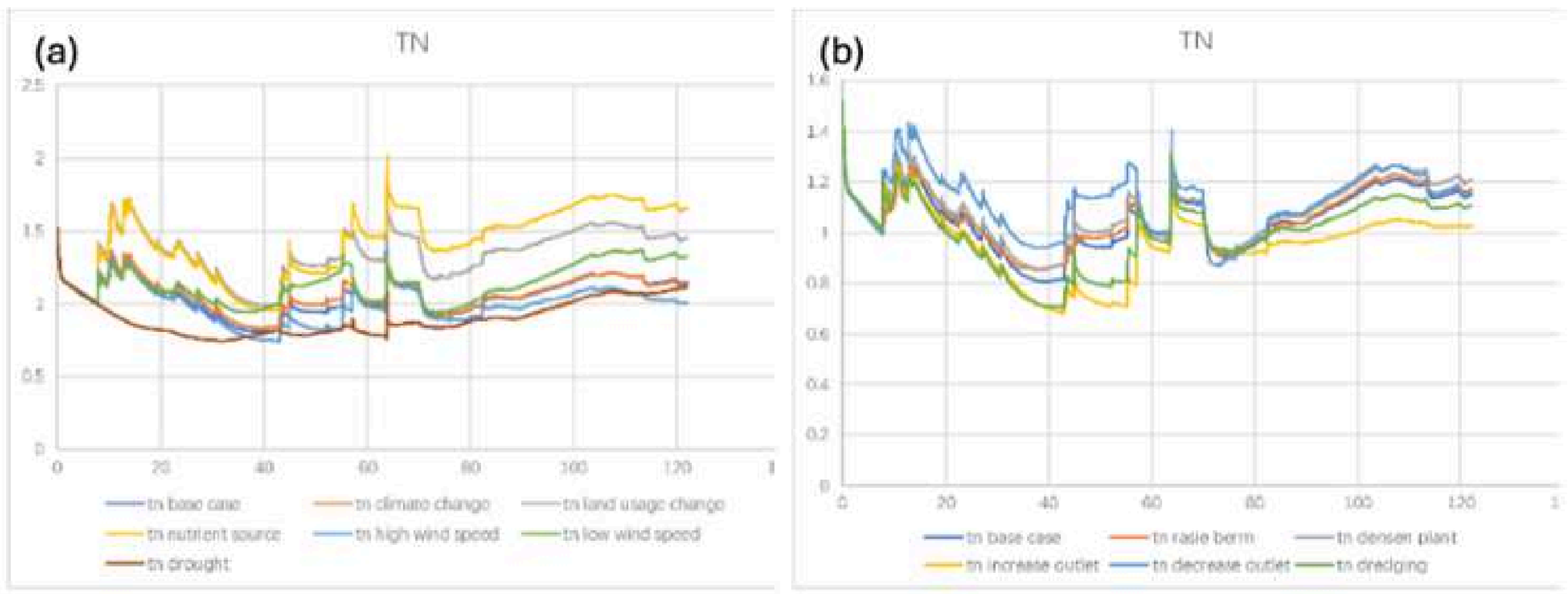

Figure 2 Time series plot of TN concentration comparing different scenarios (a) and different improvement measures (b) with the base case.

The EFDC model effectively captured nutrient dynamics, sediment interactions, and algal growth in the RO wetland. Rainfall events triggered nutrient spikes, while dry periods facilitated sedimentation. Scenario analysis highlighted TN sensitivity to external loading and the limited effects of climate change. Raising the outlet structure enhanced TN retention, whereas vegetation and dredging adjustments were less effective. Future work should improve model sensitivity to temperature and wind variations, refine vegetation and internal loading processes, and extend monitoring to enhance predictive capabilities for wetland management.

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Abstract # :TWS-016

Demonstrating Hybrid Wetlands as a Low-Maintenance Wastewater Solution for Communities in Canada

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Abstract

Canadian communities with aging wastewater (WW) treatment facilities require major upgrades to meet current effluent quality targets and growing populations. Limited financial resources exacerbate their ability to pay for and maintain mechanical systems. Constructed wetlands (CW) provide an effective, cost- efficient solution to WW facility upgrades. MAGNA Engineering Services Inc. (MAGNA) and the City of Estevan, Saskatchewan, secured approval for a pilot CW system to demonstrate potential upgrades to their WW treatment facility. The CW system utilizes hybrid vertical and horizontal flow wetlands, a phosphorus removal cell, a recirculation pump, mulch cover, and conservative sizing. These features provide treatment redundancy so that regulatory discharge permits are approved for year-round operation. The system is currently being monitored to analyse the system's performance.

Keywords: Constructed Wetlands; Nature-based Solutions; Wastewater Treatment.

Introduction

Constructed wetlands (CW) have been operating across the globe for wastewater (WW) treatment, but implementation in Saskatchewan is hindered by real and perceived risks such as slower biological processes in low temperatures result in decreased nitrogen treatment as well as regulatory scepticism about the winter viability of CW. Research shows that planted treatment systems remove significantly more nutrients (up to 95%) and carbon (up to 98%) than unplanted systems (up to 50%) in cold climates. (Allen, 2013). The MAGNA Biofilter Wetland System (MBWS™) project in the City of Estevan (the City) addresses concerns and provides further evidence to the year-round effectiveness of CWs. MAGNA aims to increase CW implementation in Canada through regulatory and public awareness and understanding of MBWS™ technology.

Background

The City, located in southeastern Saskatchewan with a population of 10,851, needed to upgrade its modified sequencing batch reactor (MSBR) WW facility (WWTF) to meet Water Security Agency (WSAS) standards and support the City's growth. MAGNA partnered with the City to design and monitor a pilot CW system as a potential solution. The system started operations in May 2024 and after one year of monitoring, the pilot will seek WSAS approval for full-scale implementation.

MAGNA Biofilter Wetland Solutions (MBWS™)

The pilot-scale MBWS™ was implemented at the City's existing WWTF to test its potential to treat raw WW (RWW) and as a polishing step for effluent from the existing MSBR. The MBWS™ consists of two trains operating in parallel. Train 1 receives RWW, whereas Train 2 receives the treated effluent from the MSBR. The trains have identical configurations, and each includes a hybrid vertical flow biofilter (VFB), followed by a horizontal subsurface flow wetland (HSSFW) and a phosphorus removal cell (PRC). Both the VFB and HSSFW are planted with native, weather-adapted species. The treated effluent from both trains is collected in the effluent well and is pumped back to the inlet of the MSBR. Returning MBWS™ treated effluent to the MSBR ensures not short circuiting of the existing treatment facility, thereby mitigating risk. The MBWS™ is designed to treat a combined flow of 5 m 3 /day or approximately 0.1% of the current average daily flow observed at the MSBR.

MBWS TM Monitoring Strategy

Weekly WW sampling and testing is conducted at each treatment unit (VFB, HSSFW, and PRC) for the parameters listed in Table 1.1 (next section). Similarly, online flow analysis is conducted daily. The end goal of the monitoring program is to demonstrate that the MBWS™ effluent meets the stringent standards provided by the WSAS.

System Performance

As shown in Table 1.1, the required parameters concentrations were achieved. The in-series treatment makes the system effective. No complex calibrations, chemical additions or mechanical interventions are required as the WW is treated mainly through microbial activity within the wetland media and its interaction with plant roots.

Abstract # :TWS-016

Demonstrating Hybrid Wetlands as a Low-Maintenance Wastewater Solution for Communities in Canada

M. A. Salinas-Toledano*, A. Skorobogatov*, J. Massig*, J. Quick*, E. Calvin*
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Table 1.1 2024 1 Average Testing Parameters and Results from Train 1 and 2 Influent (Pre-VFB) and Effluent (Post-PRC)

Demand	Target Effluent[2]	Train 1 (RWW	Train 1 (RWW	Train 2 (Treated	Train 2 (Treated
Carbonaceous	12	95.1[3]	4.9	27.5[3]	2.4
Biochemical	15	101.3	6.1	30.3	2.8
Solids					
Total	15	101.8	6.1	34.8	8
Nutrients					
Nitrate (as N)	–	1.3	2	2	2.9
Total Nitrogen	–	53.5	17.3	19.5	15.9
Unionized	1.25	0.267	0.0503	0.0303	0.0057
Total	–	14.2	2.8	5.8	2.1
Microbial					
E. coli DST [MPN/100	–	15,996[4]	905	12,134[4]	945
Total Coliforms	–	78,889[4]	5,085	72,920[4]	3,169
Physical					
pH (15°C)	–	7.7	7.4	7.4	7.4
Dissolved	–	–	3.2	–	3.9

1. The year 2024 includes sampling from the month of May to the end of December.
2. Target effluent parameters required by WSAS for discharge into open bodies of water.
3. Estimation based on BOD 5 since the parameter is not actively measured at that location
4. Post VFB values since the parameter is not actively being measured at that location

Based on the results, The City of Estevan MBWS™ sets a precedent for efficient, cost- effective, and scalable WW management solutions that meet rigorous effluent target requirements. It is a successful cold climate application for CW systems that is repeatable in small- to medium-sized communities throughout Canada, and other cold climate regions facing similar environmental and financial constraints.

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Abstract # :TWS-014

Analytical Assessment of Antibiotics for Livestock Wastewater and Runoff Treatment in Constructed Wetlands

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Abstract

The widespread use of pharmaceuticals introduces micropollutants into aquatic ecosystems, and antibiotics in particular have been a serious concern in livestock facilities. Constructed wetlands (CWs), a nature-based solution, help mitigate these pollutants, but the impact of antibiotics on CW biological processes remains unclear. This study evaluated the water quality pollutant and antibiotic removal efficiency of a CW near a livestock area in Korea. In comparison to 2010 data, the removal efficiency of most contaminants in 2024 improved, but total nitrogen (TN) removal significantly decreased. Concentrations of chlortetracycline and sulfathiazole peaked at 55.57 ppb and 72.36 ppb, respectively, within the wetland but were significantly reduced at the effluent. This variability in antibiotic removal efficiency underscores the importance of further research to optimize CW design and functionality in livestock areas.

Keywords: Antibiotics; constructed wetlands; removal efficiency

Introduction

Antibiotics are widely used for both humans and livestock, and it was previously found that around 90% of antibiotics are excreted unchanged and released into the environment in the form of manure (Jjemba, 2002). Constructed wetlands, a nature-based solution for wastewater treatment, can remove organic matter, nutrients, heavy metals, and pollutants. However, the long-term performance of livestock CWs exposed to antibiotics remains underexplored. In response, this study evaluated water quality in a livestock CW from 2010 to 2024 and analyzed antibiotic concentrations in three CW phases, providing insights for design improvements and targeted antibiotic treatment.

Methodology

The studied CW in Nonsan City, South Chungcheong Province, Korea, treats combined effluent from a piggery wastewater treatment plant (WWTP) and stormwater runoff. Water quality samples were collected from the inlet, middle, and outlet of the CW during the summers of 2010 and 2024 and analyzed for parameters such as total nitrogen (TN), total phosphorus (TP), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and orthophosphate (PO4-P). Antibiotic detection was performed using an Orbitrap Exploris 120 mass spectrometer with a Hypersil Vanquish C18 column and a 20-minute gradient method at 40°C.

Results and discussion

Comparing removal efficiencies of the CW from 2010 and 2024 in Figure 1, it can be observed that the removal efficiency has improved for TP and COD, with the highest removal efficiency improvements recorded at +57.6% and +40.2% for the two parameters, respectively. However, TN removal efficiency decreased significantly by 143.3%, likely due to the negative impact of antibiotics on nitrifying bacteria essential for TN removal, leading to its accumulation in the CW.

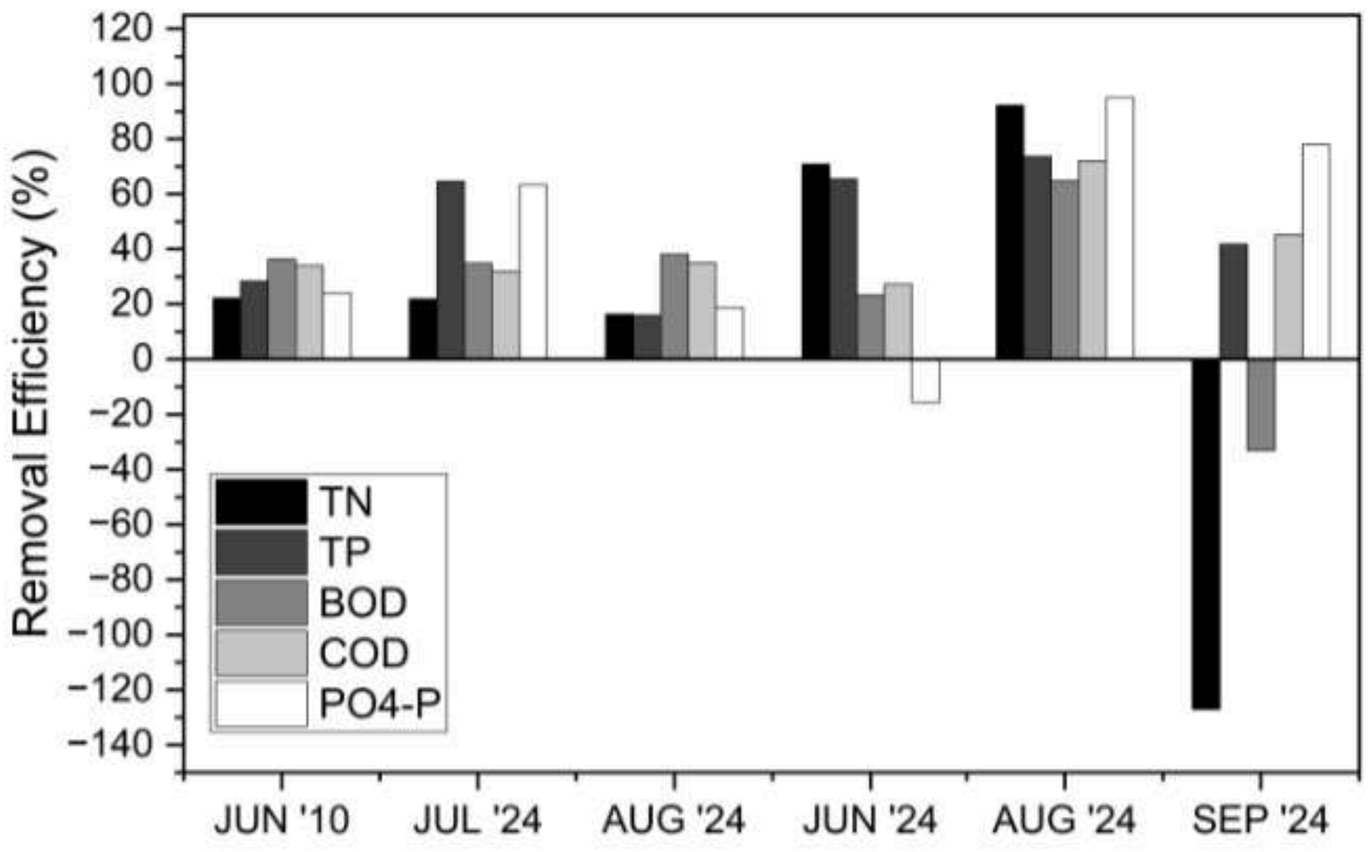

Figure 1 Removal efficiency of the constructed wetland for various water quality parameters in 2010 and 2024.

Abstract # :TWS-014

Analytical Assessment of Antibiotics for Livestock Wastewater and Runoff Treatment in Constructed Wetlands

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As shown in Table 1, high antibiotic concentrations were detected in the middle of the CW, with sulfathiazole and chlortetracycline reaching 55.57 ppb and 72.36 ppb, respectively. Significant reductions were observed at the effluent, with removal efficiencies of 99.7% for sulfamethazine and 62.3% for chlortetracycline, largely due to adsorption onto soil, organic matter, and vegetation. However, the CW showed negative removal efficiencies for amoxicillin and sulfathiazole, commonly used in piggeries. These results underscore the variability of antibiotic concentrations in CWs and the need for further research to optimize treatment in nature-based technologies.

Table 1 Concentration of different antibiotics detected in three phases of the constructed wetland.

Compound	Inlet	Middle	Outlet
Amoxicillin	*BDL	0.187	0.062
Chlortetracycline	0.4	55.57	0.151
Doxycycline	1.033	2.088	0.978
Oxytetracycline	0.08	0.474	0.072
Sulfamethazine	0.615	7.849	0.002
Sulfathiazole	BDL	72.36	0.07

*BDL – below detection limit

Conclusion

This study highlights the potential of constructed wetlands for livestock wastewater treatment while revealing variability for antibiotic exposure. Improved TP and COD removal efficiencies contrast with reduced TN removal, likely due to antibiotics inhibiting nitrifying bacteria. Furthermore, varying concentration in antibiotic removal underscores the need for further research to enhance CW design and performance.

Acknowledgement

This study was supported by the Korea Environmental Industry and Technology Institute Wetland Ecosystem Valuation and Carbon Absorption Value Enhancement Technology Development Project funded by the Ministry of Environment (2022003630005).

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Modelling and Machine Learning

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Abstract # :TUWM-005

Spatiotemporal Evaluation of SWE Estimates Across Canada: A Comparative Analysis of CanSWE, SNODAS, and ERA5-Land

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Abstract

Accurate estimation of Snow Water Equivalent (SWE) is crucial for hydrological modeling, water resource management, and climate impact studies, particularly in snow-dominated regions like Canada. This study compares three SWE datasets—CanSWE (station-based measurements), SNODAS (high-resolution gridded data), and ERA5-Land (global reanalysis data)—from spatial and temporal perspectivea across Canada. By evaluating seasonal SWE variations, particularly during peak accumulation and melt periods, the study investigates how well gridded and reanalysis datasets capture spatial variability in complex terrains compared to in-situ observations. Metrics such as temporal correlation, bias, and the root mean square deviation (RMSE) are used to quantify differences. The research also explores potential trade-offs in using model-based SWE estimates instead of direct station measurements, especially in remote areas with sparse ground observations.

Abstract # :TUWM-006

Mapping Dominant Hydrologic Processes in North America based on Machine Learning

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Abstract

Accurate identification of regional hydrologic processes is essential to improve the accuracy of hydrologic models and water resources management. This study combines process-driven hydrologic modeling with machine learning to map major hydrologic processes in North America. First, we will apply the SUMMA and mizuRoute models to the observed data of 677 watersheds and calibrate the results using Ostrich. Then we will use pyViscous to perform a global sensitivity analysis to quantify the sensitivity of the parameters and form a database of the dominant processes. Finally, several machine learning algorithms (Random Forest, XGBoost, CNN) will be systematically compared to develop a watershed characteristics-to-hydrologic process mapping model, enabling large-scale spatial identification. This framework will enhance regional hydrologic modeling and process understanding.

Abstract # :TUWM-007

Near Zero Water Modelling: Pioneering Strategies for Decarbonization in Canada's Building Sector

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Abstract

As Canada's buildings sector advances toward net zero operation, the focus on energy has overshadowed the need to optimize water use in the pursuit of decarbonization. By developing a Near Zero Water Use Strategy (NZWUS), designers can decrease GHG emissions and provide meaningful cost savings for clients. Reducing the strain on urban water systems and aligning with Greening Government Standards. The application of a modelling-based NZWUS provides designers and engineers with an actionable framework for water conservation and reuse in the existing building sector. For a building in Ottawa, ON, a 40-45% reduction in potable water use can be achieved through optimization measures, while an additional 55%-70% reduction can be achieved using alternative sources of water.

Abstract # :TBWR-004

Assessing Water Security Through Detailed River Basin-Scale Modelling: A Short Time-Step Demand Variability Modelling Framework

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Abstract

Water security is increasingly threatened by climate variability and human activities, with global freshwater demand projected to exceed supply by 40% by 2030. Even Canada, traditionally water-abundant, faces regional risks, particularly in its western provinces. This study proposes a short-time step river basin-scale system dynamics modelling framework to assess water security in the Bow River Basin, integrating municipal, agricultural, and industrial demand models. Baseline scenarios indicate seasonal water demand peaks exceeding conservation targets, with urban use projected to reach 426 lpcd under high-demand scenarios and irrigation demand rising by up to 11% by 2040. A coupled approach utilizing CWMM, EWDS, and AISS models is proposed to enhance demand-sector interactions and policy scenario modelling. This framework will serve as a decision-support tool for water management, with potential extensions to the Nelson River Basin for broader application.

Environmental Monitoring and Emissions

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Abstract # :TWS-003

N_2O Emissions in a Full-scale Wastewater Treatment Plant: Effects of Flow Modes and Key Operational Parameters

Marwan Al Saleh*, Mostafa Khalil, Ahmed AlSayed, Ahmed Elsayed, Mohamed Sherif Zaghloul, Farokh Laqa Kakar, Katherine Y. Bell, Shannon Cavanaugh, Ahmed Al-Omari, Elsayed Elbeshbishy
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Abstract

In response to global warming, developing countries are striving for net-zero emissions by 2050, emphasizing the reduction of greenhouse gas (GHG) emissions. Wastewater treatment plants (WWTPs) contribute significantly to Scope 1 emissions, with nitrous oxide (N_2O) being a key contributor due to its 300 times higher global warming potential. This study quantifies N_2O emissions and examines the influence of operational parameters under step-feed, semi-plug, and plug-flow modes in a full-scale activated sludge system. Over six months, samples were collected from 13 locations, measuring parameters such as NH 3 , NO^{2-}, NO^{3-}, sCOD, DO, and temperature. Unisense sensors recorded N_2O liquid concentrations every 30 seconds, while microbial analyses captured population dynamics across flow modes. Plug flow achieved the highest NH 3 removal but also exhibited the highest N_2O emissions (3.696 kg N-N_2O/hr), followed by semi-plug (0.444 kg N-N_2O/hr) and step-feed (0.068 kg N-N_2O/hr). Higher DO levels in plug flow mode enhanced ammonia-oxidizing bacteria activity, accelerating nitrification. However, NO^{3-} and NO^{2-} accumulation in plug and semi-plug modes indicated incomplete nitrification/denitrification, contributing to emissions. Ongoing data analysis aims to refine insights into the relationship between operational parameters, microbial populations, and N_2O production.

Keywords: Nitrous oxide emissions; Wastewater treatment; Operational parameters.

Introduction

N_2O is primarily produced during the biological nutrient removal process. Realizing the environmental effects of N_2O, the goal of N_2O research in wastewater treatment systems in the past decade has been mitigating N_2O emissions (Duan et al., 2021). To develop mitigation strategies in WWTPs, extensive studies have been carried out to link environmental factors to N_2O generation. Dissolved oxygen (DO), NO_2^-, NH_4^+, pH, and temperature have been identified as major influential factors that affect N_2O generation from WWTPs (Domingo-Félez & Smets, 2019; Wu et al., 2020).

Objectives

This study aims to quantify N_2O emissions, identify the pathways responsible for N_2O production, and link environmental factors and operational parameters to N_2O generation in a full-scale conventional activated sludge system under different flow modes: step-feed, semi-plug, and plug flow modes.

Significance of Study

The novel part of this research is the comprehensive comparison of N_2O emissions, microbial communities, operational parameters, and nutrient removal efficiency under three different flow modes. Combining these aspects will provide us with a better understanding of their correlation and establish a link between them and N_2O generation.

Methodology

Over six months, liquid samples were collected from 13 locations within the conventional wastewater treatment plant. These locations are distributed: nine locations along the selected aeration tank, influent, effluent (of the secondary clarifier), and return-activated sludge (RAS). A sampling schedule of two to three times per week was followed throughout the study period, with each flow mode (step-feed, semi-plug flow, and plug flow) running for two months. To understand the nitrification and denitrification processes under each flow mode, key parameters such as ammonia (NH_3), nitrite (NO_2^-), nitrate (NO_3^-), soluble and total chemical oxygen demand (sCOD, TCOD), total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), volatile suspended solids (VSS), dissolved oxygen (DO), pH, and temperature were measured. Additionally, two Unisense sensors were used to monitor and record N_2O liquid concentration every 30 seconds. The two sensors were installed along the tank at different locations, one in the middle of pass 1 (Location 2) and one in the middle of pass 3 (Location 6), providing continuous data on N_2O concentration and temperature. Additionally, at each sampling event, two microbial analysis samples were collected from locations (2 and 6) to identify microbial community changes across the different flow modes. These comprehensive measurements provide a detailed picture of nutrient transformations, microbial activity, and N_2O production. A sampling campaign was established to collect appropriate data to baseline the current emission. The following equipment was used: Unisense Analyzer, Unisense sensors (two probes, for liquid phase N_2O), sample bottles for all liquid phase sampling, Hatch portable DO meter, and Hatch portable pH meter.

Abstract # :TWS-003

N_2O Emissions in a Full-scale Wastewater Treatment Plant: Effects of Flow Modes and Key Operational Parameters

Marwan Al Saleh*, Mostafa Khalil, Ahmed AlSayed, Ahmed Elsayed, Mohamed Sherif Zaghloul, Farokh Laqa Kakar, Katherine Y. Bell, Shannon Cavanaugh, Ahmed Al-Omari, Elsayed Elbeshbishy
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Results and Discussion

After more than 140 days of operation, it was found that operating the aeration tank as a plug flow resulted in the highest NH_3 removal, followed by semi-plug flow and step-feed. Because of the higher DO levels in the Plug flow mode compared to the other modes, the ammonia-oxidizing bacteria (AOB) is more active, resulting in faster nitrification. As shown in Figure 2, in agreement with ammonia removal efficiency, plug flow, and semi-plug flow operations resulted in the highest N_2O emissions, while step-feed mode showed the lowest emissions. An average N_2O emission rate, defined as the estimated mass of nitrous oxide (N_2O), expressed as nitrogen (N-N_2O), released into the atmosphere per unit time, was observed to be 3.696 kg N-N_2O/hr for the plug flow mode, 0.444 kg N- N_2O/hr for the semi-plug flow mode, and 0.068 kg N-N_2O/hr for the step-feed mode. This can be explained by noting that, while certain operational parameters, such as moderate dissolved oxygen levels and limited carbon availability, support ammonia removal, they are suboptimal for controlling N_2O emissions. These conditions favor nitrification but stimulate N_2O-producing pathways, such as nitrifier denitrification and incomplete hydroxylamine oxidation. In the plug flow mode, NO_3 and NO_2 accumulate, indicating incomplete nitrification and/or denitrification. N_2O is predominantly produced at the boundary between aerated and unaerated zones, even though this setting is sub-optimal for nitrifiers and denitrifiers (Ji et al., 2015; Wrage et al., 2001).

Future and Ongoing Work

Among the three flow modes, samples collected are ongoing microbial analysis to analyze changes in microbial populations. In addition, comprehensive data analysis is ongoing, such that NH_3 removal rates, N_2O emissions, NO_3 production rates, and DO levels are being compared across the three flow modes to determine if there are any significant differences. ANOVA is being used to detect such a difference. Moreover, correlations and regressions are being studied to identify the primary driver parameters of N_2O emissions, focusing on possible parameters like DO, sCOD, NH_3, NO_3, and NO_2. Findings from this study are expected to provide useful insights into how WWTPs can reduce N_2O emissions while maintaining nutrient removal efficiency.

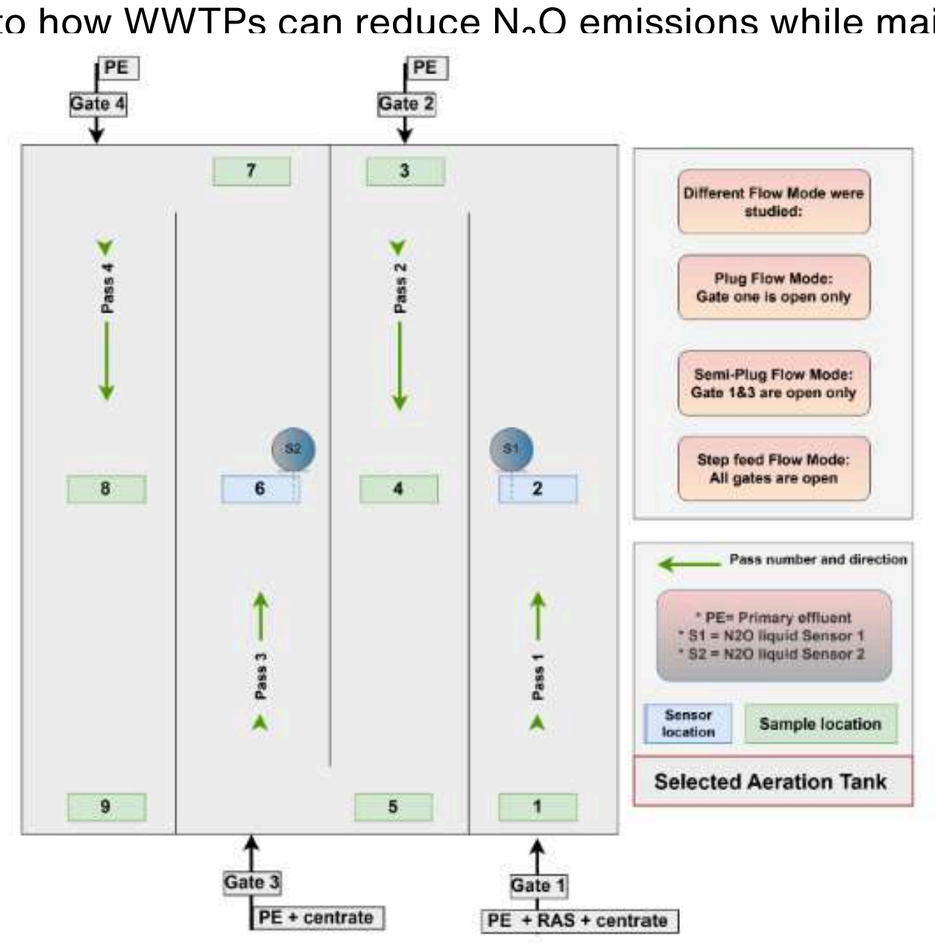

Figure 1. The layout of the selected tank indicates liquid sampling locations and sensor placements.

Abstract # :TWS-003

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Abstract # :TBWR-008

Beyond the WRRF fence: Accounting for WRRF-induced nitrous oxide emissions from receiving water bodies

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Abstract

Emission factors based on literature are used to evaluate the N 2 O emissions induced by the effluent discharge. These factors are applied to the effluent total nitrogen load, i.e. the effluent-induced N 2 O emissions only come through the in-river conversion of total nitrogen. Therefore, dissolved N 2 O in the effluent is not actually considered. In this work, dynamic modelling was used to evaluate the contribution of dissolved N 2 O to the total effluent-induced emissions and the overall carbon footprint of a WRRF. Results show that by neglecting that fraction, WRRF-induced receiving water emissions are considerably underestimated, and contribute to the overall carbon footprint of a WRRF.

Keywords: Nitrous oxide; Indirect emissions; Receiving waters; Carbon footprint; Modelling

Introduction

The water sector contributes to greenhouse gas (GHG) emissions through both direct and indirect emissions. Despite being the fifth-largest source of methane and the third largest source of nitrous oxide (N 2 O) globally, the wastewater sector is understudied in comparison with other sectors such as energy and transportation (Song et al., 2024). As more jurisdictions pursue net-zero carbon emissions, the reporting and mitigation of both direct (Scope 1) and indirect (Scopes 2 and 3) GHG emissions from wastewater treatment are crucial. Direct emissions of N 2 O from processes have been the focus of numerous studies for monitoring (Vasilaki et al., 2019), modelling (Mannina et al., 2016; Khalil et al., 2024) and control (Flores-Alsina et al., 2011). Indirect emissions have been studied much less. Specifically, the quantification of emissions that are due to treated effluent discharges is limited to the use of an N 2 O emission factor based on literature and relative to their total nitrogen (TN) (IPCC, 2019). However, this method only considers the fraction of nitrogen that will be transformed into N 2 O and neglects the dissolved N 2 O already present. This contribution explores the impact of the consideration of dissolved N 2 O in the effluent discharge on the carbon footprint of a water resource recovery facility (WRRF). The objectives are to 1) evaluate the N 2 O emissions from all three Scopes for a WRRF and 2 assess the impact of neglecting dissolved N 2 O in the effluent discharge in the carbon footprint of a WRRF.

Methods and results

The Québec City East WRRF in Canada is looking to upgrade their facility to ensure nitrogen removal for upcoming regulations. Three upgrade scenarios are considered. In the decision process, the GHG emissions for all three scenarios are to be compared.

Scope 1 emissions

The actual Québec City East WRRF operates biofilters. All three upgrade scenarios are based on biofilters. Hence, to quantify direct (Scope 1) GHG emissions a biofilter model was used to simulate the treatment line. The model was initially developed on the WEST (DHI, Denmark) simulation software by Zhu (2020) to simulate the operation of the N- removing biofilters of the Seine Aval WRRF in Paris, France. Québec City influent data were used as input data and experimental data was used to calibrate the model of the actual Québec City East WRRF. The N2O emissions from the process were simulated using parameters estimated with experimental data from the Seine Aval WRRF biofilters (Bollon et al., 2016).

Scope 2 and 3 emissions

The heating and electrical consumption data for the three scenarios were available from detailed design calculations to evaluate Scope 2 emissions. For Scope 3 emissions, the quantification was limited to construction (steel, concrete and excavation) and chemicals (methanol and lime). Combined with emission factors from literature, the available date allowed the quantification of indirect emissions.

Effluent discharge

The most recent GHG accounting guidelines (IPCC, 2019), published by the International Intergovernmental Panel on Climate Change (IPCC), have effluent TN-emission factors based on the oxygenation level of the receiving water body. The emission factors for well-oxygenated environments and low oxygen environments are respectively 0.5% and 1.9% kg N-N 2 O/kg TN. The following equation is used:

Abstract # :TBWR-008

Beyond the WRRF fence: Accounting for WRRF-induced nitrous oxide emissions from receiving water bodies

Daniel Andres Mendoza Grubert* & Peter A. Vanrolleghem
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The emission factors are the result of the compilation of 62 data points for well-oxygenated environments and 59 for low-oxygen environments (IPCC, 2019). However, the IPCC method only considers the fraction of nitrogen that will be transformed into N 2 O by evaluating emissions based on effluent TN. Studies have shown that the mixed liquor can contain considerable dissolved N 2 O concentrations (Kampschreur et al., 2008; Bollon et al., 2016). It can be assumed that this N 2 O load will be emitted from the receiving waters. The WEST model used to quantify Scope 1 emissions also outputs the dissolved N 2 O in the effluent discharge.

Results

Figure 1 shows the effect of including dissolved N 2 O in the calculations. Note that the conversion of nitrogen to N 2 O and the stripping of dissolved N 2 O were considered instantaneous. Dynamic modelling allows to see the dynamics during a dry day, for instance. These results show that the impact of the dissolved N 2 O on the emissions from the effluent discharge is not negligible. The emissions from the dissolved N 2 O are larger than the emissions resulting from the in-river conversion of TN to N 2 O. In conclusion, WRRF- induced nitrous oxide emissions from receiving water bodies can represent more than one third of a WRRF's total yearly GHG emissions.

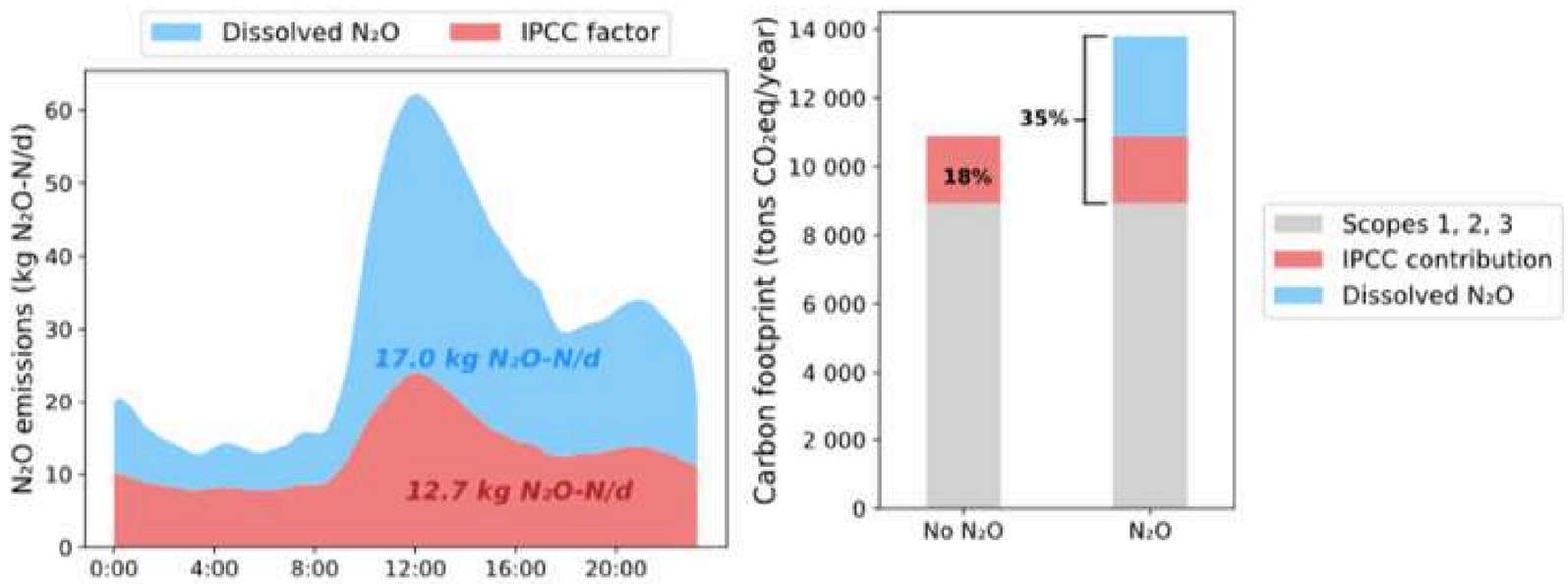

Figure 1. Effect of considering dissolved N2O for effluent discharge on a daily basis(left) and a yearly basis in comparison with all emissions related to Québec City East WRRF (right) for dry weather for scenario 3.

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Abstract # :TBWR-005

Microwave Sensing Technology for Hydrocarbon Monitoring in Water

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Abstract

When accidents occur during the transportation of crude oil, gasoline, or diesel, the oil contains hydrocarbons spilled or leaked into the waterways which will pose significant environmental and ecological threats. Hydrocarbon spills need effective monitoring solutions. In order to address the critical need for real-time water quality monitoring, particularly the hydrocarbons. Our research proposes to design a microwave sensor capable of real-time, sensitive and low-cost hydrocarbon monitoring. The real-time microwave sensor can detect and report oil spills promptly. Initial tests on inorganic mixer water samples demonstrate high sensitivity to inorganic contaminants at concentrations as low as 500 ppb. Future work includes enhancing the sensors design for hydrocarbon detection of natural contaminants.

Keywords: microwave sensor; hydrocarbon detection; real-time monitoring; water quality

Alberta is a province that contains oil resources, and daily oil transportation activities are busy. Once an accident happens during the oil transportation through roads, rails, or pipelines, the oil will spill or leak into the waterways. At that time, the water resources, environment, and ecological system will be seriously impacted. [1] Therefore, having a real- time hydrocarbon monitoring sensor allows handling the spill immediately and reduces the impact.

Currently, there are several monitoring sensors for detecting oil spills, especially the hydrocarbons in water. Each monitoring sensor has unique advantages and limitations. The most common sensor for detecting oil spills in water is optical sensors. Thermal infrared sensor, ultraviolet sensor, and laser-induced fluorescence sensor are examples of the optical sensors. An optical sensor is sensitive and rapid for detecting the hydrocarbon, but because the optical sensor relies on the light, several factors will affect the results, such as the weather, cloud, and turbidity containment. [2] [3] Electrochemical sensor is another sensitive and quick response sensor that can be used to detect oil spill. Electrochemical sensor is through voltammetry or potentiometry to measure the contaminants, but the electrode in the sensor is easily being drifted, so the performance of the sensor will be reduced during the time and it needs maintenance. [4] The microwave sensor is operated based on the dielectric properties to detect the materials.

Currently, the microwave sensor is used in various fields, such as biomedical, material, and environmental. The microwave sensor is a sensor that has high sensitivity, high adaptability, and low cost. Microwave sensor is a suitable sensor that can be used to detect the hydrocarbons in water. The objective of this research is to design a novel, real-time and sensitive microwave sensor for monitoring oil spills in the waterways. We are a cross- disciplinary research team, the collaboration between electrical engineering and environmental engineering.

Developing and designing a microwave sensor for detecting the hydrocarbon in water is a step-by-step work. Before the sensor detects the hydrocarbon, understanding the response of natural contaminants in the river as the background is an important first-step. The natural contaminants, such as inorganic, organic and turbidity contaminants in the water will be tested first. Since we aim at the microwave sensor to be used in the real world, water quality data of a major Alberta river were used as the background to develop the sample solution.

Based on water quality data of the river, individual and mixture of inorganic contaminants solutions have been tested. The solutions were tested by using our specially-designed two- wire microwave sensor. The sensor has high sensitivity to inorganic contaminants, which can detect the contaminants as low as 500 ppb concentration. Figure 1 shows the sensor amplitude response versus the potassium nitrate concentration, which shows the sensor is sensitive to low concentrations. The responses of individual and mixture of inorganic contaminants have been collected as the background, supporting further development of detecting the hydrocarbon contaminant.

Abstract # :TBWR-005

Microwave Sensing Technology for Hydrocarbon Monitoring in Water

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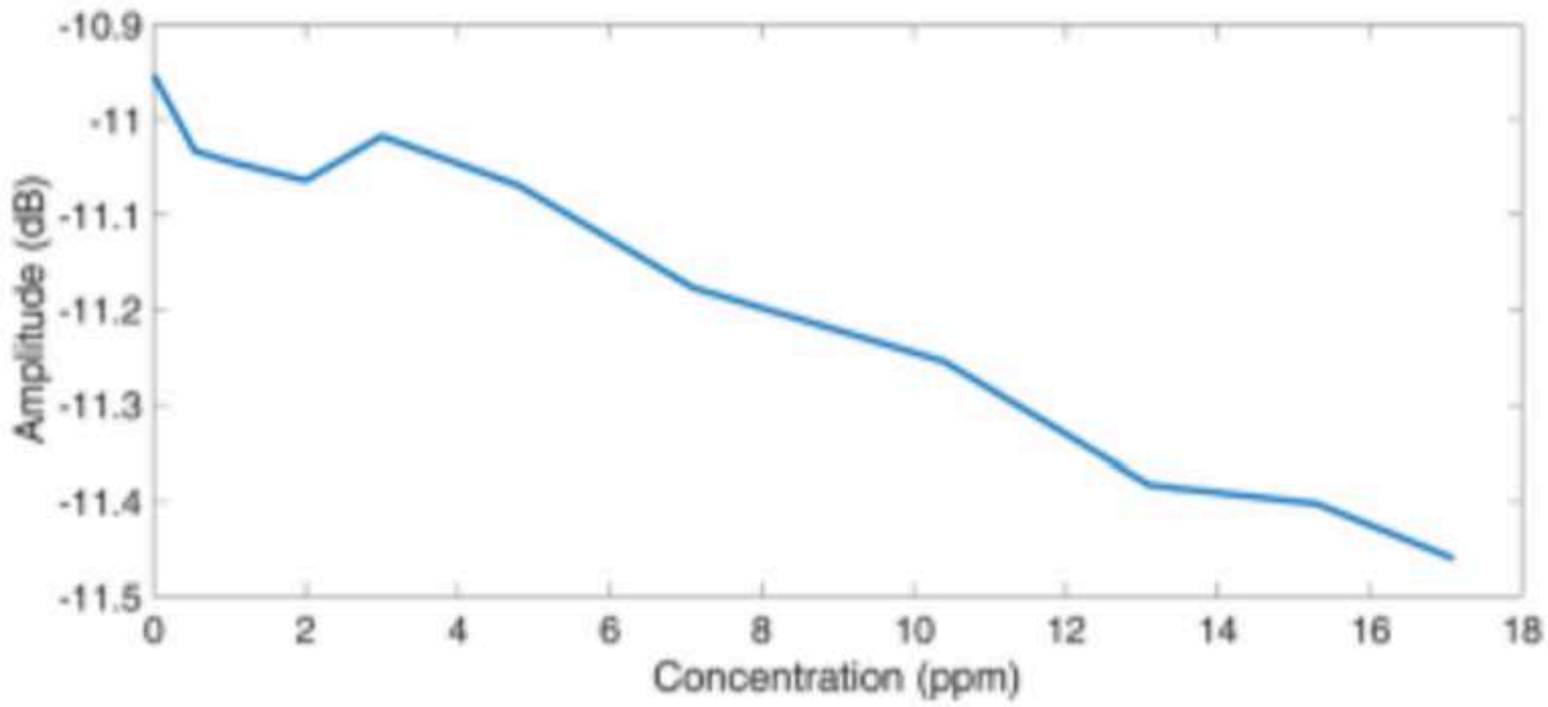

Figure 1 Sensor amplitude response vs. KNO 3 concentration

Next step, our team will enhance the design of the microwave sensor, and test its response to the hydrocarbon standard mixer solution, which will enable us to detect hydrocarbons in waterways with natural contaminants.

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Abstract # :TWS-001

Assessment of Microplastic Distribution and Abundance in the Kirtonkhola River, Barisal, Bangladesh

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Abstract

This study assess the pressing issue of microplastic pollution by investigating its sources, distribution, and impacts in the Kirtankhola River, Bangladesh. Surface water samples were collected from ten locations and analysed using microscopy and Fourier Transform Infrared (FTIR) spectroscopy. The analysis revealed an average microplastic concentration of 1.25 particles per liter, with polyethylene and polypropylene identified as the predominant polymer types. Spatial distribution revealed peak microplastic concentrations in the ferry terminal area, driven by anthropogenic pressures, wastewater, and textile-polymer industry discharge. The primary sources of microplastics were attributed to plastic waste from urban runoff and industrial effluents. These findings highlight the urgent need for effective waste management strategies and stringent policy measures to mitigate microplastic pollution and protect aquatic ecosystems.

Keywords: Microplastic pollution; Freshwater Ecosystems; FTIR Spectroscopy

Background and Nature of the Issue or Problem

Microplastic pollution is a critical threat to aquatic ecosystems, impacting biodiversity, water quality, and public health. Defined as plastic particles smaller than 5 mm (Rochman et al., 2015), microplastics originate from sources like fragmented plastic debris, synthetic textiles, and industrial discharges (Andrady, 2011; Sarijan et al., 2021). While marine microplastic pollution has been widely studied, freshwater systems, especially in developing regions like Bangladesh, remain understudied despite their importance for livelihoods and biodiversity. The Kirtankhola River in Barisal is under severe anthropogenic stress. Essential for drinking water, irrigation, and fisheries, it faces escalating pollution from ferry terminals, agricultural runoff, industrial discharges, and urban effluents (Jambeck et al., 2015; Rochman et al., 2016). These activities heighten the risk of microplastic contamination with cascading ecological and socioeconomic impacts. This study addresses the knowledge gap by examining the scale of microplastic pollution in this vital water body to inform targeted policies and management strategies for mitigating freshwater microplastic pollution in Bangladesh.

Findings and Results

Systematic sampling at ten locations along the Kirtankhola River during winter, with three replicates per site, revealed microplastic contamination at all sites. Concentrations ranged from 78.33 to 187.67 MPs/L, peaking at 187.67 MPs/L near port activities, attributed to poor waste management and industrial effluents (Figure 1a). Morphological analysis identified fragments (57%), and fibers (33%) as dominant forms linked to plastic degradation and synthetic textiles. Smaller particles (<0.5 mm) constituted 71% of MPs, highlighting risks of bioaccumulation and long-range transport in aquatic ecosystems (Rochman et al., 2015). Color analysis showed red, navy blue, and brown particles associated with dyed plastics and industrial waste (Rochman et al., 2015). FTIR spectroscopy (Figure 1b) revealed distinct vibrational modes for each polymer, such as polyethylene terephthalate (PET), polyvinyl chloride (PVC), cellulose acetate (CA), and polypropylene (PP), indicating contamination from packaging and industrial sources. CA showed absorption bands at 2941 cm^{-1} (C–H stretching), 1729 cm^{-1} (C=O stretching), and 1022 cm^{-1} (C–O stretching). PET exhibited peaks at 1732 cm^{-1} (C=O stretching) and 1368 cm^{-1} (C–O stretching). PP was identified by features at 795 cm^{-1} (C=C bending), a C–H shoulder at 1369 cm^{-1}, and a C=O band at 1739 cm^{-1}. Ethylene-vinyl acetate (EVA) displayed bands at 1735 cm^{-1} (C=O stretching), 1366 cm^{-1} (C–O stretching), and 720 cm^{-1} (CH_2 deformation). PVC was characterized by peaks at 985 cm^{-1} (C=C bending) and 814 cm^{-1} (C–Cl stretching), confirming its industrial origin (Liza et al., 2024; Masura et al., 2015).

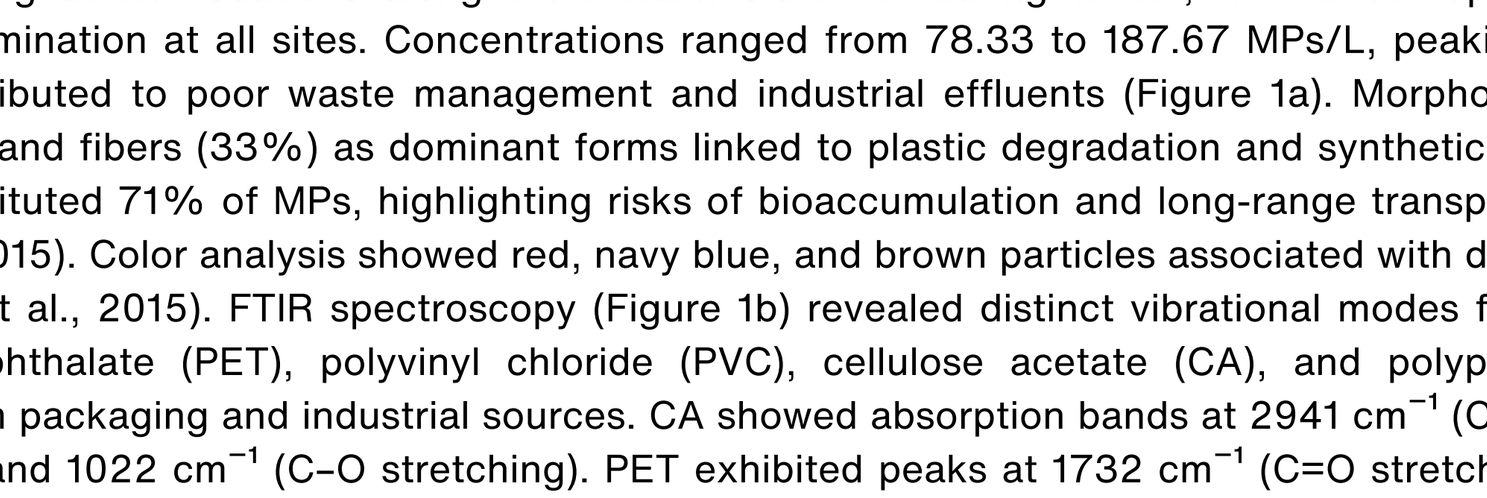

Figure 1. (a) Spatial distribution map of microplastic; (b) FTIR spectrum of Microplastics

Abstract # :TWS-001

Assessment of Microplastic Distribution and Abundance in the Kirtonkhola River, Barisal, Bangladesh

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Significance and Impact

The Kirtankhola River faces severe microplastic pollution, with smaller particles (<0.5 mm) posing risks of bioaccumulation and trophic transfer. Toxic polymers such as EVA, PVC, and PET threaten aquatic ecosystems and communities dependent on the river (Sarijan et al., 2021; Wright & Kelly, 2017). Immediate action is required, including improved waste management, stricter regulations, and public awareness campaigns. This study provides a critical foundation for developing mitigation strategies and policies to protect freshwater ecosystems.

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Resource Recovery and Nutrients Removal

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Abstract # :TWS-008

Simultaneous denitrification and phosphorus removal of biofilters with active wood-based media impregnated with iron hydroxide

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Abstract

In this study, the simultaneous denitrification and phosphorus removal by anaerobic biofilters based on activated iron hydroxide [Fe(OH) 3] wood by-products was evaluated and the effluent of the columns was characterized structurally and morphologically by various techniques of X-ray diffractometry (XRD), scanning electron microscopy (SEM) and energy-dispersive X-ray (EDX). The phosphorus removal performances were excellent in biofilters, C1 without nitrates (99.9%) and C2 with nitrates (98.2%) and a denitrification rate of 80% was achieved in C2. However, an increase in the C2 effluent phosphorus concentration was observed from the 412th day of operation due to denitrification.

Keywords: Biofilters; denitrification; phosphorus removal

To meet phosphorus discharge requirements, research at Investissement Québec in collaboration with Université Laval focused on the development of a passive phosphorus process (Techno-P) characterized by biofilters filled with activated wood based media impregnated with iron hydroxide. Recently, research (1) has shown that the presence of nitrates (5 to 25 mg N-NO3/L) in biofilters has a negative impact on phosphorus removal, due to the modification of conditions favourable to the reductive dissolution of iron. The objective of the study is to evaluate the simultaneous denitrification and phosphorus removal performances in anaerobic biofilters. The experimental setup consists of 2 biofilters (C1 and C2) one meter high and 15 cm in diameter, filled with activated wood-based media. The biofilters were fed for 461 days with a synthetic wastewater (municipal and industrial) containing phosphorus and nitrates. The phosphorus concentrations tested were 5 (from 0 to 347 days of operation) and 100 mg P-PO4/L (from 347 to 461 days of operation) for the 2 biofilters. A nitrate concentration of 20 mg N-NO3/L was applied to biofilter C2, C1 served as a control. The biofilters were operated anaerobically and fed by immersion under 2 hydraulic loads of 100 and 200 L/m 2 /d using peristaltic pumps.

The effluent of the columns was characterized structurally and morphologically by various techniques of X-ray diffractometry (XRD), scanning electron microscopy (SEM) and energy-dispersive X-ray (EDX). Regular sampling and periodic analyses at the inlet and outlet of the biofilters were carried out to evaluate the behavior for physico chemical parameters: total phosphorus, nitrates, pH, temperature, and redox potential.

The results for denitrification and phosphorus removal are presented in Figure 1.1. While the phosphorus removal performance is excellent for the first 412 days (≤ 0.3 mg P/L), it subsequently deteriorates in C2 containing nitrates until reaching 21.6 mg PO 4 /L on the 461 st day of operation. The phosphorus removal rate was 99.9% for biofilter C1 compared to 98.2% for biofilter C2. In addition, the percentage of denitrification for biofilter C2 is 80%. The effluent characterization for biofilters C1 and C2 reveals the presence of a precipitate of iron oxide (Fe2O3) as indicated in Figures 1.2 and 1.3, in addition to calcium carbonate (CaCO3) in C2 as shown in Figures 1.4 and 1.5. These findings highlight that iron hydroxide-activated wood-based anaerobic biofilters are effective in removing phosphorus and nitrates from wastewater.

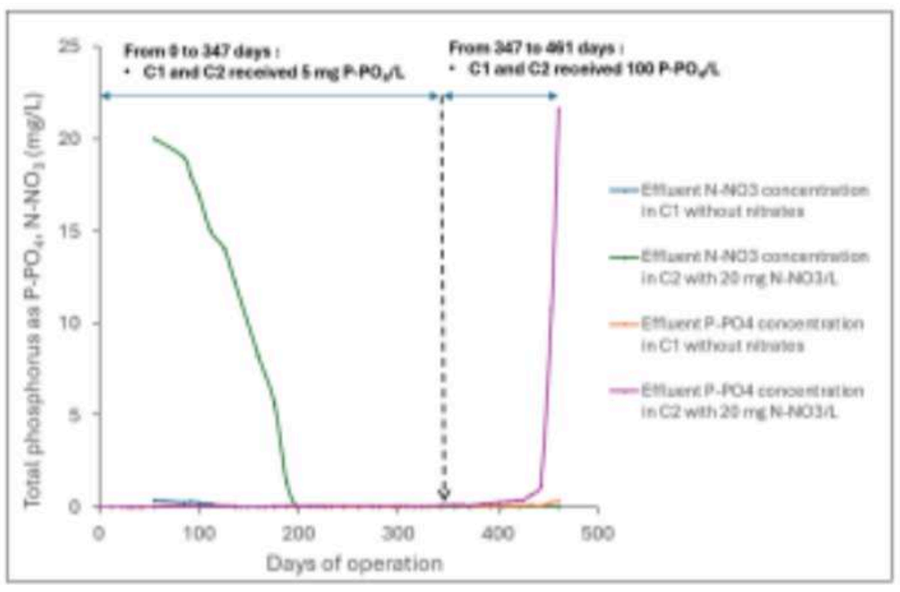

Figure 1.1 Total phosphorus and nitrates concentrations in the effluent

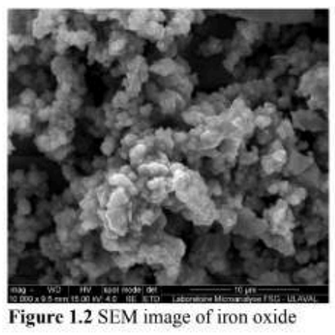

Figure 1.2 SEM image of iron oxide

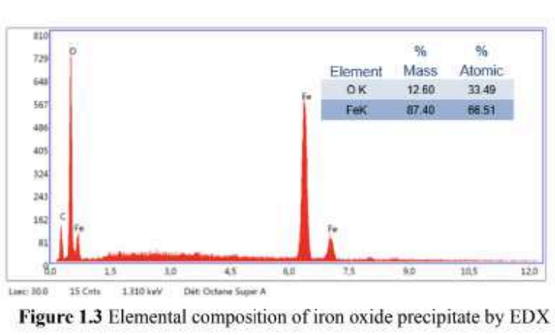

Figure 1.3 Elemental composition of iron oxide precipitate by EDX

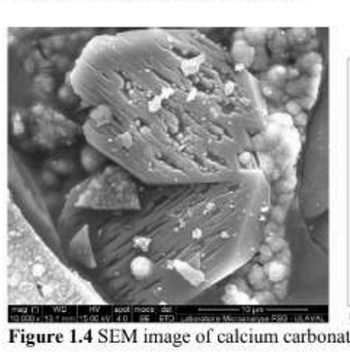

Figure 1.4 SEM image of calcium carbonate

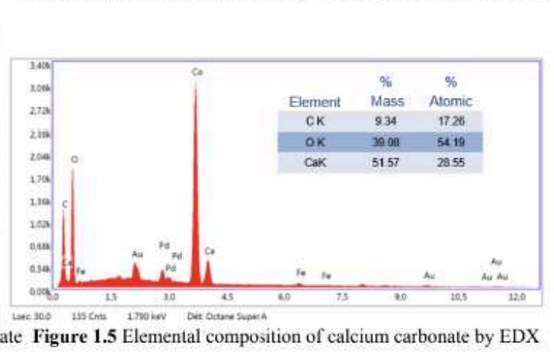

Figure 1.5 Elemental composition of calcium carbonate by EDX

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Abstract # :TWS-011

Investigating the Fate of Phosphorus in the Primary Sludge Stream at the Great Lakes Water Authority (GLWA) Water Resource Recovery Facility (WRRF): Chelation and Iron Redox Transformation

Jiawei Liu*, Wenxing Zuo, M. Uzair, Y. Zhang, G. Daigger
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Abstract

This study investigates increased phosphorus recycling from solids handling systems at the Great Lakes Water Authority (GLWA), where waste sludges are not stabilized through digestion, coupled with iron recycling. Batch tests were conducted to explore phosphorus and iron transformations under anaerobic and aerobic conditions. Jar test explored the effect of chelation on the precipitation of phosphorus by iron. Results revealed that ferric-to-ferrous reduction under anaerobic conditions leads to phosphorus solubilization, with chelation by organic matter preventing vivianite formation. Aeration tests confirmed that reoxidized ferric ions precipitate phosphorus effectively. These findings provide insights into mitigating internal phosphorus recycling, enhancing phosphorus recovery, and optimizing wastewater treatment operations. Further research is needed to clarify the role of organic matter in iron interactions and improve recovery strategies.

Keywords: Nutrient Removal and Recovery; Chelation; Process Optimization

This study investigates observations of increased phosphorus recycling from solids handling systems in GLWA, where waste sludges are not stabilized through anaerobic or aerobic digestion, coupled with iron recycling. Several hypotheses are developed and tested through batch and jar tests to explain why this occurs, providing insights that could help in understanding and leveraging this phenomenon to develop strategies for mitigating internal phosphorus recycling and enhancing phosphorus recovery potential. Utilizing a High Purity Oxygen design for the bioreactor process, the GLWA facility employs ferric chloride dosing for chemical phosphorus removal. However, past operational changes and the large secondary clarifier volume provide an anaerobic aerobic cycle and sufficient volatile fatty acids (VFAs) for the growth of Polyphosphate Accumulating Organisms (PAOs), enabling biological phosphorus removal (Jun et al., 2023). Previous research identified significant phosphorus release in the Waste Activated Sludge (WAS) stream due to anaerobic conditions in the underflows of the secondary clarifier and gravity thickener. Residual ferric ions are biologically reduced to ferrous ions, forming vivianite and causing pipe scaling (Liu et al., 2023).

Batch tests were conducted to simulate anaerobic conditions in the gravity thickener over 8 hours using fresh primary sludge (PSD) samples. Nitrogen gas sparging maintained anaerobic conditions, and contents were mixed continuously for solid suspension. Additional tests utilized underflow samples from primary and secondary thickeners (Mix) under similar conditions. An aerated batch test evaluated the impact of oxidation on phosphorus and iron forms, with aeration applied to the PSD sample after staying anaerobically for about 24 hours (PSD_24). Jar tests, using fresh and 24-hour anaerobically stored primary sludge, examined chelation by comparing blank samples with those spiked with fresh phosphorus, ferric, and ferrous ions. Total/soluble phosphorus (TP/SP), total/volatile suspended solids (TSS/VSS), chemical oxygen demand (sCOD) were analyzed according to the standard methods (APHA, 2017). Results from Figures 1 and 2 show increased solubilized phosphorus and iron in both PSD and Mix sludge samples. We hypothesize that ferric-to-ferrous reduction under anaerobic conditions breaks ferrihydrites with adsorbed phosphorus, leading to solubilization. High organic matter content likely chelates ferrous ions, preventing vivianite formation. Also, Phosphorus release from biological degradation was evident, particularly in Mix sludge samples, as ammonia levels increased. Jar tests further explored these findings with spiked phosphorus and iron dosages (5.85 mg phosphoric acid, 5 mg Fe as ferric chloride or ferrous sulfate). In the phosphorus-spiked case, the results showed phosphorus insolubilization in the 24-hour PSD sample but minimal changes in fresh PSD. With ferrous dosing, no phosphorus decrease was observed in the 24-hour PSD sample, suggesting rapid chelation of fresh ferrous ions in high-organic samples. A 40% reduction of phosphorus was observed in the fresh PSD sample. However, the phosphorus-to-iron decrease ratio (~0.15) was below that for vivianite formation, suggesting ferrous ions may have reacted with non-phosphorus compounds, potentially sulfide from anaerobic sulfate reduction, which preferentially precipitates with iron. Dosing ferric ions effectively insolubilized both residual and spiked phosphorus in fresh and 24-hour PSD samples, regardless of organic loading. To further investigate whether ferrous iron could be reoxidized to ferric and effectively precipitate phosphorus, an aeration test was performed. Aeration tests with 24-hour PSD showed that oxidizing ferrous to ferric iron reduced soluble phosphorus and iron synchronously, confirming that reoxidized ferric ions could react to precipitate phosphorus. Aeration also decreased sCOD levels, indicating lower organic matter allowed more free iron ions to react with phosphorus.

Abstract # :TWS-011

Investigating the Fate of Phosphorus in the Primary Sludge Stream at the Great Lakes Water Authority (GLWA) Water Resource Recovery Facility (WRRF): Chelation and Iron Redox Transformation

Jiawei Liu*, Wenxing Zuo, M. Uzair, Y. Zhang, G. Daigger
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In conclusion, this study provides a deeper understanding of phosphorus and iron transformations under anaerobic and aerobic conditions in the primary sludge stream of GLWA. It also offers valuable insights for improving the control of potential phosphorus recovery designs. While the results confirm some hypotheses, further investigation is needed to clarify the role of specific organic matter components in chelation and their influence on ferrous ion interactions. Additionally, understanding the chemical pathways governing ferrous reactions under varying chelation conditions, as well as the resistance of ferric ions to such effects, is essential. Addressing these challenges will enhance the optimization of phosphorus removal and recovery and improve the operational efficiency of wastewater treatment systems, contributing to more sustainable and cost-effective resource management.

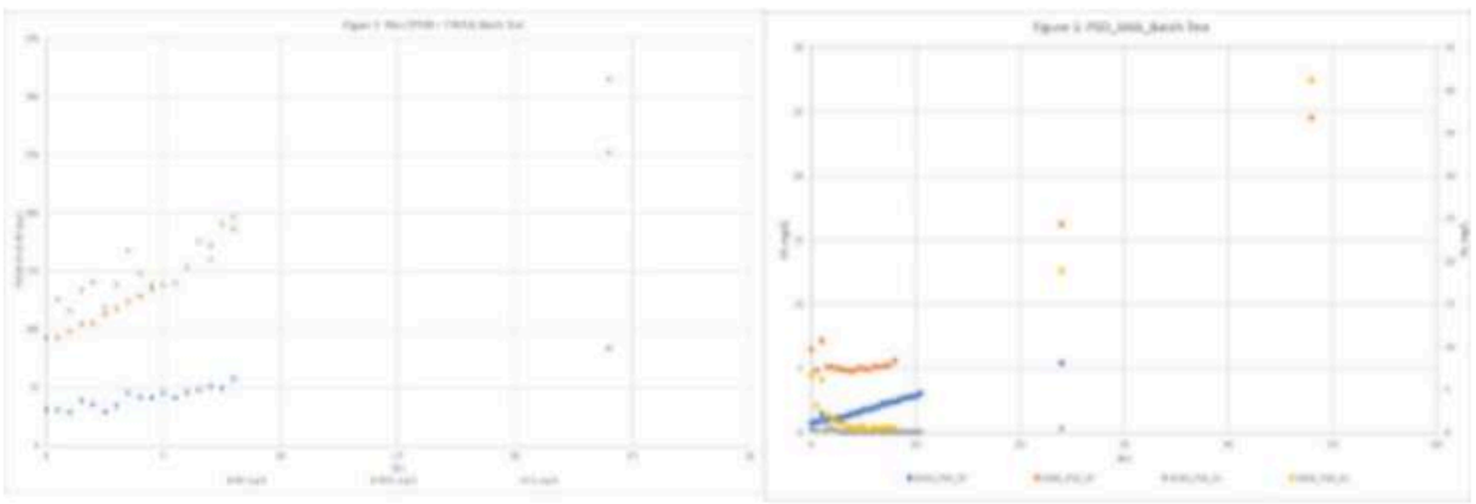

Figure 1 and 2 Batch Test Results (SP & SFe, mg/L) for Fresh Primary Sludge Sample (Left), Batch Test Results (SP and SFe, mg/L) for Mixed Sludge Sample (Primary + Wasted Thickened Sludge) (Right)

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Abstract # :TRRR-002

Ultrafiltration Fractionation of Municipal Sludge-Derived Hydrothermal Liquefaction Aqueous Stream for Understanding Inhibition during Methane Recovery

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Abstract

Hydrothermal liquefaction (HTL) is a promising approach for municipal sludge management, offering biocrude oil recovery and eliminating biosolids production, etc., as advantages. However, it produces a substantial aqueous byproduct containing recalcitrant and potentially inhibitory compounds. The molecular weight (Mw) distribution of these potentially inhibitory substances and their effect on anaerobic biodegradability remain largely unexplored. Ultrafiltration (UF) was conducted to fractionate HTL aqueous into Mw>300, 300>Mw>100, 100>Mw>10, 10>Mw>1, and Mw<1 kDa fractions and biochemical methane potentials (BMPs) assays were conducted to assess the anaerobic biodegradability of each fraction. The results indicated that the highest percentage of organics (65%) was found in the Mw<1 kDa range, whereas the 10>Mw>1 kDa had the lowest percentage (8%). While results showed no significant differences in cumulative specific methane production across various Mw fractions, the Mw <1 kDa fraction exhibited the highest methane production rate. UF fractionation improved the rate but not the extent of anaerobic degradation, with only 55% of the theoretical methane potential achieved across all Mw fractions. This indicates that HTL aqueous contains inhibitory substances, even within the Mw range below 1 kDa, requiring further characterization to fully understand their impact on anaerobic biodegradability.

Keywords: Municipal sludge; Hydrothermal liquefaction aqueous phase; Anaerobic biodegradability

Municipal sludge can be converted into biocrude oil through hydrothermal liquefaction (HTL), which is the most suitable thermochemical technology for processing wet biomass, including sludge (1). However, the HTL of municipal sludge generates large volumes of aqueous stream that requires treatment. HTL aqueous stream can be treated via anaerobic digestion (AD) for methane production, but its inhibitory effects on AD are reported but not well understood. For instance, the molecular weight (Mw) distribution of organics in HTL aqueous and its effect on anaerobic biodegradability has not been explored. Therefore, this study aimed to investigate the Mw distribution of organics and potential inhibitory compounds in the HTL aqueous phase and their impact on anaerobic biodegradability. Dewatered mixed sludge (20% total solids by wt.) from a wastewater treatment plant (BC, Canada) was processed at HTL temperature, pressure, and retention time of 350˚C, 166.8 bar, and 15 min, respectively, and the aqueous stream was recovered. The HTL operating conditions were determined based on the previous optimization for maximizing biocrude oil from the same feedstock (2). The HTL aqueous Mw distribution of organics and potential inhibitory compounds was determined through ultrafiltration (UF) fractionation using 300, 100, 10, and 1 kDa molecular weight cut-off UF (MwCO) membranes. A wide range of conventional and trace contaminants were monitored. The anaerobic biodegradability of different Mw fractions (permeates and retentates), along with glucose (positive control) was determined using biochemical methane potential (BMP) assays, and the methane production results were fitted using the first-order kinetic model. The Mw<1 kDa molecular weight fraction contained the highest percentage (65%) of organic substances, including soluble sugars, soluble chemical oxygen demand (COD), soluble proteins, total volatile fatty acids, and phenolics, whereas the 10> Mw> 1 kDa had the (8%). Despite this distribution, the molecular weight profile of the organics in HTL aqueous did not impact the total cumulative methane production over a 32-day period, as shown in Figure 1. However, it did influence the methane production rate, with the lower molecular weight fraction (1 kDa) exhibiting the highest rate (0.53 day -1), while the unfiltered fraction displayed the lowest rate (0.38 day -1) as shown in Table 1. These findings suggest that HTL aqueous contains compounds with Mw exceeding 1 kDa that inhibit the rate of anaerobic degradation. Although the 1kDa fraction demonstrated the highest methane production rate, it only reached 55% of the theoretical value (350 mL/g COD at 0˚C, 1 atm), similar to the other fractions, indicating that 45% of the COD remains undegraded at the end of the 32-day digestion. Therefore, further characterization of HTL aqueous for compounds with molecular weights below 1 kDa is necessary to fully understand the nature of inhibitory organics and their impact on AD, which are ongoing at the UBC's Bioreactor Technology Group.

Abstract # :TRRR-002

Ultrafiltration Fractionation of Municipal Sludge-Derived Hydrothermal Liquefaction Aqueous Stream for Understanding Inhibition during Methane Recovery

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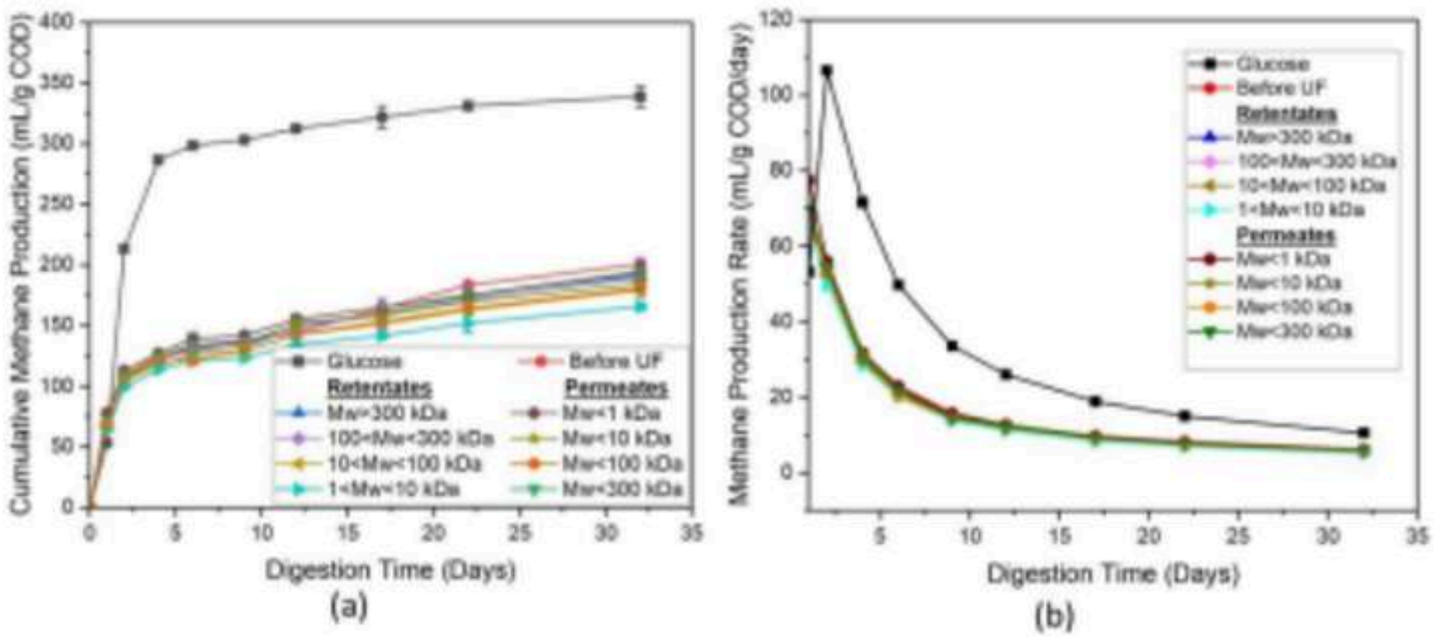

Figure 1 (a) Specific cumulative methane yield, and (b) methane production rate achieved by municipal sludge derived HTL aqueous permeates and retentates for different membrane MwCOs.

Table 1. Kinetic coefficients from the first-order model for the different molecular weight fractions

MwCO (kDa)	P_0 (mL CH_4/g COD)	k (day^{-1})	R^2
Before UF	168 ± 3[a]	0.38 ± 0.04	0.90 ± 0.01
Retentates			
1 < Mw < 10	141 ± 4	0.52 ± 0.02	0.93 ± 0.00
10 < Mw < 100	153 ± 4	0.47 ± 0.01	0.91 ± 0.00
100 < Mw < 300	159 ± 11	0.45 ± 0.09	0.91 ± 0.02
Mw > 300	159 ± 5	0.46 ± 0.06	0.91 ± 0.01
Permeates			
Mw < 1	162 ± 5	0.53 ± 0.04	0.93 ± 0.01
Mw < 10	157 ± 6	0.49 ± 0.05	0.92 ± 0.00
Mw < 100	151 ± 2	0.49 ± 0.04	0.92 ± 0.01
Mw < 300	158 ± 0	0.46 ± 0.06	0.90 ± 0.01

Note: ± indicates the standard deviation of triplicate measurements. P_0 = ultimate specific methane yield; k = first-order specific methane production rate.

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Abstract # :TWS-010

Co-Fermentation of Long-Chain Fatty Acids with Sewage Sludge: Effects on Fermentation Performance

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Abstract

This study evaluates the impact of co-fermenting long-chain fatty acids (LCFAs) with primary sludge on biohydrogen and volatile fatty acid (VFA) production under acidic (pH 5) and alkaline (pH 10) conditions. Oleic acid (OA) and palmitic acid (PA) were tested at concentrations of 3, 7, and 12 g/L. At pH 5, hydrogen production increased by 32.4%–125.1% in LCFA-containing batches, while at pH 10, it was inhibited by 24.0%–59.4%. This inhibition correlated with reactive oxygen species (ROS) generation, suggesting oxidative stress as the primary mechanism. At pH 5, OA reduced total VFA production by 9%–29%, while PA had a less pronounced effect, highlighting the differing impacts of saturated and unsaturated LCFAs. Alkaline conditions suppressed both hydrogen and VFA production but improved sludge dewaterability compared to acidic conditions. Further research is needed to elucidate the mechanisms behind the varying effects of saturated and unsaturated LCFAs.

Keywords: anaerobic fermentation; wastewater sludge; biohydrogen; volatile fatty acids; long chain fatty acids

Background

The rise in global population, urbanization, and the implementation of stricter environmental regulations have led to increased wastewater treatment and greater sludge production (Li et al. 2023). Sludge management accounts for 30-40% of capital and 50% of operating expenses for wastewater treatment plants (WWTPs) (Chen et al. 2021). With energy consumption and emissions central to WWTP operations, sludge resources must be efficiently recovered and utilized beyond traditional methods (Capodaglio and Callegari 2023). WWTPs utilize sludge fermentation to produce volatile fatty acids (VFAs) as a carbon source for biological nutrient removal (BNR) processes (Wang et al. 2021). Additionally, sludge fermentation generates biohydrogen, a clean and energy-dense fuel, with three times the energy density of fossil fuels and water as its sole combustion by-product (Balachandar et al. 2020; Xu et al. 2019). However, challenges such as low hydrogen and VFA yields arise due to low carbon content in the substrate (Yang and Wang 2017). Co-fermentation with fat, oil, and grease (FOGs), rich in long-chain fatty acids (LCFAs) like oleic acid (OA) and palmitic acid (PA), offers a potential solution due to their high carbon content (Peces et al. 2020). While LCFAs have shown methane production benefits in anaerobic digestion (AD) (Salama et al. 2019), high concentrations can inhibit the process (Mostafa et al. 2020). Furthermore, co-digestion outcomes depend on acidic or alkaline conditions (Liu et al. 2020). Research on sludge co-fermentation with LCFAs has been limited, primarily focusing on VFA production, with hydrogen production effects remaining largely unexplored. This study aimed to evaluate the impact of primary sludge co-fermentation with OA and PA at concentrations of 3, 7, and 12 g/L under acidic and alkaline conditions.

Results

Cumulative hydrogen production at pH 5 and pH 10 is shown in Figures 1(a) and 1(b), respectively. The results depict that pH levels significantly influence hydrogen production in LCFA-containing batches. Hydrogen production in LCFA-containing batches was considerably higher at pH 5 compared to the control, with increases ranging from 32.4% to 125.1%. In contrast, at pH 10, hydrogen production was inhibited, with reductions between 24.0% and 59.4%. The solubility and degradability of LCFAs are significantly influenced by pH levels (Bertin et al. 2014). The increase in hydrogen production at pH 5 and its inhibition at pH 10 observed in this study suggest that pH induced changes in LCFA solubility and accumulation under alkaline conditions can inhibit the hydrogen-producing microbes.

Abstract # :TWH-002

Waste as a Business in the Resource and Re-use Recovery Model

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Abstract
This Paper will focus on the Ways Waste can be Re-used, Re-cycled and used a Resource in our day-to-day lives. It will focus on the different approaches we can use Waste to generate Different forms of Energy and the way Waste can be used to Generate Income for Households and the Community at large.

Keywords: Re-use Resource and Recycle.

Waste can be seen as items that people discard or throw away because they have hazardous properties and it is of no value (Opeyemi, 2012).Waste is all around us however the way in which we can use waste to our benefit is still wanting hence creating Problems for most countries more so here in Uganda where the country grapples with Waste Management; A case to note is that last year,2024 the country woke up to news of people being buried alive by Heaps of Waste in Kitezi.

This waste, which is enormous in Nature, can be channeled to a form that supports the Local economies through the Re-use, Recovery and Resource Model, There are different categories of waste, for example; Solid waste, Animal by-product, Electronic waste, Food waste, Agricultural waste, end of life vehicles and Gas cylinders to mention but a few. All these waste can be recycled in order to generate wealth for individuals, organizations and governments. In this manner, it improves the standard and well-being of the people living in a particular environment. Recycling is capable of leading to development in a setting because it reduces waste and at the same time generates wealth.

The idea of turning waste into a resource is viewed under the concept of Resource, Recovery and Re-use (RRR) business model. A business model describes how a business creates, delivers and captures value (Osterwalder & Pignuer 2010). There is Supported evidence that Waste can Support Local Economies and stop being viewed as something unwanted. My findings indicate the From Waste Different Products like Briquettes, Fertilizers and Decorations can all be made from Waste to support Local Economies. Various companies in Uganda both Private and Public enterprises have ventured into the business of generating revenue from waste. Among the companies involved in this business is National Water and Sewerage Corporation a government parastatal. According to the daily monitor newspaper of Monday, November 28 th 2016, the Company will be able to generate 650 kilo watts of electricity from the Bio gas generated at the sewerage treatment plant in Bugolobi.

The Significance of this Study therefore is find Practical Ways Waste can be channeled into a useful Resource to benefit Local Economies and the Domestic Households . The Study also helps to find different policies Governments can put in place to harness different forms of waste so as to benefit from the Tax base and also tackle the problem of Waste in Communities.

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Anaerobic Bioprocess and Microbiology

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Abstract # :TTT-003

Enhanced Biogas Production from Cattle Manure: Integrating Hyperthermophilic Hydrolysis with Mesophilic Anaerobic Digestion

Basem Haroun*, Mohamed El-Qelish* , Mina Nayebi Shahabi*, Seyedehfatemeh Kianizadeh*, Christopher Muller**, Farokh Kakar**, Katherine Bell**, Shubhashini Oza**, Embrey Bronstad** & George Nakhla*
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Abstract

Mesophilic anaerobic digestion of cattle manure (CM) was investigated in a 22-L continuously stirred tank reactor (CSTR) (mother reactor, MR) for 540d at an SRT of 24.4d and OLR of 2.95 g COD/L/d (phase 1) followed by a 0.4-L hyper-thermophilic hydrolysis reactor operated at 1d and 2d SRT (HTH2) and 75°C (phase 2). The results of the MR after HTH2 recycling indicated that average biodegradability based on methane yield, and daily methane production rate of CM in the MR at steady state were 46.4% ± 3%, and 13.9 ± 1.19 L CH 4 /d, respectively, with overall removal efficiencies of lignin, cellulose, and hemicellulose of 20%, 57%, and 60%, respectively, compared to control MR without recycling of 42% ± 5%, , and 12.9 ± 0.73 L CH 4 /d, respectively, with removal efficiencies of lignin, cellulose, and hemicellulose of 12%, 56%, and 54%, respectively. Biomethane potential tests (BMP) were conducted at 37°C on the hyper-thermophilic digestates as well as thermally treated digested cattle manure (DCM) treated at 70°C for 6h-24h.

Keywords: lignin; cellulose; hemicellulose; methane yield; BMP

Background

The United States and Canada annually generate substantial quantities of livestock manure, amounting to 250 and 31.7 million tons of dry solids, respectively, which have a high content of recalcitrant lignin, cellulose, and hemicellulose 1 . Although anaerobic digestion of animal manure has gained significant interest recently methanogenic archaea are not able to degrade the recalcitrant lignin, cellulose, and hemicellulose necessitating thermal, chemical, and biological pretreatments which are usually not cost-effective 2 . Thus, the objectives of this study are to assess the impact of thermal post treatment at 75°C on DCM solubility and anaerobic digestibility, and to investigate the impact of hyper-thermophilic hydrolysis process on the methanogenic activity.

Methodology

Feed and inoculum

CM was collected from a cow farm located in, Lindsay, Ontario, Canada. After collection, the CM was diluted to a range of 7% - 8% solids and was processed through a Kady mill at 60Hz for 10 minutes then stored at 4°C to be fed to the MR.

Mother reactor (MR) set up

A 22-L lab-scale continuous stirred tank reactor (CSTR) (mother reactor) was operated for over 540 days under mesophilic conditions and fed with cattle manure (0.9L CM/d) at an average organic loading rate (OLR) of 2.9 g COD/L/d, and SRT of 24.4 d (phase1). The mother reactor was inoculated initially with anaerobic digester sludge collected from Stratford wastewater treatment plant, Ontario, Canada. Digested cattle manure samples were collected and fed to the HTH2 reactor and recycled back to the MR (phase 2).

Hyper-thermophilic hydrosis reactor (HTH) set up

A 0.4 L HTH reactor operated at an HRT of 2d (henceforth referred to as HTH2), 75 °C, and fed daily with 0.2 L of DCM collected from the mother reactor while 0.2 L of HTH2 was recycled with 0.9L of CM to the MR in phase 2. In parallel, a 0.4L of HTH at 1 d SRT (henceforth referred to as HTH1) was operated to assess the impact of SRT on the degree of solubilization and acidification of DCM as well as post anaerobic digestion of DCM.

Thermally treated DCM

DCM in phase 2 was treated thermally in batch mode at 50oC and 70 oC for 6h, 15h, and 24h using a hot plate stirrer (Corning® hotplate with digital display, Sigma).

Biomethane potential tests (BMPs)

Automated biomethane potential test (AMPTS) was used to test the biodegradability of DCM, HTH1, HTH2, and thermally treated DCM treated at 70°C as substrate using ADS as inoculum at inoculum-to-substrate ratio (ISR) of 2 g VSS/g VS substrate. Additionally, HTH1 and HTH2 were tested without adding ADS to assess the methanogenic activity of
the hyper-thermophilically treated DCM. Lignin, cellulose, and hemicellulose were characterized weekly for raw CM, DCM, and HTH effluent according to NREL methods. TCOD, SCOD, ammonia, VFAs, TN, and SN were analyzed using Hach vials. TSS, VSS, TS, VS were analyzed according to Standard Methods for the Examination of Water and Wastewater.

Abstract # :TTT-003

Enhanced Biogas Production from Cattle Manure: Integrating Hyperthermophilic Hydrolysis with Mesophilic Anaerobic Digestion

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Results and Conclusions

Mother reactor performance

Digestion of CM with HTH2 recycling demonstrated enhanced performance compared to without recycling. Steady-state results revealed an average biodegradability based on methane yields, and a daily methane production rate of 46.4% ± 3%, and 13.9 ± 1.19 L CH 4 /d after HTH2 recycling, compared to 42% ± 5%, and 12.9 ± 0.73 L CH 4 /d without recirculation. With recirculation, the MR exhibited improved removal efficiencies of lignocellulosic components, achieving 20%, 57%, and 60% removal of lignin, cellulose, and hemicellulose, respectively versus 12%, 56%, and 54%, respectively. Methane production increased by 8% after HTH2 effluent recirculation.

Hyper-thermophilic hydrolysis reactor performance

The degrees of solubilization and acidification for the hyper-thermophilic hydrolysis of DCM at 1d SRT and 2d SRT were 105 and 131 (mg SCOD/g VSS initial), and 33 and 38 (mg VFAs/g VSS initial), respectively. HTH process removed lignin, cellulose, and hemicellulose by 4.5-7.8%, 4.1-11%, and 12-18%, respectively. Hyper-thermophilic hydrolysis process increased the solubilization and acidification of DCM by 81%-82% and 76%-83%, respectively.

Biomethane potential tests (BMP) results

BMPs were conducted at 37 °C using DCM from the MR, HTH1 and HTH2 effluents as well as thermally treated DCM at 70°C. The results showed that an additional post anaerobic digestibility of 14% and 9% for HTH1 and HTH2 compared to the untreated digested CM. Batch thermal treatment of DCM at 70 oC affected 7%-13% higher biodegradability depending on the contact time, which is consistent with the MR performance and the HTH BMPs. These results provide strong evidence that hyper- thermophilic hydrolysis at 75 °C improves post digestibility of DCM by 8% in continuous flow systems and 7-14% in batches.

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Abstract # :TRRR-003

Enhanced High Solid Anaerobic Digestion for improving methane production and H_2S Removal with addition of nitrogen-nanobubbles

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Abstract

This study investigates the effect of nitrogen nanobubble-supplemented water (NBW) on the high-solid anaerobic digestion (HSAD) of source separated organics (SSO) to enhance methane production with simultaneous biogas desulfurization. Compared to the control, the addition of NBW improved methane production from 120 L to 170 L for 28 days of batch operation, while average H_2S concentration in biogas decreased by 66.67%. This could be attributed to better mass transfer and microbial activity facilitated by NBW. These findings highlight the potential of NBW to optimize HSAD with percolate recirculation.

Keywords: High-Solids Anaerobic digestion (HSAD); Nanobubble water; Biogas; Hydrogen Sulfide (H_2S)

Background

Anaerobic digestion (AD) has drawn significant attention as a sustainable biogas production technology. Biogas produced from AD can be utilized for heat and electricity generation in cogeneration plants. Biogas can be upgraded to renewable natural gas (RNG) and injected into natural gas grids, contributing to reduced greenhouse gas emissions and decreased reliance on fossil fuels [1]. Objective: Biogas quality is often compromised due to the presence of impurities, particularly hydrogen sulfide (H2S), leading to serious equipment corrosion and other environmental concerns [2]. Here, NBW has shown the potential to enhance AD through improved mass transfer and microbial activity [3]. However, the application of NBW in HSAD of organic solid waste remains largely unexplored. Therefore, in this study, we investigated NBW supplementation as a strategy to enhance methane production and biogas desulfurization in HSAD with percolate recirculation.

Observations

The reactor amended with NBW exhibited higher cumulative methane production (~170L) compared to the control (~120 L) over the first 28 days of operation (Figure 1.1), following a similar initial trend but with greater overall methane production. The improvement in methane production could be due to improved mass transfer, gas solubility, and microbial activity. These findings highlight NBW's potential to enhance the efficiency of the HSAD system [4]. The NB reactor also showed a decline in H 2 S levels in biogas compared to the control, dropping from 600 ppm on day 16 to around 200 ppm by day 24, while the control reactor decreased more gradually to 300 ppm (Figure 1.2). This suggests that NBW integration also enhances biogas desulfurization, likely by improving mass transfer and promoting sulfide-oxidizing bacterial activity. Maintaining low H2S levels is essential for improving biogas energy efficiency and usability [5].

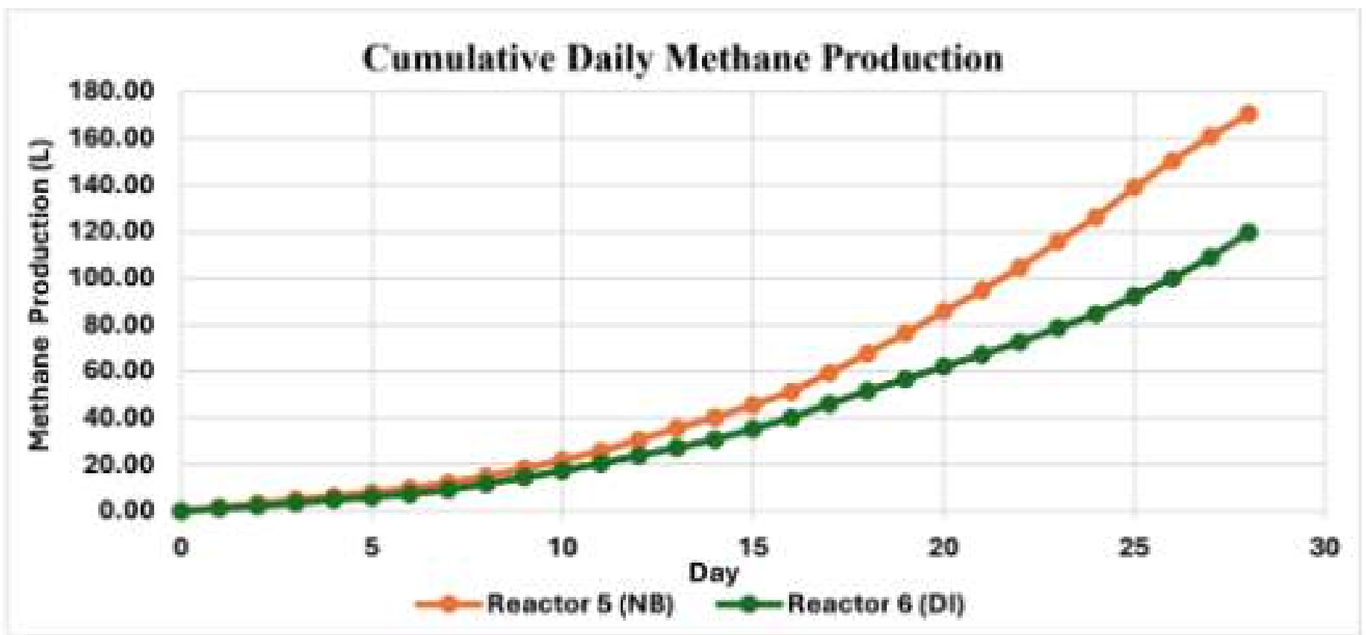

Figure 1.1. Cumulative methane production from the HSAD.

Abstract # :TRRR-003

Enhanced High Solid Anaerobic Digestion for improving methane production and H_2S Removal with addition of nitrogen-nanobubbles

Samiullah*, Anindya Amal Chakrabarty *, Samruddhi Sali*, Tae Hyun Chung* & B.R. Dhar*
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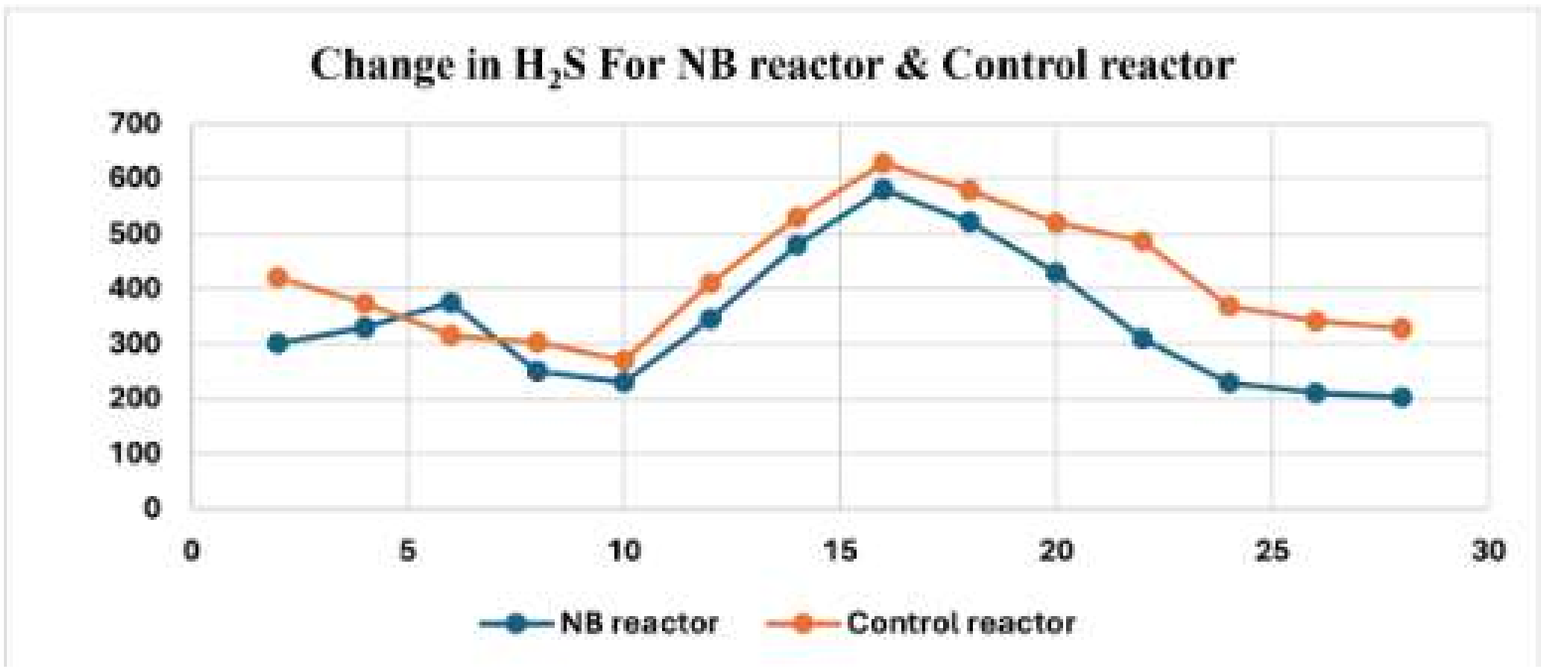

Figure 1.2. H 2 S concentration in NB reactor and control reactor.

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Abstract # :TIWW-006

Anaerobic digestion of distillery industrial wastewater under mesophilic conditions: Impacts on performance stability and microbial community dynamics

Anqi Mou*, Xinya Yang* & Yang Liu **
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Abstract

Distilleries generate acidic pot ale (low pH, high chemical oxygen demand (COD)) and spent caustic (high pH) wastewaters, posing disposal challenges. This study examines anaerobic co-digestion in up-flow anaerobic sludge blanket (UASB) reactors to balance pH, enhance hydrolysis, and boost methane yields. A 1:5 spent caustic-to-pot ale ratio achieved higher biochemical methane potential (BMP) (92%) than mono- digestion (86%) under mesophilic conditions. After long-term operation, co-digestion also achieved higher organic loading rates (up to 13.6 g COD/L/d) while maintaining stable operation. Enhanced specific methanogenic activity and sludge stability indicated improved methanogenesis process. Microbial analysis showed enriched hydrogenotrophic methanogens. This strategy effectively utilizes complementary wastewater characteristics, mitigating pH imbalances and improving hydrolysis of high-solid wastewater. The result lowers environmental impact, recovers energy, and supports sustainable distillery wastewater treatment.

Keywords: Distillery wastewater; Mesophilic condition; Microbial community.

Distillery wastewater management poses significant challenges due to the distinct characteristics of its by-products: high-organic pot ale with low pH and highly alkaline spent caustic. Improper disposal of these wastewaters can lead to severe environmental consequences, while strict discharge regulations have made wastewater disposal increasingly expensive for the distillery industry. This study explored the long-term feasibility of co-digesting pot ale and spent caustic wastewater in up-flow anaerobic sludge blanket (UASB) reactors under mesophilic conditions. The objective is to achieve stable reactor operation, enhance methane yields, and reduce environmental impact through effective waste treatment and energy recovery. Co-digestion markedly improved reactor performance by neutralizing pH, diluting toxic substances, and enhancing hydrolysis efficiency. The results showed that mixing spent caustic and pot ale at a 1:5 volume ratio led to higher biochemical methane potential (BMP) (up to 92%) than pot ale wastewater (86%). And after long-term operation, the co-digestion reactor achieved higher organic loading rates (13.6 g/L/d). Microbial community analysis revealed the enrichment of fermentation bacteria and hydrogenotrophic methanogens, underscoring the enhanced hydrolysis and methanogenesis process.

This study offers a way for distilleries to manage the wastewaters, comply with regulations, and reduce costs. By mixing different waste streams to balance pH levels and make treatment more effective, co-digestion not only generates useful renewable energy but also promotes environmentally friendly industrial practices.

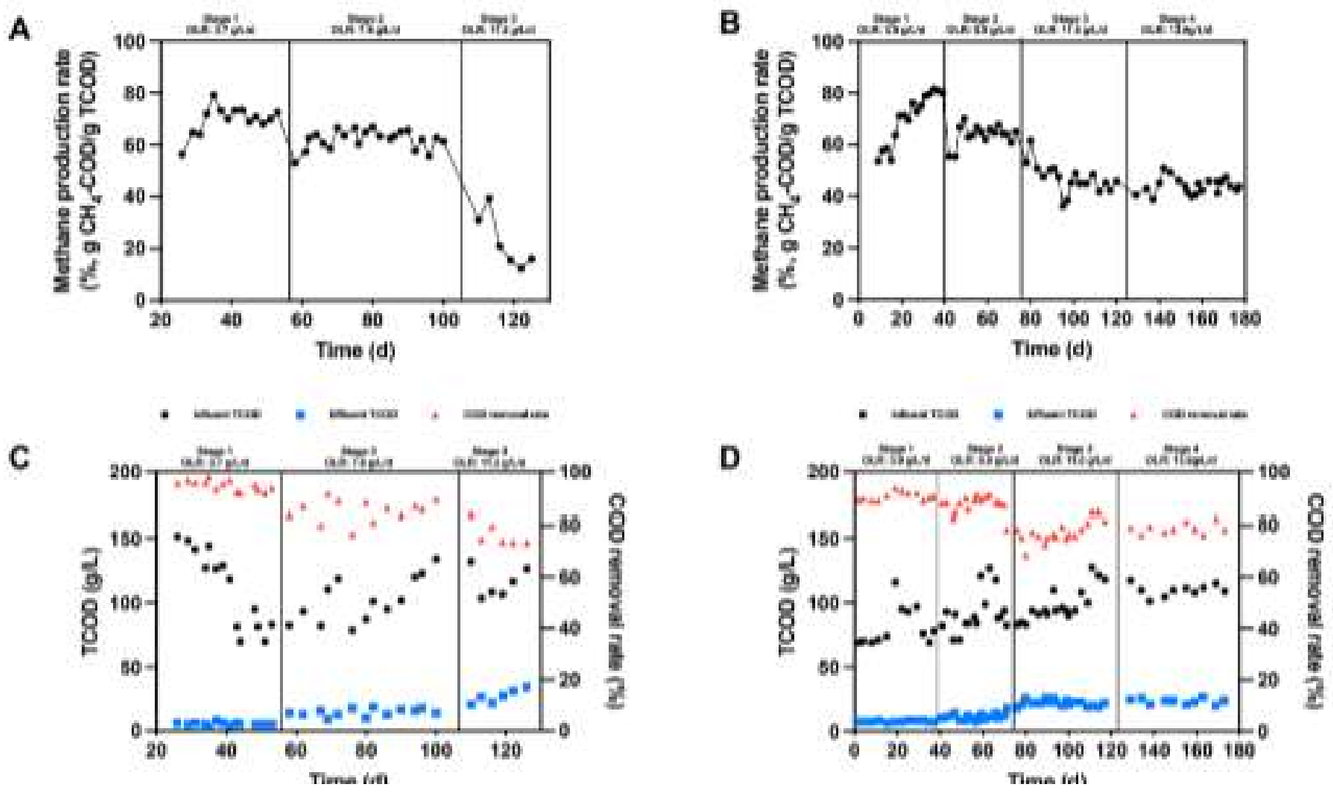

Figure 1.1 Methane production rate of control reactor (pot ale wastewater) (A) and co-digestion reactor (B) and influent TCOD, effluent TCOD, and COD removal rates of control reactor (C) and co-digestion reactor (D) after long-term operation at different stages.

Abstract # :TIWW-006

Anaerobic digestion of distillery industrial wastewater under mesophilic conditions: Impacts on performance stability and microbial community dynamics

Anqi Mou*, Xinya Yang* & Yang Liu **
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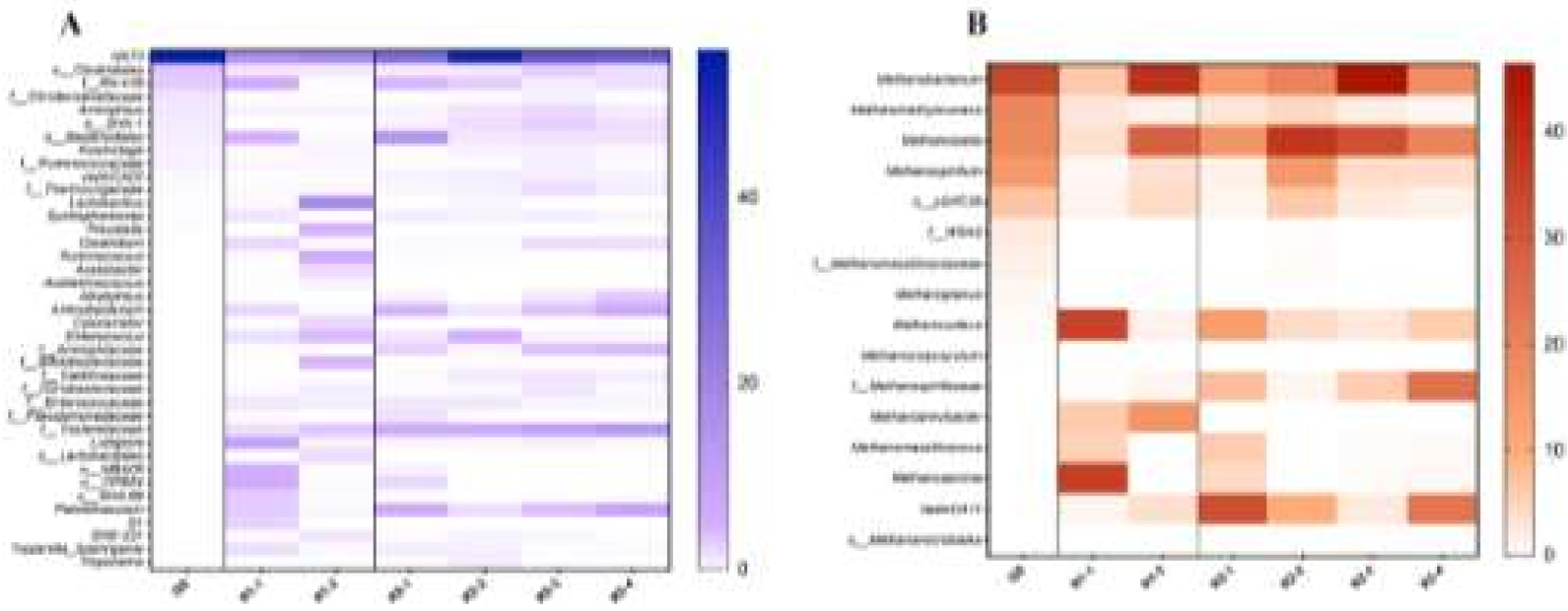

Figure 1.2 Heatmap for the relative abundance of main bacterial communities (A) and archaeal communities (B) of inoculum anaerobic granular sludge (GS), control reactor (R1, pot ale wastewater), and co-digestion reactor (R2) after long-term operation at different stages. R1-1 represents Stage 1 of R1. (family: f_; order: o_; class: c_; p: phylum) if not identified at the genus level.

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Abstract # :TRRR-004

The Performance, Mechanism, and Microbial Community Dynamics of Sulfate Reducing Ammonium Oxidation (SULFAMMOX) During Long-Term Operation

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Abstract

The Sulfate-Reducing Ammonium Oxidation (SULFAMMOX) process, observed in up-flow anaerobic sludge blanket (UASB) reactors, has demonstrated effective removal of both nitrogen and sulfate from wastewater. During long-term operation, variations in the influent ammonium-to-sulfate ratio (NH^{4+}-N/SO_4^{2-}) and hydraulic retention time (HRT) influenced system performance. Despite these variations, the nitrogen-to- sulfate consumption molar ratio stabilized at approximately 2, providing strong evidence for the SULFAMMOX mechanism. Additionally, elemental sulfur was detected as a byproduct, further supporting the occurrence of sulfur-related transformations within the system. While no specific SULFAMMOX bacteria have been identified, several microbial taxa associated with the nitrogen and sulfur cycles were detected, suggesting their potential involvement in the process.

Keywords: Mechanism; N/S consumption molar ratio; SULFAMMOX community

Background

The Sulfate Reducing Ammonium Oxidation (SULFAMMOX) process represents a notable advancement in wastewater treatment, utilizing sulfate as the electron acceptor for ammonium. This unique approach allows for the simultaneous removal of nitrogen and sulfate compounds from wastewater. Notably, SULFAMMOX generates elemental sulfur (S0) as a byproduct, which holds significant environmental and economic value. The recovered sulfur can be repurposed as fertilizer or reintegrated into production processes across various industries, thereby offering both environmental benefits and economic incentives (Rikmann et al., 2012). Furthermore, SULFAMMOX demonstrates remarkable compatibility with wastewater streams containing elevated levels of nitrogen and sulfur compounds, commonly found in sectors such as oil refineries, pharmaceuticals, and fertilizer production facilities. This versatility underscores the adaptability of the SULFAMMOX process, making it a promising solution for addressing complex wastewater treatment challenges across diverse industrial settings. However, the mechanism underlying SULFAMMOX remains unclear. The molar ratio of consumed NH^{4+}/SO_4^{2-} can be estimated to be approximately 2. Previous studies on SULFAMMOX have not explored independent sulfate as the sole electron acceptor for ammonium in the system. In this study, only ammonium and sulfate as the feed were introduced, with varying concentrations added at different stages to investigating the performance, mechanism and its microbial community of SULFAMMOX.

Key Findings and Results

In the absence of alternative electron acceptors, the system demonstrated the simultaneous removal of nitrogen and sulfate, suggesting the potential occurrence of the SULFAMMOX process. As shown in Fig. 1.1, the stabilization of NH^{4+}/SO_4^{2-} consumption molar ratio at approximately 2, along with the detection of elemental sulfur in the sludge, provides further evidence supporting this hypothesis. Based on the performance, a potential metabolic pathway for the SULFAMMOX process has been proposed.

$$8NH_4^+ + 3SO_4^{2-} \rightarrow 3S^- + 4N_2 + 12H_2O + 8H^+ \quad \Delta G_1^\circ = 280.01\ kJ/mol$$

$$8NH_4^+ + 3S^- + 5SO_4^{2-} + 8H^+ \rightarrow 8S^0 + 4N_2 + 20H_2O \quad \Delta G_2^\circ = -642.81\ kJ/mol$$

$$\textbf{Overall: } 2NH_4^+ + SO_4^{2-} \rightarrow N_2 + S^0 + 4H_2O \quad \Delta G^\circ = -45.35\ kJ/mol$$

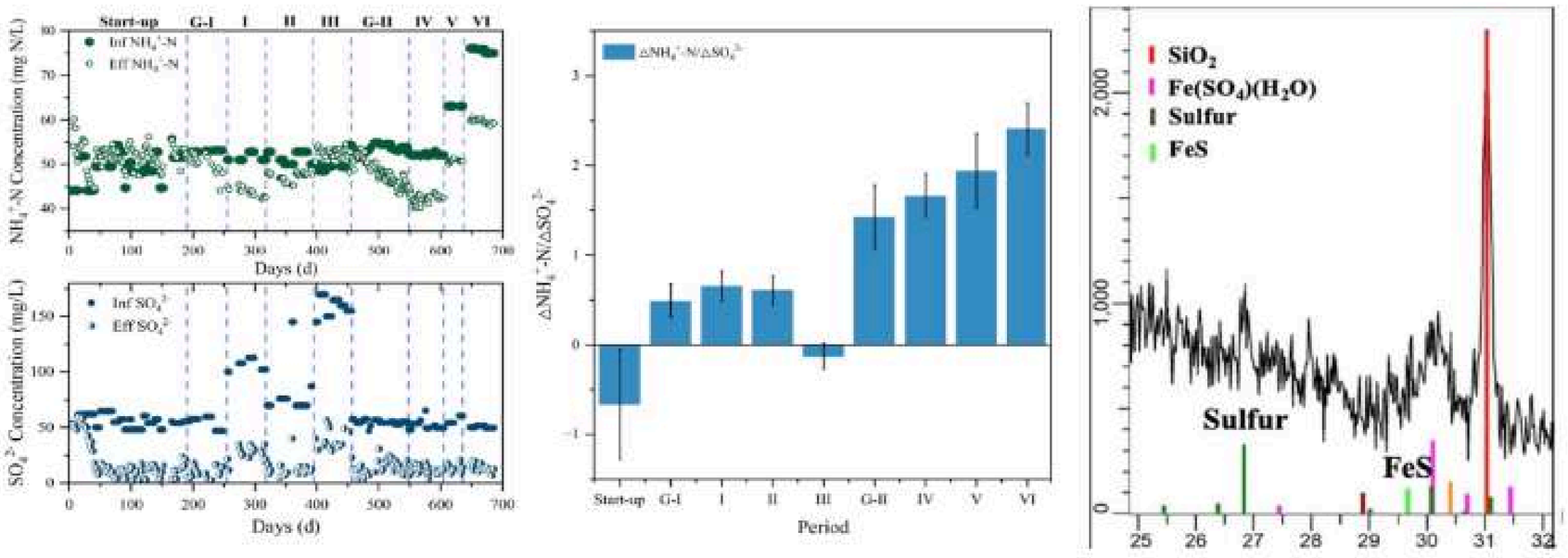

Figure 1.1 Performance of reactors during operation period: NH^{4+} and SO_4^{2-} concentration in the influent and effluent, consumed NH 4 + /SO 4 2- molar ratio and the corresponding

Abstract # :TRRR-004

The Performance, Mechanism, and Microbial Community Dynamics of Sulfate Reducing Ammonium Oxidation (SULFAMMOX) During Long-Term Operation

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XRD result for the sludge XRD analysis of reactor solids identified the presence of elemental sulfur and metal sulfides, providing indirect evidence supporting the existence of SULFAMMOX- associated microorganisms within the microbial community. At the genus level, Brocadia, a well-characterized ANAMMOX genus, accounted for 9% of the microbial population.

Additionally, sulfur-related bacteria, including Sulfurovum, an autotrophic genus capable of oxidizing sulfide (S_{2-}) to elemental sulfur using nitrite (NO_{2-}) as an electron acceptor, were detected across different operational phases, suggesting their potential role in the sulfur transformation processes within the system.

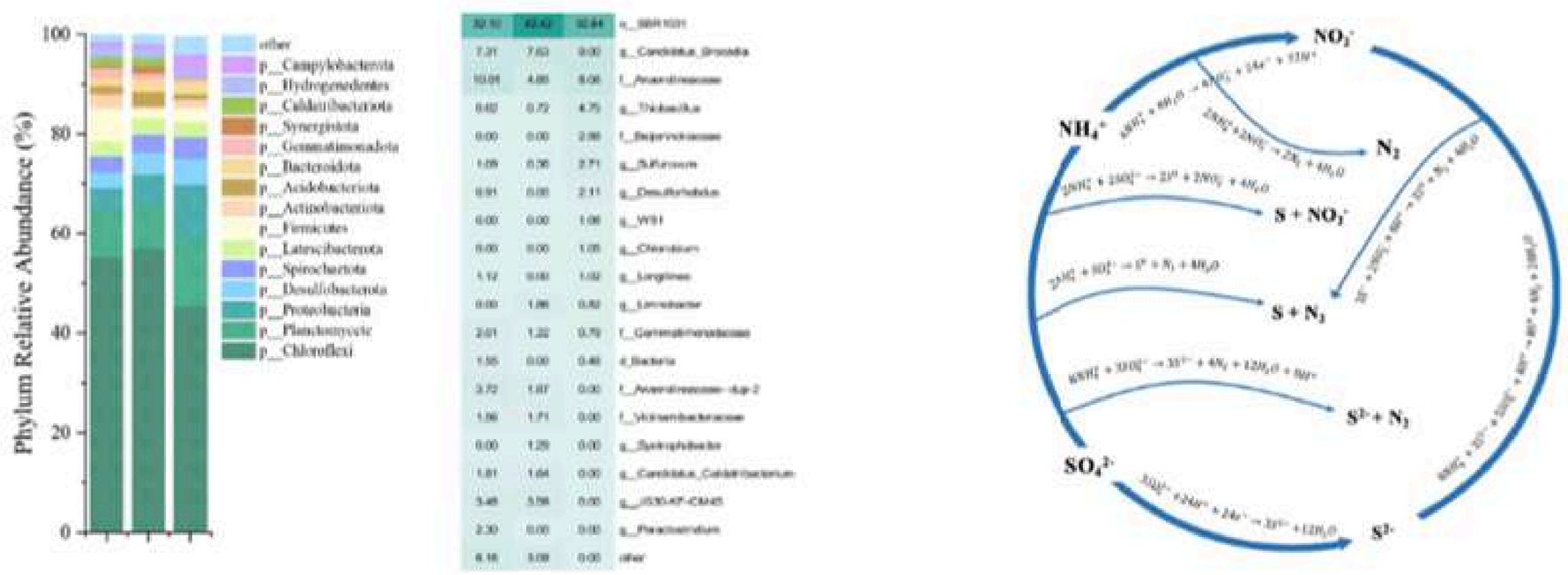

Figure 1.2 Phylum level and genus level composition of the reactor and diagram of potential changes of equations in N and S cycles and corresponding reactions in the reactor

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Abstract # :TBWR-009

Bridging Communities for Drinking Water Resiliency in the Athabasca Watershed

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Abstract

Watersheds connect ecosystems, communities, and economies, yet effectively managing them amidst climate change, competing land uses and fragmented governance presents significant challenges. The Athabasca Watershed Council (AWC) has engaged drinking water providers to document their experiences adapting to variability in water quality and availability and their calls for greater collaboration with upstream stakeholders. These insights, alongside ongoing AWC climate resiliency projects, such as drought resilience training, water quality monitoring and riparian restoration, underscore the need for community-driven approaches to managing water resources. This work integrates these localized actions into a basin-wide framework to ensure sustainable practices that align with the diverse needs of communities while fostering collaboration for long-term resiliency.

Keywords: Drinking water resiliency; Climate adaptation; Community collaboration

Background

Watersheds are essential connectors yet managing them sustainably in the face of climate change and other stressors requires bridging communities to align local and basin-level strategies. Drinking water service providers are uniquely positioned to offer insights into variability in water quality and quantity, but their voices are often underrepresented in larger water management strategies. The Athabasca Watershed Council (AWC) aims to address this gap by engaging with providers, documenting their experiences, and integrating their knowledge into basin-wide frameworks like the State of the Watershed (SOW) reporting and Integrated Watershed Management Plans done by the 11 watershed councils in Alberta.

Interviews with drinking water providers in the Athabasca watershed shared common themes, including their need to adapt to hydroclimate variability through system upgrades and water treatment adjustments. Their most consistent call was for increased collaboration with upstream stakeholders, highlighting the importance of connecting communities across the basin to address shared challenges.

Methods

The AWC's work includes engaging with drinking water providers to document their adaptive strategies and identifying shared challenges and opportunities. Providers' feedback has been contextualized alongside climate research and ongoing climate resiliency projects, including multi-year drought resilience training for municipalities, water quality monitoring, riparian restoration, and benthic invertebrate studies. These projects support and inform localized water management while contributing to broader watershed health.

Findings and Results

Engagement with drinking water providers revealed several key insights:

1. Localized knowledge is critical to addressing hydroclimate variability. Providers highlighted the need for real-time data and flexible systems to adapt to seasonal and long-term changes in water availability and quality.
2. Collaboration bridges gaps. Providers emphasized the importance of engaging with upstream stakeholders to address source water protection challenges.
3. Localized action benefits the basin. Climate resiliency projects implemented by the AWC, such as riparian restoration, demonstrate that small-scale efforts can align with and enhance basin-wide goals.

Significance and Impact

The AWC's work demonstrates that bridging communities and integrating local knowledge into basin-level frameworks can lead to sustainable, climate-resilient water management. By amplifying the voices of drinking water providers and fostering collaboration, these efforts align with the conference theme and provide a replicable model for other watersheds.

Lessons Learned and Unanswered Questions

The importance of fostering trust and transparency among stakeholders became evident throughout this work. However, unanswered questions remain about sustaining long-term collaboration and scaling localized successes to larger watersheds. Future efforts will focus on increasing the practice of multi-stakeholder source water protection planning in the Athabasca Watershed. In addition, the AWC will adapt their State of the Watershed reporting to ensure drinking water resiliency and climate variability are represented and integrated into basin-level strategies.

Abstract # :TUWM-008

Impact of the Hygroscopic Properties of Water Conduits in Artificial Mangroves for Climate-Resilient Cities

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Abstract

Severe heat events and flooding events are becoming more and more prevalent, and misbalances in the water cycle and heat distribution due to urbanization exacerbate these trends. Current mitigation technologies like green walls and green roofs are effective, but very expensive to install and maintain, leading to economic disparities in access to climate-resilient cities. Devices that mimic the capillary-pressure-driven water transport of trees have garnered attentions due to their potential as an alternative to currently existing green roofs/walls (Wang et al., 2020; Lee, 2021). Here, we demonstrate the feasibility and scalability of mangrove- mimicking devices that exhibit three different water transport functions in mangrove trees: solute rejection at the root, water conduction through the stem, and evaporation through leaves. Specifically, we investigate the effectiveness of hygroscopic material as the fast water-conducting stem and its function to enhance the evaporation rate at the artificial leaves. As a representative hygroscopic material, we 3D-printed a porous, hydrophilic stem using cellulose. The leaf for evaporation was fabricated by casting a polyhydroxyethylmethacrylate hydrogel film. A commercial seawater reverse osmosis membrane was used as the root membrane. We demonstrate the stable desalination performance of this artificial mangrove tree operated under large negative pressure up to -20 bar at varying environmental conditions. Then, we show that the tight binding between the cellulose stem and the hydrogel leaf leads to the oversaturation of hydrogel with water, which results in an enhanced water evaporation rate at the leaf. Finally, we measure the water flux at the root and at the leaf simultaneously for different leaf-to-root area ratios. The results show that the water flux at the root is nearly independent of the leaf-to-root area ratios, indicating that the device would attain high dewatering rates with large evaporation areas, such as on the side of a building. Our work supports the feasibility and scalability of a tree-mimicking device that could be installed onto the walls of buildings, providing passive cooling and flood resilience.

Keywords: Artificial mangrove; Capillary pressure; Cellulose; Climate-resilient cities

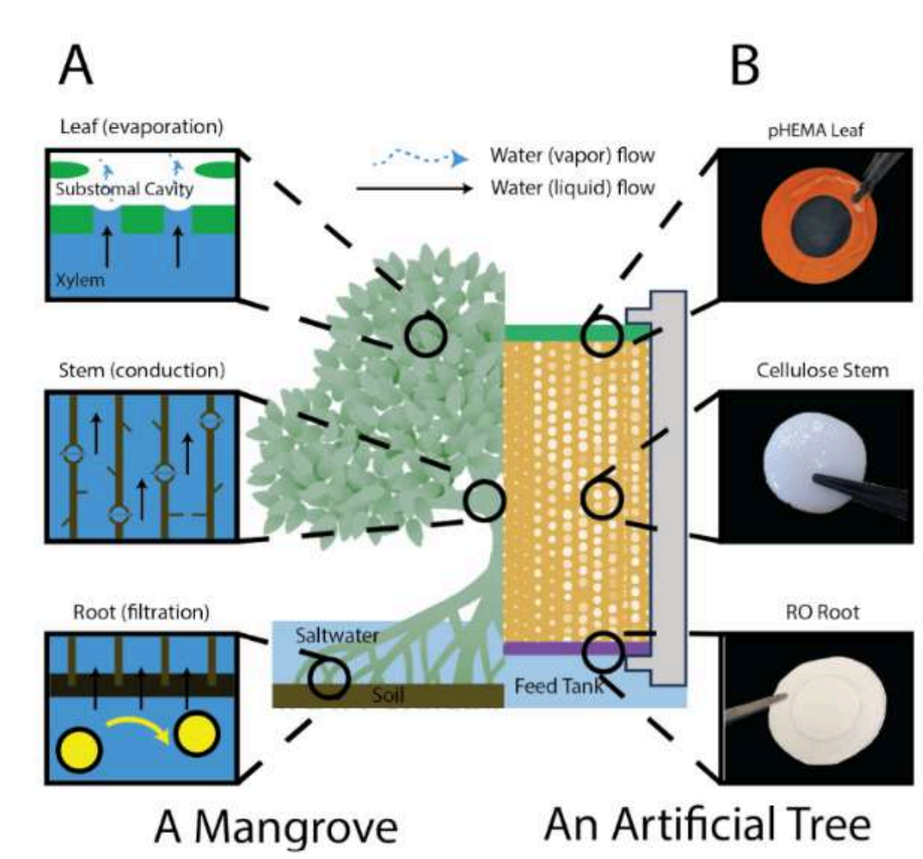

Figure 1. Comparison of the water transport functionalities in A) the natural mangrove and in B) the artificial mangrove.

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Abstract # :TBWR-003

Short-term streamflow forecasting on the Oldman River

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Abstract

Accurate daily and weekly streamflow forecasts are essential for optimizing dam operations, enhancing water use efficiency, and supporting flood control decisions. This study focuses on improving short-term streamflow prediction by developing short-term daily streamflow forecasts for the Oldman River, Alberta, using four state-of-the-art machine learning models: ANNs, SVRs, XGBoost and LSTM approaches. Four models are developed for each 1-5 day ahead forecast. The performance of the models is evaluated based on statistical measures and the best-performing models will be selected for further analysis. Preliminary results show that the SVR model provides the best accuracy for one-day-ahead forecasts, with an R^2 of 0.97, capturing both trends and magnitudes of streamflow with low variance. By incorporating these forecasts into a reservoir management model, this research aims to optimize water releases and improve water supply allocation and flood control.

Keywords: Streamflow forecasting; machine learning; reservoir management

Accurate streamflow predictions are essential for optimizing reservoir operations, regulating water storage, and ensuring efficient utilization of water resources to meet the demands of various sectors, including agriculture, industry, and domestic use (Cho & Kim, 2022). These predictions also help in addressing challenges such as flood control and drought mitigation by enabling informed decision-making for water allocation, conservation measures, and alternative water sourcing (Kumar et al., 2023). In recent decades, machine learning models have emerged as promising tools for streamflow forecasting (Cheng et al., 2020). Unlike traditional physically-based models, machine learning techniques can effectively capture nonlinear input-output relationships without requiring prior knowledge of catchment characteristics (Yaseen et al., 2015). These models have been widely applied to forecast streamflow at short-, mid-, and long-term scales, demonstrating their potential to improve prediction accuracy and reliability in the face of rapid climate change and evolving hydrological variables (Ahmed et al., 2024).

This study focuses on developing and comparing week-ahead daily streamflow forecast models for the Oldman River in Alberta using four advanced machine learning methods: Artificial Neural Networks (ANNs), Support Vector Regression (SVRs), Extreme Gradient Boosting (XGBoost) and Long Short-Term Memory (LSTM). These models can handle the nonlinear dynamics of hydrological systems while offering precise day-to-day streamflow predictions. Unlike weekly averages, the daily temporal resolution provided by these forecasts is critical for reservoir operators who require detailed information for making informed decisions on water allocation and reservoir operations. The ultimate goal of this research is to improve reservoir management by integrating accurate, short-term streamflow forecasts into operational strategies. The models use hydrometeorological data from upstream of the forecast sites, including daily streamflow, temperature, and precipitation records collected from weather stations in the watershed provided by government agencies, including the Water Survey of Canada, Environment and Climate Change Canada (ECCC) and Alberta Climate Information Service (ACIS). Pre-processing techniques, including feature selection, scaling, and splitting the data into training and testing sets, are applied to ensure the models and robustness. Models are trained on historical data using an 80/20 split for training and testing, and feature selection is performed to identify the most relevant predictors, which were used to train and test the machine learning models. The models are evaluated based on statistical performance metrics, including root mean squared error (RMSE) and R-squared (R 2). The preliminary results from the model SVR as presented in Figure 1, show that the predicted streamflow closely aligns with the actual streamflow matching the fluctuation with higher accuracy. In terms of metrics, the forecasts have R 2 of 0.97, 0.92, 0.87, 0.81 and 0.76 for 1-5-day forecasts respectively. The accuracy decreases steadily while the MAE, MSE and RMSE increase, indicating growing prediction error with forecast horizon.

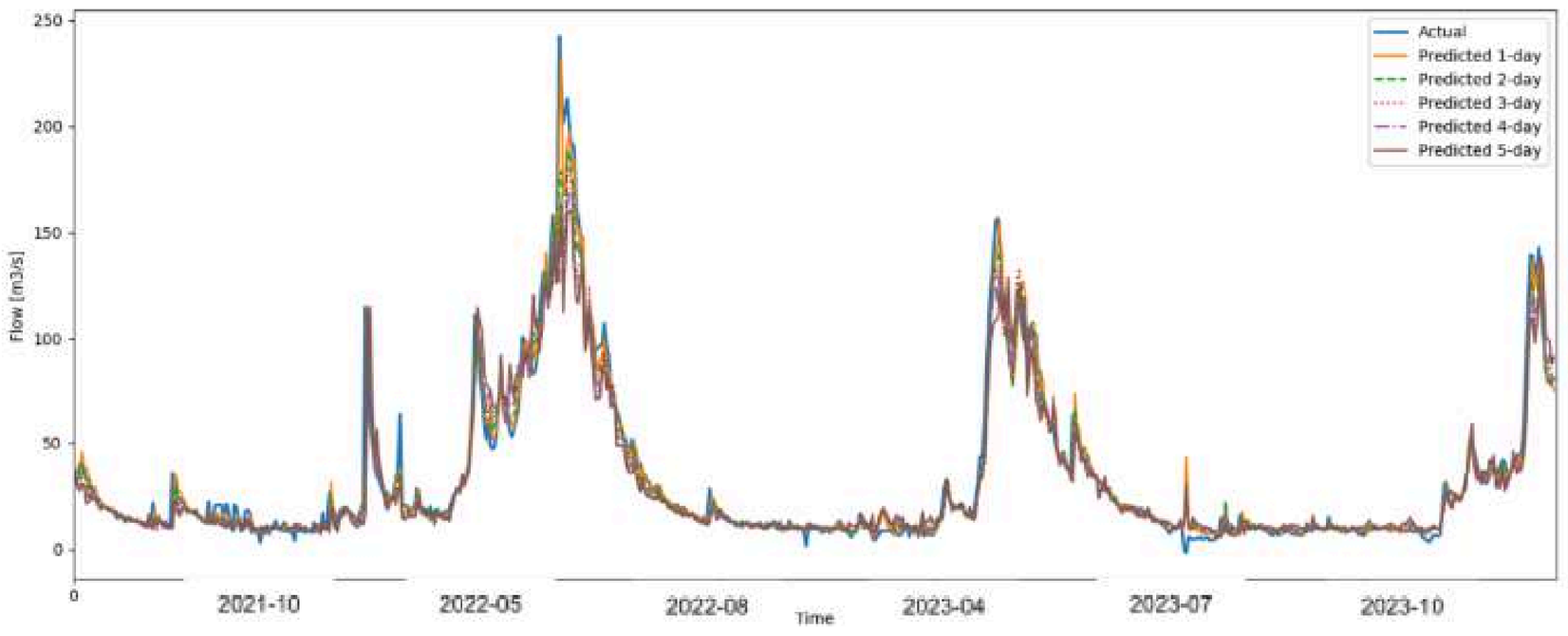

Figure 1. Five days ahead SVR inflow forecast of Oldman dam

Abstract # :TBWR-003

Short-term streamflow forecasting on the Oldman River

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Abstract # :TUWM-014

Estimating Demand for Reliable Piped Water Supply in Kumasi, Ghana

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Abstract

This paper quantifies household demand for reliable piped water supply in Kumasi, Ghana. The study first examines household seasonal piped water use based on data from the national utility. The study then deploys a household survey to estimate seasonal coping costs and willingness-to-pay for constant supply. All findings were triangulated via Key Informant Interviews with representatives from the national utility who suggested actions to improve piped water supply reliability in Kumasi. The study reveals higher piped water consumption in the dry season, with seasonality having more impact on low-income households' consumption. Coping costs and willingness-to-pay were higher in the dry season, but notably, middle-and- high income households incurred higher coping costs and offered higher willingness-to-pay bids due to higher intermittencies and exorbitant private water charges.

Keywords: Coping strategies; Coping costs; Willingness-to-pay

Background

Owing to high piped water supply intermittencies in Kumasi, piped water users rely on alternative sources (coping strategies) which may be unhealthy. Currently, piped water supply in Kumasi is 11 hours daily 5 days a week. The Ghana Water Limited attributes this to limited revenue from tariffs. Meanwhile, customers incur at least 65% more than their current utility bill in coping with supply intermittencies. The cost of coping with unreliable supply can indicate household demand for improving piped water supply reliability. Coping cost is, however, a revealed preference valuation technique, and is liable to not thoroughly capturing costumers' intrinsic preferences and income dynamics which are important variables to consider when regulating tariffs. To address this, the study also assesses households' willingness-to-pay (WTP). Vast literature shows that household coping costs and WTP may be influenced by seasonality due to varying alternative water sources, making it imperative to estimate demand across the different seasons in Kumasi.

Methodology

This study adopted the mixed methods approach involving a household survey, key informant interviews, and secondary data analysis to answer three research questions: (1) How does household piped water use vary across wet and dry seasons? (2) What are the coping strategies adopted to deal with supply intermittencies and what implications do these have on household water expenditures across seasons? (3) How do estimations of coping costs compare to household willingness-to-pay? A total of 83 households were selected for the household survey using the simple randomized sampling technique. The survey generated data on adopted coping strategies, associated coping costs, and willingness-to-pay (WTP) for reliable piped water supply. The secondary data analysis involved water consumptions records of 914 households in Kumasi to determine variations in piped water use across seasons.

Results and Discussion

Assessing Seasonal Variations in Piped Water consumption Secondary data analysis revealed higher household piped water consumption in the dry season, which was consistent with Ibrahim et al. (2021) and Mason (2015). Findings from the current study commonly attributes this to limited reliance on alternative sources in the dry season, especially rainwater, as majority of the respondents (n=52 or 62.7%) moved from rainwater harvesting in the wet season to purchasing truck water in the dry season. Higher piped water consumption in the dry season was also due to increased water demand for cleaning, washing, and showering in the harmattan's dry-dusty winds. Evaluating Seasonal Variations in Household Coping Costs and WTP Higher average monthly coping cost in the dry season is consistent with results obtained by Whittington et al. (1991) in Nigeria and Cook et al. (2016) in Kenya, which both indicate that higher coping costs in the dry season could be due to the predominant adoption of purchasing coping strategies. This aligns with results from the current study which revealed that 79.4% of the low-income households and 73.5% of the middle-and- high income category adopted purchasing coping strategy in the dry season, but only 5.9% and 22.5% respectively adopted purchasing coping strategy in the wet season.

Comparing Seasonal Household Coping Cost and WTP Bids

The study revealed a strong positive correlation of (ρ=0.784) between household WTP and coping costs in the dry season but a weak positive correlation (ρ= 0.286) in the wet season. This suggests that households incurred higher coping costs in the dry season and offered higher WTP bids due to reduced access to cheap coping strategies. Notably, the average cost of purchasing coping strategy in the dry season was GHS67.3 or $11.27 higher than the average monthly utility bill of all households.

Abstract # :TUWM-014

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** University of Oxford, United Kindom

Contributions of work

There is an extensive body of literature on the coping strategies adopted by households in developing cities in sub-Saharan Africa. Studies which focused on quantifying household coping costs for tariff revisions are sparse, however. There are also only few studies which compared household coping costs and WTP for tariff reforms; these studies focused on households in South America. Tellingly, no study has quantified seasonal demand for reliable piped water supply in sub-Saharan Africa using both household coping costs and willingness-to-pay.

Findings from the household survey shows that improved piped water supply reliability, especially in the dry season, would not only make safe and affordable water accessible to households in Kumasi, but would also generate higher revenue for the utility. Inferences from Cook et al. (2016) reveals that households did not incur high coping costs in the dry season in Kenya due to reliance on water treatment coping strategies. Investing in household water treatment in Kumasi will reduce the pressure on the limited reticulation network in the dry season while providing safe water access to the numerous poor households that typically cannot afford vended water. In informing tariff revisions, findings which show that all households are willing to pay more than their current utility bill is indicative of possible tariff increases in both seasons. Findings that show higher WTP in the dry season is suggestive of room for higher tariffs in the dry season. Higher WTP bids from the middle-and-high income households, especially for the dry season implies room for cross-subsidization. Importantly, it was revealed that successfully implementing, enforcing, and sustaining these reforms is predicated on resulting improvements in piped water supply reliability.

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Abstract # :TUWM-013

Assessing the Impact of Periodic Maintenance on Water Quality in Storage Tanks: A Case Study of Iron and Manganese Contamination within a Water Distribution Network

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Abstract

Persistent customer complains of turbid water through standpipes. This occurrence is intermitted as turbid water clears up over a brief period. Complains were accompanied with samples taken by customers and were observed to present a brownish red shiny appearance. Further samples were taken from raw water source, various points on the water treatment plant, transmission lines, water storage systems and the distribution system for further analysis. Aside from the presence of dissolved matter contributing to high turbidities in the water, this observation is also an indicator for the presence of Iron in drinking water.

Keywords: Water Quality; Maintenance; Distribution

Background

Persistent user complaints of intermittent turbid water through standpipes were noted. Complaint samples were brownish red with a shiny appearance, indicating high turbidity and the presence of iron/manganese in the drinking water.

Objectives

1. Investigate the suspected presence and source of iron and manganese contamination.
2. Assess the impact of cleaning on iron and manganese levels within the water transmission and distribution network.

Methodology

Fieldwork for this study was conducted within the Navrongo District of Ghana Water Limited. Samples were collected from the Tono Dam (raw water source), various reservoirs at the Tono Water Treatment Plant, transmission lines, distribution network, user complaint sites, and high storage tanks. Twenty-eight water samples were collected for analysis alongside flushing lines, tank inspection, cleaning, and disinfection. Post-cleaning, 32 samples were collected over 10 days. Samples were taken in 500mL plastic bottles, rinsed with sample water, acidified, labeled, packed in an ice chest, and transported at about 5°C. The samples were tested for iron and manganese using a calibrated HACH DR3900 spectrophotometer.

Results

The concentration of iron in samples from the Tono Water Treatment Plant, transmission, and distribution systems ranged from 0.12 mg/L to 0.97 mg/L, 0.05 mg/L to 7.15 mg/L, and 0.06 mg/L to 0.99 mg/L, respectively, pre-maintenance, compared to the WHO (2003) permissible limit of 0.3 mg/L. Post-maintenance, iron concentrations ranged from 0.00 mg/L to 0.97 mg/L, with only raw water exceeding the permissible limit. Manganese concentrations in the same samples ranged from 0.026 mg/L to 0.96 mg/L, 0.013 mg/L to 1.03 mg/L, and 0.063 mg/L to 1.842 mg/L, respectively, pre-maintenance, compared to the permissible limit of 0.3 mg/L (WHO, 2011). Post-maintenance, manganese concentrations ranged from 0.002 mg/L to 0.05 mg/L, all within the permissible range. The major source of Iron and Manganese contamination within the water distribution system was from the Steel Tank which serves the areas experiencing erratic turbid water supply. The results indicated that, even though the raw water had levels of iron and manganese beyond WHO permissible limits, levels were significantly reduced to permissible levels after treatment.

Conclusion

Periodic maintenance of water storage tanks is crucial for removing sediment and corrosive by-products, reducing turbidity, and ensuring consistent water quality. Regular tank cleaning effectively mitigates iron and manganese contamination, ensuring a reliable and safe water supply.

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Significance of work

This study underscores the importance of routine maintenance in preventing water quality issues, reducing consumer complaints, and protecting public health as part of holistic urban water management. The findings emphasize the need for utilities to prioritize tank cleaning and maintenance schedules to ensure a safe and reliable water supply. Periodic maintenance in this case plays a crucial role in ensuring good quality water within the distribution system and thus supports the theme “Bridging Communities, Shaping the Future of Water Together” by preventing contamination from chemical contaminants such as Iron and Manganese in this case study, bacteria, sediments etc. thus ensuring safe drinking water for communities to enhance health and livelihood of the people as well as reducing the risk of water-borne diseases. Routine maintenance can involve community participation and create an opportunity for promoting awareness about water conservation, water quality and management and thus bridging communities through collaborative efforts. Another significant impact on the theme is Routine maintenance ensures the community’s confident reliability on the supply of quality water and sustainability of water storage systems, supporting long-term water security and community development.

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Integrating Machine Learning in Flood Forecasting: A Case Study of Dharla River, Bangladesh

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Abstract

This study integrates machine learning (ML) and hydraulic modelling using HEC-RAS to forecast floods in the Dharla River floodplain. Digital Elevation Model (DEM), river morphology, and climate data (temperature and precipitation) was utilized in Python and ArcGIS. Multi-Variable Linear Regression (MLVP) machine learning algorithm was used to related river discharge and water levels, and resulting equation was used to predict future discharge and water level, based on future temperature and precipitation data from CMIP6 dataset for the 2020s to 2100s. Future discharge and water level hydrographs obtained were used as input in HEC-RAS to simulate flood inundation. Results indicate a general increase in the extent of inundated areas between the 2000s and 2100s.

Keywords: Machine learning; hydraulic modelling; flood forecasting; climate change

Flood is a major hazard in Bangladesh. Climate change with impacts like changes in temperature, patterns of precipitation is making the flood forecasting more challenging. The Dharla River, originating in the Himalayas, enters Bangladesh through Lalmonirhat, flowing into the Brahmaputra through Kurigram [1] is one of the prominent rivers of Bangladesh. Notable flood events concerning the Dharla River include August 2018, when water level at Dharla Bridge Point in Kurigram was 131 cm above the danger mark [1] as reported by Bangladesh Water Development Board (BWDB) and in June 2022, it flowed 22cm above danger mark at Setu Point [2] . Thus, flood mapping of Dharla River is of high importance. Despite prior HEC-RAS based flood inundation studies being present, no machine learning based study to predict future flooding has been carried out. This study proposes a machine learning based flood inundation in the Dharla River and its floodplain (Kurigram and Lalmonirhat districts) under the RCP 8.5 (Representative Concentration Pathway) climate change scenario, utilizing CMIP6 (Coupled Model Intercomparison Project) climate dataset (Temperature and Precipitation). Discharge, water level (WL) and river cross section data was obtained from BWDB. In some periods, data was measured irregularly and thus, interpolation for missing WL data and rating curves for missing discharge data were used to generate a continuous daily times series of discharge using observed river WL values. A HEC-RAS 1D model was developed calibration and validation purposes, completed to obtain a Manning's n value of 0.03. Using the machine learning algorithm of multi-variable linear regression (MLVR), available discharge and water level (as dependent variables) from 2000-2020 were related with corresponding temperature and precipitation data (as independent variables). 80% of the data was used for training the model, and the rest 20% for testing to evaluate its performance. Future temperature and precipitation values (available in CMIP6 dataset) were input into MLVR trained model to predict the discharge and water level of the river from 2021 to 2100. The predicted flow values were used to simulate future flood events in the Dharla River and its flood plains from 2021 to 2100, using a 2D HEC-RAS model. Subsequently, relevant maps describing the extent of flood inundated areas were prepared in ArcGIS. It was found that there was a general increase in the extent of flood inundated areas from 2021 to 2100.The flood maps developed may be used by government agencies and policymakers in identifying flood prone areas, planning flood mitigation strategies and infrastructure development, implementing early warning system and evacuation plans, and incorporating climate adaptive policies for flood vulnerable regions in the Dharla River Basin.

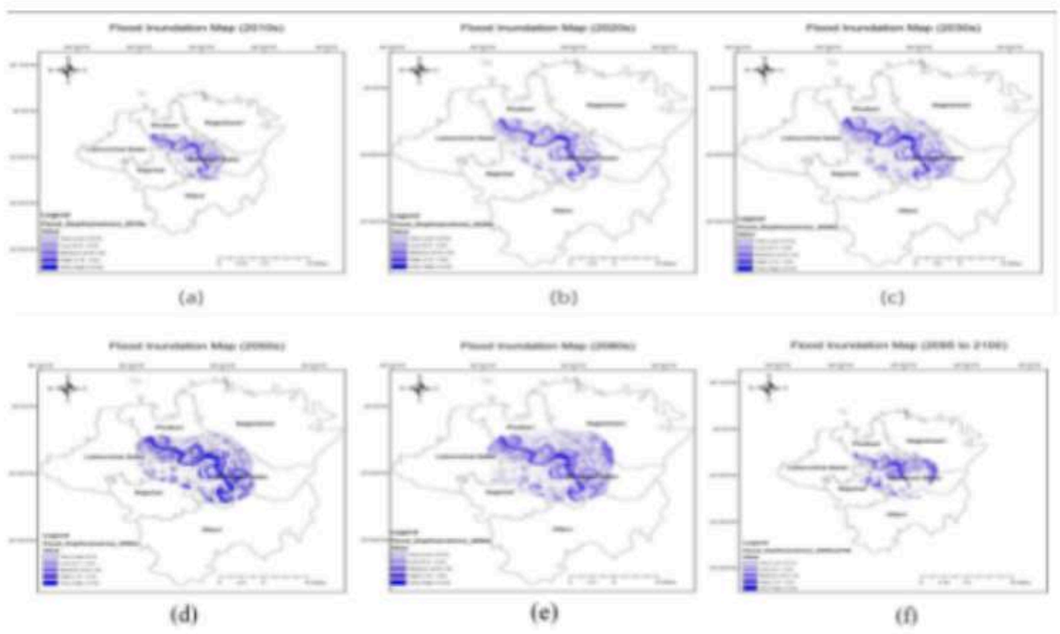

Figure SEQ Figure * ARABIC 1: Flood Inundation Maps for (a) 2005-2015, (b) 2016-2025, (c)2026-2035, (d)2036-2065, (e)2066-2095, (f) 2095-2100

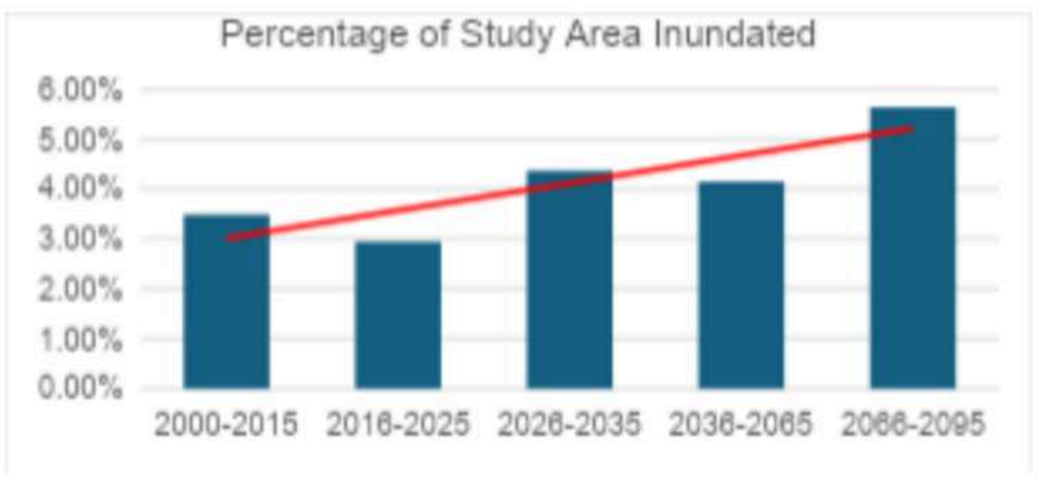

Figure 2: Study Area affected over time

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Optimising digital monitoring for operational efficiency: the case of Ghana Water LTD. (GWL)

Mawunyo Kwami Kofiloto*, Michael Botse-Baidoo* & Emmanuel Nkwantabisa Opoku*
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Abstract

Urban water utilities in sub-Saharan Africa face challenges from climate change, urbanization, and aging infrastructure, driving the need for efficient water management through robust monitoring and evaluation. GWL is addressing these challenges by adopting advanced digital technologies like water balances, smart meters, Automated Meter Reading (AMR), and sensor networks for real-time tracking of water usage. These tools optimize distribution, reduce losses, and enable data-driven interventions. In Accra North and Santeo Districts, boundary meters and domestic smart meters have improved water availability and reduced reliance on manual meter reading, lowering operational costs. Real-time monitoring, combined with Water Conservation and Demand Management (WCDM) strategies, enhances GWL's capacity for proactive resource management and improved service delivery. By integrating smart technologies, GWL is advancing sustainable urban water management, ensuring reliable supplies for growing urban populations while building resilience to environmental and infrastructural challenges.

Keywords: Conservation; Monitoring, Efficiency; Smart Meters; Urban, Management.

Results and discussions

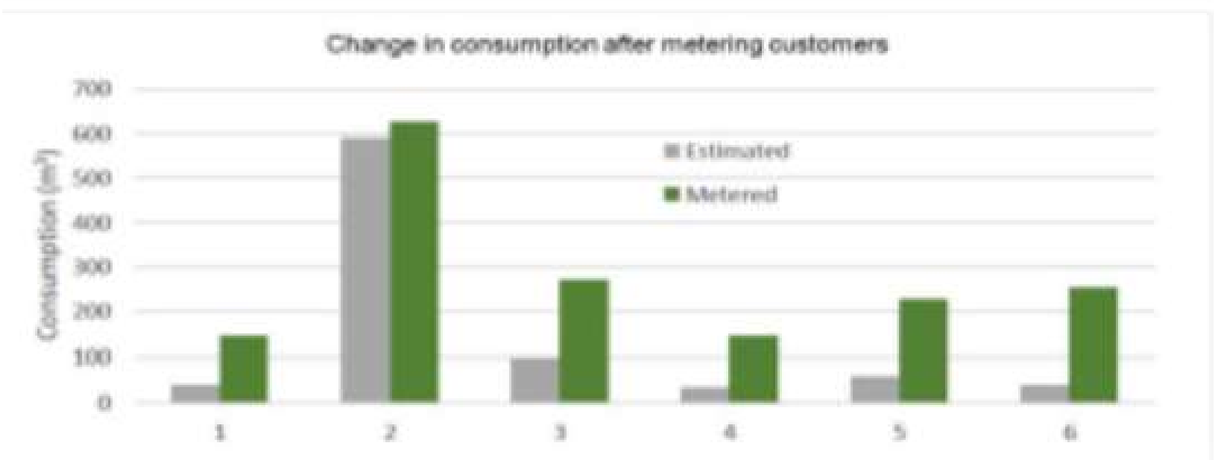

Fig. 1 Showing the true reflection of the consumption pattern of random consumers revealed through metering

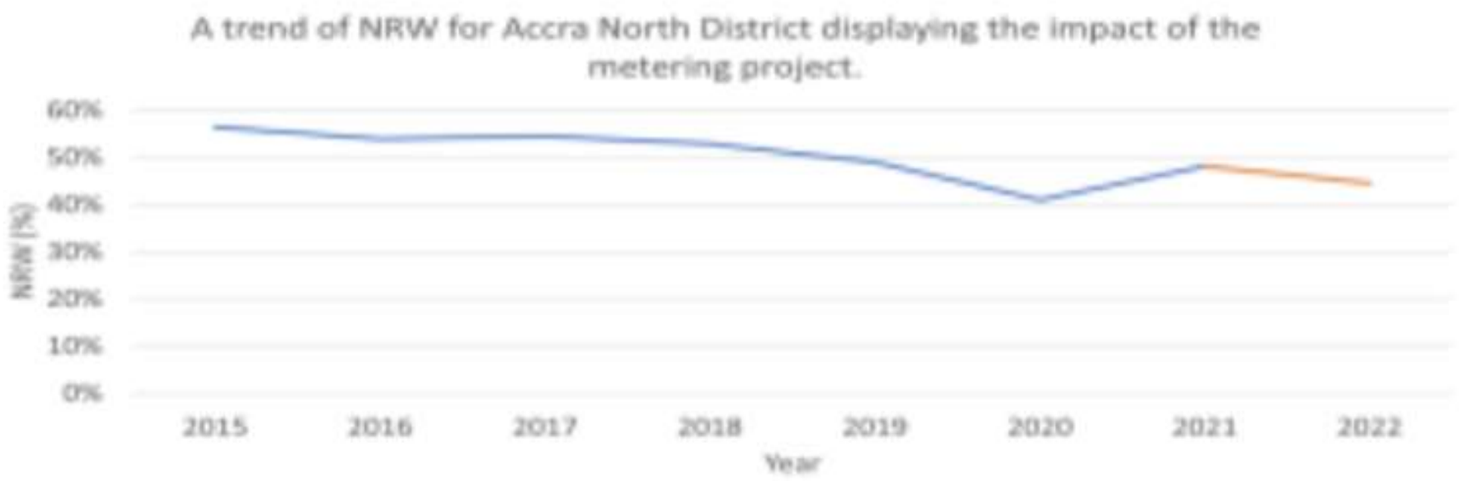

Fig. 2 Showing the impact of the smart metering in Accra North district.
The installation of meters has also seen some reduction in NRW as shown in the graph above.

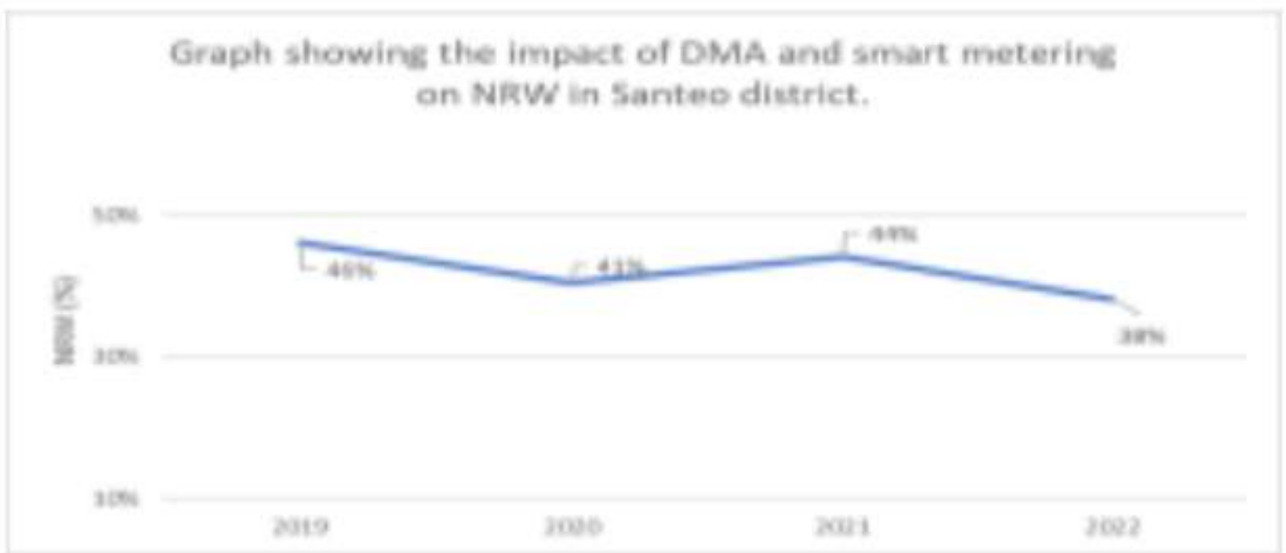

Fig. 3 Showing the impact of the DMA and smart metering in Santeo district

Optimising digital monitoring for operational efficiency: the case of Ghana Water LTD. (GWL)

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Bridging the Water Gap: Leveraging Women-Led Microentrepreneurship for Ensuring Safe Water in Salinity-Affected Coastal Bangladesh

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Abstract

The Bangladesh Coastal Zone (BCZ) faces severe water scarcity due to rising salinity and climate change, affecting 43.8 million people. Traditional water treatment approaches including central water treatment plants and rainwater harvesting systems have struggled due to lack of community ownership and management. Tetra, a social enterprise, introduces an innovative business model by installing customized water treatment plants with autonomous water ATMs and integrating the leadership of local women in service delivery by empowering them as water entrepreneurs and business partners. This initiative simultaneously ensures sustainable access to safe drinking water and promotes economic empowerment and social transformation. By reducing the burden of water collection, improving accessibility, ensuring financial and operational sustainability in water delivery, and enhancing women's leadership, Tetra's model strengthens climate resilience and community well-being. Its success highlights a scalable and sustainable approach to ensuring water security for hard-to-reach water scarce regions globally.

Keywords: Water security; Women empowerment; Climate resilience

The Bangladesh Coastal Zone covering an area of 47,201 km^2 covers 19 districts that accommodates 43.8 million (Bangladesh Bureau of Statistics, 2022). Being a low-lying area with exposed coastal area and having socio-economic factors like high population density and poverty, this coastal zone is one of the most vulnerable areas that are at the high risk of sea level rise and salinity. Different research and projects led by the World Bank, Department of Public Health Engineering (DPHE) and the Institute of Water Modelling (IWM) indicate that aquifer saline zone will increase by 2.27% by 2050, freshwater zone will decrease by 3.44%, severe salinity zone will increase by 14% by 2050 (Choudhury et al., 2014 and annual report IWM, 2012). Government and NGO initiatives adopted several approaches like central water treatment plants and rainwater harvesting projects which could not sustain in the long run due to lack of ownership and technical capacity within the community. Centralized water treatment plants operate for specific hours resulting in long queues and often get abandoned due to lack of management and operational and financial sustainability. Rainwater harvesting also proved to be challenging for the community, as the systems continuously become contaminated with bacteria and microplastics and even spread diseases due to poor management of catchment areas. Due to lack of proper care in catchment selection, asbestos poisoning was observed which posed serious health threats (Ghosh & Ahmed, 2022). Under such circumstances Tetra, a social enterprise, came up with its unique model of setting customized water treatment plants along with water ATMs managed by women microentrepreneurs.

In the last miles of the coastal Bangladesh, Tetra is installing autonomous solar-powered water desalination and purification systems that can produce 3000 liters of drinking water per day and distributes water through water ATMs. To manage each of these systems Tetra selects a woman from the community and trains her with necessary skills required to manage the water treatment system. These women microentrepreneurs perform routine maintenance of the plants such as backwashing along with recharging the water ATM cards of the customers. In addition, the women microentrepreneurs help in increasing the reach of Tetra's customer base. The microentrepreneurs are provided 20% share from the sales of water which is playing a significant role in the economic empowerment of the women in the coastal areas. As the plants run autonomously, the required engagement of women micro-entrepreneurs are only 2 hours in a week that allows busy homemakers and farmers to take it as an additional source of income. Tetra ensures that the major technical challenges are taken care of, and technical assistance is available whenever it is required. Women micro-entrepreneurs ensure that the water service delivery is seamless in the community. This unique partnership ensures that the plant operation is sustainable, profitable, and equitable.

In most places of the coastal belt of Bangladesh, the women are overburdened with the task of fetching water. They need to walk a long way to distant plants, stand in long queues and come back with the heavy containers which impact them negatively with several health conditions like backpain and fatigue in the long run. Tetra is taking the plant-level purification to the last mile by decentralising the water plants and ensuring that the water is accessible 24/7 within 5-10 minutes of walking distance. As a result, women in the community can collect water as per their convenience. By recharging the ATM cards with the help of the female microentrepreneurs during their convenient time, community members can save significant amount of time and energy that make their daily lives easier.

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With the introduction of Tetra's water treatment plants, water security is safeguarded in the climate vulnerable coastal belts with access to safe drinking water for the marginalized communities. In addition, a redesign of the socio-economic position of the women is seen with the women micro-entrepreneurship model. Overall, not just the women microentrepreneurs but all women and young girls in the coastal communities are being empowered due to the easy accessibility of fresh water.

The combination of Tetra's technical capacity with the local leadership of women entrepreneurs is a unique and pioneering model in ensuring safe water and locally led adaptation to climate change in coastal Bangladesh. The evidence that Tetra has generated about the acceptability and sustainability of this intervention model in a hard-to-reach, climate-vulnerable community makes it worthwhile exploring the replicability of this model globally.

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Methylmercury in a Northern Yukon Creek due to Victoria Gold heap leach failure and mobilization of contamination from historical placer mining

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Abstract
Victoria Gold's Eagle Gold mine operated within the historical Mayo Mining District, which has a long history of placer mining. A heap leach facility failure at Eagle Gold released contaminated heap leach solution into the surrounding environment, eventually remobilizing historical mining pollutants due to changes in groundwater pathways. A large constituent of these remnants is mercury, now being detected as methylmercury within the nearby Creek. CoreGeo has aided in the remediation of this site through technical analysis, the drilling of monitoring and production wells, as well as ongoing surface and groundwater monitoring and compliance related sampling.

Keywords: Microplastics; Wastewater sludge; Laser Direct Infrared Imaging.

Research background
The versatility and affordability of plastics have led to their global acceptance, but they have now become a global threat, causing the pressing issue of microplastic (MPs) pollution. MPs, defined as plastic particles smaller than 5 mm, are particularly challenging to quantify due to their variable sizes, shapes, and compositions(Barboza and Gimenez, 2015). Wastewater treatment plants serve as both sources and sinks of MPs in the environment. Furthermore, the high organic content of wastewater sludge (WWS) adds complexity to the separation and quantification of MPs which themselves are undigestible organic sludge. At present, no standardized protocol exists for analyzing MPs in WWS.

Significance
A newly developed standard protocol for the WW pretreatment called Ferrosonication (Fe-UIS) can significantly reduce the temperature, time and effort required for the sample preparation, making the MP analysis more efficient in the WW matrix (Mathew, Bhardwaj, et al., 2024). Owing to the complexity of wastewater sludge (WWS), density separation is to be done as an additional pretreatment procedure after Fe-UIS. However, during density separation, there is a chance of losing MPs trapped in undigested organic matter through pore-filling interactions. This entrapment can increase the density of MPs and make them difficult to separate. Thus, Fe-UIS pretreatment approach can disintegrate organic matter and prevent them from settling down recalcitrant. Rather than using the conventional separation funnel, centrifugation using the density gradient solution makes extraction of MPs from WWS faster and more efficient. Using $ZnCl_2$ as the density gradient solution is a cost-efficient solution and can be reused (Rodrigues, Gonçalves, et al., 2020). This optimized pretreatment protocol for WWS brought down the sample preparation time considerably from 2 to 3 days to less than 12 hours (Mathew, Pulicharla, et al., 2024). Laser direct infrared imaging (LDIR) is a promising analytical technique for the quantitative analysis of MPs but is not explored for MPs analysis in WWS so far.

Methodology
About 50 mL of the primary WWS was placed in a 250 mL glass beaker. A 1:1 Fenton reagent (0.05 M $FeSO_4$ + 30% H_2O_2) was added to the WWS and made up to 200 mL. The pH was adjusted to 2–3 using 100 µL H2SO4. Fe-UIS pretreatment was done at 31% amplitude for 30 minutes. After Fe-UIS, the pretreated WWS was filtered onto cellulose filter paper (Ahlstrom-Munksjö qualitative filter papers; pore size 10 µm) and the residues were washed out using $ZnCl_2$ (density 1.6 g/mL). Density separation was done in a separating funnel for 8 hours. The supernatant after density separation was filtered onto Polycarbonate (PCTG) Gold-Coated Membrane Filters (Sterlitech 0.8 micron, 40/20 nm Coating, 25 mm diameter) using Millipore Glass Microanalysis Filtration setup. Quantitative analysis of MPs in terms of their chemical composition was studied in detail using Agilent 8700 LDIR Chemical Imaging System. A fully automated analysis was done using the Clarity software (Agilent version 1.5.58) using Microplastics Starter 2.0 library. Particle analysis was done on the selected area (~16mm diameter) of the filter, with a size range of 20–500 µm. The pretreatment protocol was validated by adding a known concentration of MPs and recovery efficiency was calculated.

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Results and Discussion

Figure 1.1 shows the data regarding the number, type and size distribution of the total number of MPs detected by LDIR. Polyurethane (PU) was the most abundantly detected MPs in the primary sludge followed by polyethylene (PE), polypropylene (PP), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polyoxymethylene (POM). The most detected MPs with high confidence were >50 µm followed by MPs in the 50-100 µm range. High-density MPs such as polylactic acid (PLA) and polytetrafluoroethylene (PTFE) were also detected but with 80% confidence. A 100% recovery efficiency was obtained after Fe-UIS and density separation pretreatment with the known number of spiked MPs. Thus, the developed pretreatment protocol for WWS is efficient for MP analysis. The density gradient solution (ZnCl2: 1.6 g/mL) used could separate even the high-density MPs present in WWS.

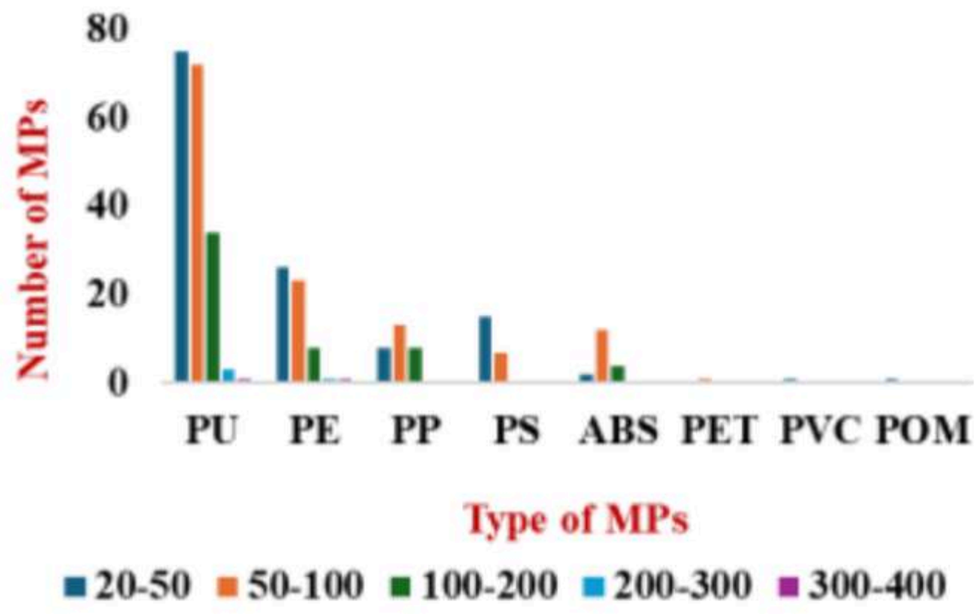

Figure 1.1: Distribution of MPs detected by LDIR based on the number, type and size

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Enhancing Humic Acid Removal in Water Treatment: The Role of Metal-Organic Frameworks in Adsorption and Coagulation

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Abstract

The increasing presence of humic acid (HA) in water poses challenges for treatment due to its impact on colour, taste, and odour, as well as its role in algal blooms. This study explores metal-organic frameworks (MOFs) for HA removal through adsorption and enhanced coagulation. Four MOFs—UiO-66(Zr), MIL- 100(Fe), ZIF-8, and Al-fum—were synthesized and characterized. Adsorption experiments assessed the effects of contact time, pH, and dosage. UiO-66(Zr) and MIL-100(Fe) reached equilibrium within 10-15 min, while ZIF-8 and Al-fum took 60 min. ZIF-8 exhibited the highest adsorption capacity (754 mg/g) under neutral pH. MOF adsorption significantly enhanced coagulation, achieving 100% HA removal under optimized conditions. Post-adsorption coagulation showed ZIF-8 and UiO-66(Zr) improved removal efficiency, whereas MIL-100(Fe) and Al-fum showed variable trends. Kaolin addition further enhanced HA removal. The study highlights MOFs, particularly ZIF-8, as promising materials for organic matter removal in water treatment.

Keywords: Humic acid; MOFS; Enhanced Coagulation

Introduction

The increasing presence of humic acid (HA) in water systems poses significant challenges for water treatment, affecting colour, taste, and odour while also contributing to harmful algal blooms. Traditional removal techniques, such as coagulation flocculation and membrane filtration, often show limited efficiency due to the complex nature of HA.

This study explores the use of metal-organic frameworks (MOFs) as adsorbents and coagulation enhancers to improve HA removal. Four MOFs—UiO-66(Zr), MIL 100(Fe), ZIF-8, and Al-fum—were synthesized and characterized for their adsorption capacities and effects on coagulation performance.

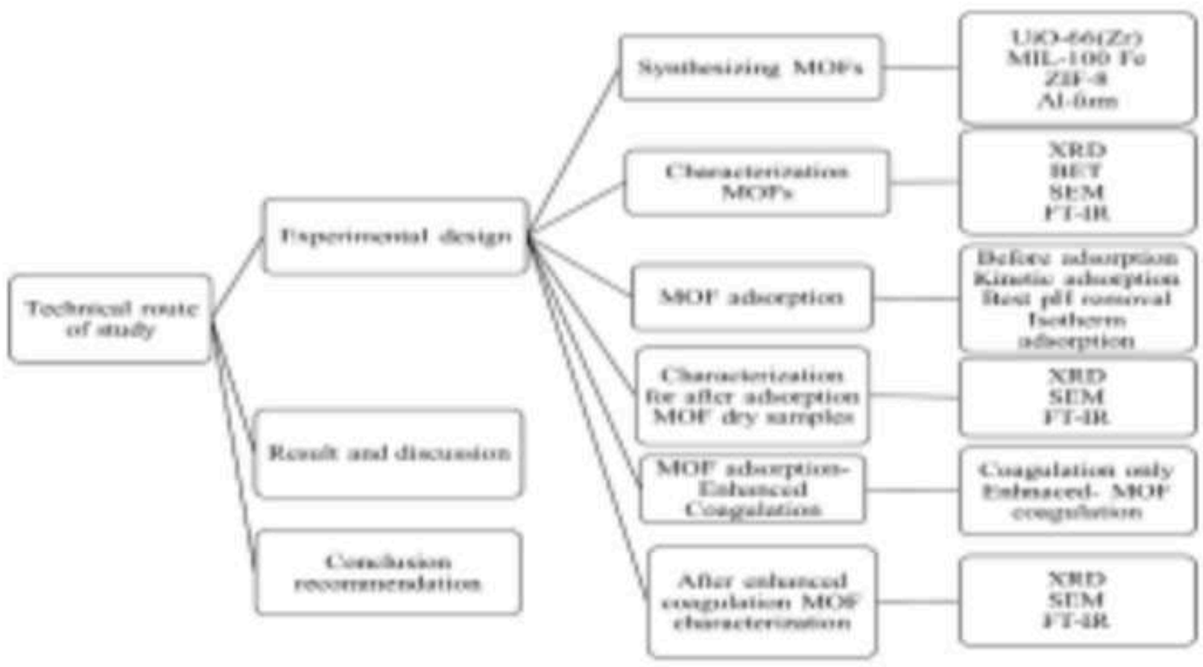

Figure 1.1 Technical route of the study

Methodology

Synthesis and Characterization: Four MOFs were synthesized: UiO-66(Zr), MIL 100(Fe), ZIF-8, and Al-fum. These were characterized using PXRD, BET surface analysis, SEM, and FTIR spectroscopy. Adsorption Experiments: Batch experiments were conducted to evaluate the effects of contact time, pH, and adsorbent dosage on HA removal. Equilibrium adsorption capacities were determined using Langmuir and Freundlich isotherm models. Enhanced Coagulation Studies: Coagulation experiments were performed using Polyaluminium chloride (PAC) with MOF-assisted pre-adsorption strategies. The study examined the impact of MOFs on turbidity reduction, UV254 absorbance, and residual HA concentration.

Analytical Techniques: HA concentrations were analysed using a UV-Vis spectrophotometer, while coagulation efficiency was assessed through turbidity measurements.

Results and discussion

Adsorption Performance: UiO-66(Zr) and MIL-100(Fe) exhibited the fastest adsorption equilibrium (10-15 min), while ZIF-8 and Al-fum required 60 min. ZIF-8 had the highest adsorption capacity (754 mg/g), performing best at neutral pH, while UiO-66(Zr) and MIL-100(Fe) showed optimal performance under acidic conditions. MOFs maintained their structural integrity post-adsorption, as confirmed by PXRD and FTIR analysis.

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Table 3.1 Summary of adsorption capacities for each MOF.

MOF Type	Adsorption Capacity (mg/g)	Optimal pH
UiO-66(Zr)	500	Acidic
MIL-100(Fe)	480	Acidic
ZIF-8	754	Neutral
Al-fum	620	Acidic & Basic

Coagulation Enhancement: MOF-assisted coagulation achieved nearly 100% HA removal under optimal conditions. ZIF-8 and UiO-66(Zr) exhibited superior UV254 removal efficiency when applied as pre-adsorption agents before coagulation. Kaolin addition further improved the overall coagulation efficiency by enhancing floc aggregation.

Table 2.2 Turbidity performance, UV254 removal, and HA removal efficiency after enhanced coagulation for different MOFs.

MOF Type	Turbidity Removal (%)	UV254 Removal (%)	HA Removal (%)
UiO-66(Zr)	92	85	98
MIL-100(Fe)	88	78	95
ZIF-8	97	95	99
Al-fum	90	88	97

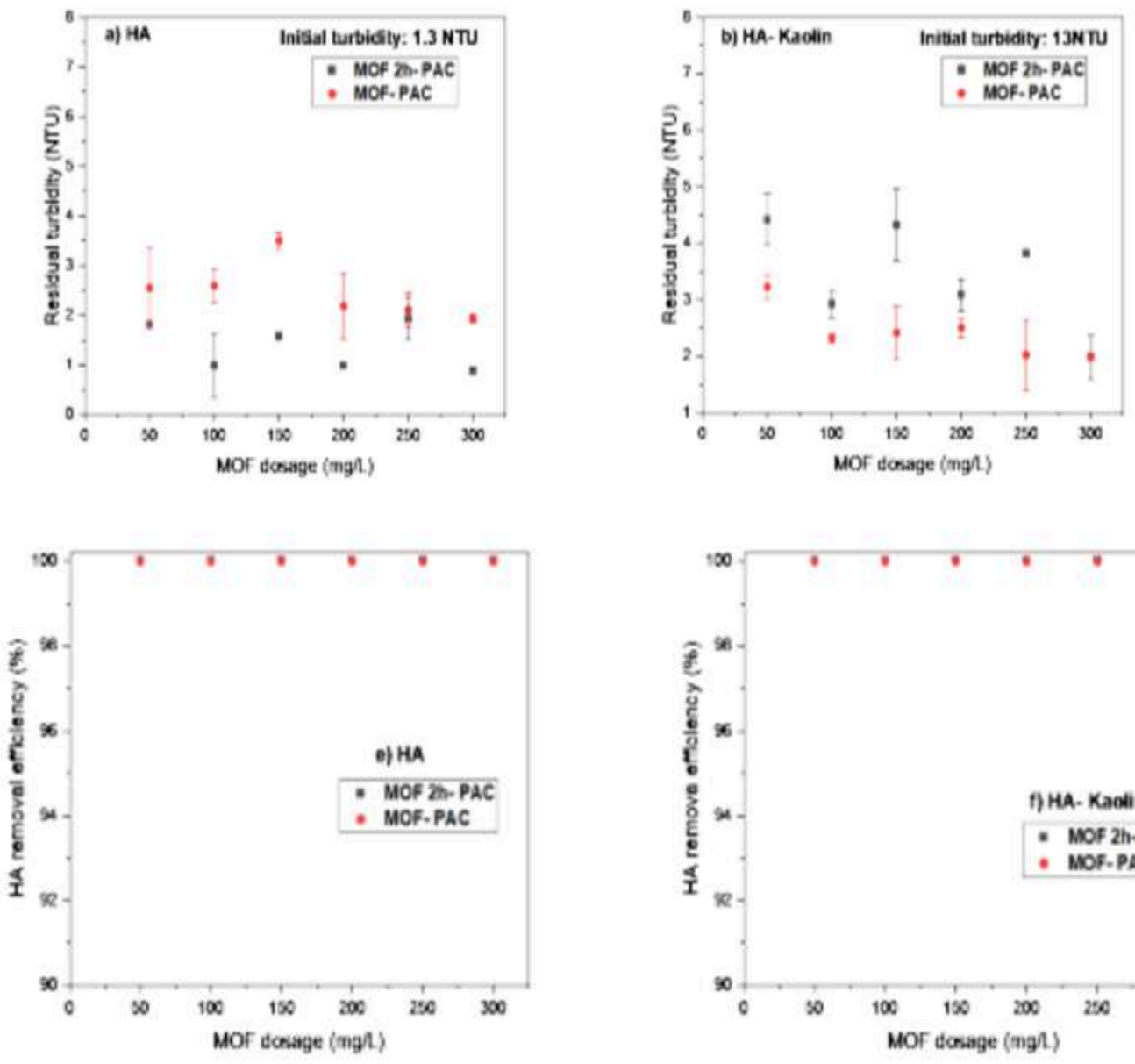

Figure 3.1 Effect of ZIF-8 MOF on the residual turbidity: (a) HA water and (b) HA-kaolin water, UV254 removal efficiency: (c) HA water and (d) HA-kaolin water, and HA removal efficiency: (e)) HA water and (f) HA-kaolin water

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Conclusion

This study demonstrates that MOFs, particularly ZIF-8, can effectively enhance HA removal through adsorption and coagulation. The findings suggest that incorporating MOFs into water treatment processes can improve coagulation efficiency, reduce residual turbidity, and enhance the removal of dissolved organic matter. Future research should focus on scaling up these findings for industrial applications and evaluating long-term MOF stability.

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Assessment Of Microbial Fuel Cell And Microbial Electrolysis Cells: Biosensors For Real-Time Monitoring Of Oil Sands Process Water

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Abstract

Microbial electrochemical cell (MXC)-based biosensors have emerged as a potential candidate for accurate detection and regular assessment in wastewater treatment operations. Selecting appropriate biosensors is critical for detecting and monitoring contaminants, particularly persistent compounds that resist biodegradation and pose analytical challenges. Here, MXCs applying external resistance (microbial fuel cells (MFCs)) and anode potential (microbial electrolysis cells (MECs)) find applications. This work aims to compare MFC and MEC sensing modes for detecting naphthenic acids (NAs) in oil sands process water (OSPW) for monitoring. Standing time, sensitivity, and electrochemical losses are examined. It was found that MFCs led to stable current output in a shorter standing time of 3h than 15 h needed by MEC biosensors. The coefficient of determination (R2) increased from 0.911 for MEC to 0.945 for MFC, suggesting a better linear relationship between current and analyte concentration for MFC biosensors, a self-powered real-time monitoring tool.

Keywords: electrochemical technologies; biosensors; real-time monitoring

Background

Microbial electrochemical cell-based biosensors provide an attractive alternative, real-time monitoring option via microbe-induced organic oxidation at the anode and oxidant reduction at cathode, offering greater versatility. MFCs and MECs use bacteria as the biological recognition element to detect target constituents and produce an electric output (Lagarde et al., 2011). However, there is no clear consensus about what type of biosensor should be used or hold superiority for detection, as the choice depends on the nature of the constituent. Future research is needed to identify the optimal MXC configuration for handling diverse constituents effectively.

Key challenges and research gap

Alberta, Canada, is home to one of the largest oil reserves in the world, making it a major contributor to global oil production. The naphthenic acids (NAs) found in OSPW stored in oil sands tailing ponds are of concern due to their toxicity, persistence (half-life of nearly 13 years), and potential seepage into surface and groundwater (Fennell and Arciszewski, 2019). In the last two decades, MXCs have expanded wastewater and soil treatment applications, particularly in quality control, environmental management, and data collection (Bhatnagar et al., 2024). However, studies on monitoring transient NAs are limited. This gap between theoretical perception and practical application highlights the need to explore and optimise sensing mode for continuous monitoring tools that could enable effective decision making.

Findings

The standing time required for achieving a stable positive output from MFC and MEC biosensors was identified. Interestingly, MFC biosensors exhibited stable positive current within an hour of feeding at 100Ω, while MEC biosensors took at least 20h to reach a positive current magnitude. A corresponding calibration curve was established based on the steady transient peak currents measured under the charging-discharging operation. The current record showed a linear relationship with the OSPW concentration for both MFC and MEC biosensors. Thus, a satisfactory calibration curve is established, suggesting CD operation for MXC biosensors is suitable for measuring different OSPW concentrations in an aqueous solution.

The CD operations were implemented to determine the optimal charging time to be used for calibration tests based on our previous work (Chung et al., 2020). Different charging times were investigated to optimize the charging time, while the discharging time was kept constant at 1 min. During the CD operation, the current recorded was fitted against the OSPW concentration. The linear equations obtained for MFC and MEC biosensor, where a higher slope of 0.466 for MFC compared to 0.087 for MEC, suggests better sensitivity of MFC biosensor over MEC. Further, the coefficient of determination (R2) increased from 0.911 for MEC to 0.945 for MFC, suggesting a better linear relationship between current and NA concentration in OSPW with MFC biosensors (Fig. 1).

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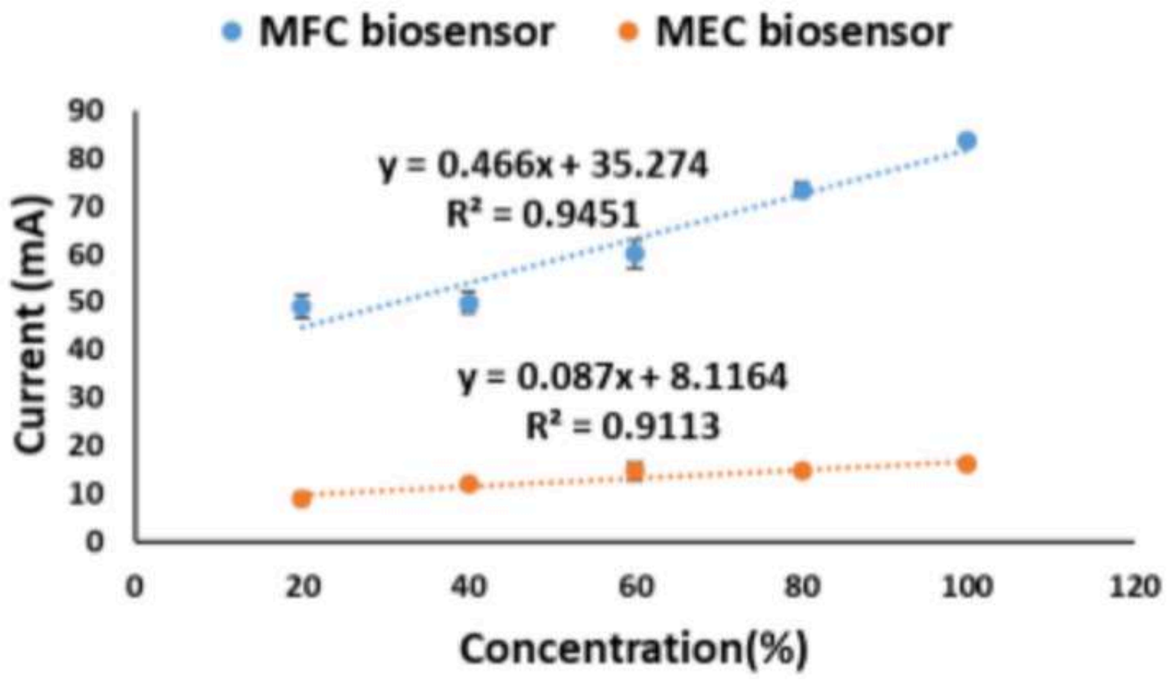

Fig. 1 Calibration curves established from CD cycles for MFC and MEC biosensors at different OSPW concentrations (20-100%).

Our results demonstrated that the CD operation of biosensors provides precise calibration for real OSPW. Sensitivity analysis suggests both MFC and MEC biosensors can be applied to quantify the level of NAs in OSPW.

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Impact of Salinity on Women Health Under The Scenario of Climate Change: A Study in South Western Coastal Bangladesh

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Abstract
The southwestern coastal region of Bangladesh faces a critical shortage of fresh drinking water due to salinity intrusion, exacerbated by climate change. This study examines the adverse health impacts of consuming saline water, particularly on women, who are disproportionately affected. Using secondary data from research studies and reports, along with primary data collected from 242 women in the Khulna region through participatory research methods, the study highlights the severe consequences of intaking saline water. Findings indicate increased risks of hypertension, pregnancy complications, miscarriages, and menstrual disorders among women exposed to saline water. Additionally, high sodium levels contribute to skin diseases and urinary tract infections. With climate projections indicating further sea level rise and worsening salinity, the study underscores the urgent need for targeted interventions, including improved access to safe drinking water and women-centered health programs as part of broader climate adaptation strategies.

Keywords: Salinity Intrusion; Climate Change; Coastal Bangladesh

Introduction

The climate-vulnerable southwestern coast of Bangladesh experiences a severe scarcity of fresh drinking water due to salinity intrusion. Different research and projects indicate that the aquifer saline zone will increase by 2.27% by 2050, the freshwater zone will decrease by 3.44%, and the severe salinity zone will increase by 14% by 2050 (Choudhury et al., 2014). The consumption of saline water leads to both immediate and long-term health hazards such as cardiovascular diseases, kidney diseases, diarrhea, and abdominal discomfort. Even though the whole coastal community is prone to the health risks of intaking saline water, women are disproportionately affected in this scenario. Women in the coastal belt are often seen to be impacted more intensely in terms of menstruation, pregnancy, hypertension, skin diseases, and other related health conditions.

Methodology

Secondary data were compiled from different research studies and reports regarding the impacts of water salinity on women & health in the south western coastal region. In order to collect primary data, a survey on 242 women of different age groups, and socio-economic and marital conditions were conducted through participatory research (PR) methods, including questionnaire survey, Focus Group Discussions (FGD), and Key Informant Interviews (KII). A quantitative analysis was made with the secondary and primary data to assess the impact of water salinity on women's health in coastal Bangladesh.

Result and Analysis

Pregnant women in coastal areas face higher risks of hypertension, pre-eclampsia, and eclampsia due to the high sodium content in saline water. Pregnant women consuming saline water having systolic BP≥120 and diastolic BP≥80 had sodium concentration in urine samples 1.109 times and 1.064 times higher respectively compared to women having less systolic and diastolic pressure. (Rony et al. 2016). Survey results showed that 26.7% of women who use saline water daily went through miscarriages.

In a study by Shammi et al. (2019) it was analyzed that high-sodium water consumption in coastal areas leads to broader health impacts particularly affecting reproductive health. From the primary survey results, it was seen that for women who drink and use saline water on a regular basis, 62.2% of those women experience irregular menstruation cycles, 68.5% go through heavy bleeding and 66.7% reported extreme cramps during menstruation.

High sodium intake from saline water was associated with elevated blood pressure in women. Reducing sodium concentrations in drinking water by 100mg/l was found to lower blood pressure significantly in women by 0.97/0.55 mmHg (systolic/diastolic) (Scheelbeek et al., 2017). Shammi et al. (2019) analyzed that, women who consume slightly saline water (1,000–2,000 mg/L) have a 17% higher risk of developing hypertension, while those drinking moderately saline water (≥2,000 mg/L) face a 42% higher risk compared to those who freshwater (1,000 mg/L). Among the surveyed women in the Khulna region, 55.2% had high blood pressure. Khanam et al. (2023) reported that using saline water for personal hygiene can lead to skin issues such as rashes, fungal infections, and urinary tract infections. According to primary survey data, 64.9% of women who use saline water experience skin rashes and itching, 48.1% suffer from skin dryness.

Impact of Salinity on Women Health Under The Scenario of Climate Change: A Study in South Western Coastal Bangladesh

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Conclusion

Climate change projections predict a serious impact on water salinity in coastal Bangladesh. Under such circumstances, the climate-induced salinity of this region will increase risks of health hazards on women. This study emphasizes the necessity for targeted interventions in coastal Bangladesh to ensure access to safe drinking water and integrate women-focused health programs into broader climate change adaptation.

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A socio-technical analysis of solving the school sanitation crisis in South Africa: A case study of the BORDA-designed Decentralised Wastewater Treatment System (DEWATS)

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Keywords: School Sanitation; DEWATS; Ressource Recovery

Background

According to the 2023 General Household Survey, 82.7% of KwaZulu-Natal (KZN) had access to improved sanitation facilities, with 51% having flush toilets, 31.7% with VIP toilets and 13.8% with unventilated pit toilets (StatsSA, 2024). Environmental hygiene plays an important role in the prevention of many diseases. Proper sanitation is one of the key elements in improving environmental hygiene (Strande, 2024), particularly for children (for the purpose of this study, children will refer to those of school-going age, between the ages of 7-17 years). Access to a clean environment, health, water and sanitation, is enshrined in South Africa's Constitution, as well as subsequent relevant policies. In August 2018, the President of South Africa launched the Sanitation Appropriate for Education (SAFE) Initiative to replace basic pit toilets with appropriate sanitation in accordance with the Minimum Uniform Norms and Standards for Public School Infrastructure - section 5A (1) (a) of the South African Schools Act (No. 84 of 1996).

Nature of problem

Pupils from more 3,000 schools in the country risk falling into pit toilets, at least 253 schools are without water and 248 schools have no sanitation at all (SAHRC, 2021). The Bremen Overseas Research and Development Association (BORDA) is a global NGO with the goal of having enhanced living conditions and preserve the environment. In the South Africa office, located in the eThekwini Metropolitan Municipality, BORDA works under this mandate, to extend the wastewater infrastructure for inhabitants of peri urban areas, new and existing low-income housing developments, informal settlements and schools (BORDA, 2024). Challenges facing school rural and informal settlement ablution facilities within eThekwini Municipality include vandalism, misuse and a lack of maintenance.

Leading to many schools in the Metro, going without operational and hygienic sanitation systems (EWS, 2012). For 10 years (2012-2022), the DEWATS at the school remained un-maintained, as an almost forgotten project. To gage its efficiency and overall suitability as a sustainable sanitation system, a year-long sampling campaign was undertaken.

Brief methodology

The study location was Sarasvati Primary School (Frasers, Tongaat in KZN, South Africa), serving a poor community characterised as informal within eThekwini Municipality. The community uses waster-based communal ablution blocks, whilst the school received newly constructed water-based 10 toilets, 11 handwash basins and 3 urinals, all to the treated by a BORDA-designed decentralised wastewater treatment system (DEWATS). The DEWATS was designed with a biogas collection chamber to collect gas for cooking, two rainwater harvesting tanks for flushing and irrigation and anaerobic baffled reactor (ABR). The parameters tested for in the effluent samples at Sarasvati Primary School, over the period of November 2022 – December 2023. In terms of section 39 of the National Water Act (No. 36 of 1998), there are certain general authorisation (GA) limits to adhere to for discharge of waste or water containing. For this system the GA limits, for irrigation of land up to 50 m^3, used as the compliance measure, are as below :

- Chemical Oxygen Demand (COD) = 5000 mg/L
- pH = 6≤x≤9
- Electrical Conductivity (EC) = 200 mS/m
- Faecal Coliforms (FC) = 100 000 NPN/100 mL

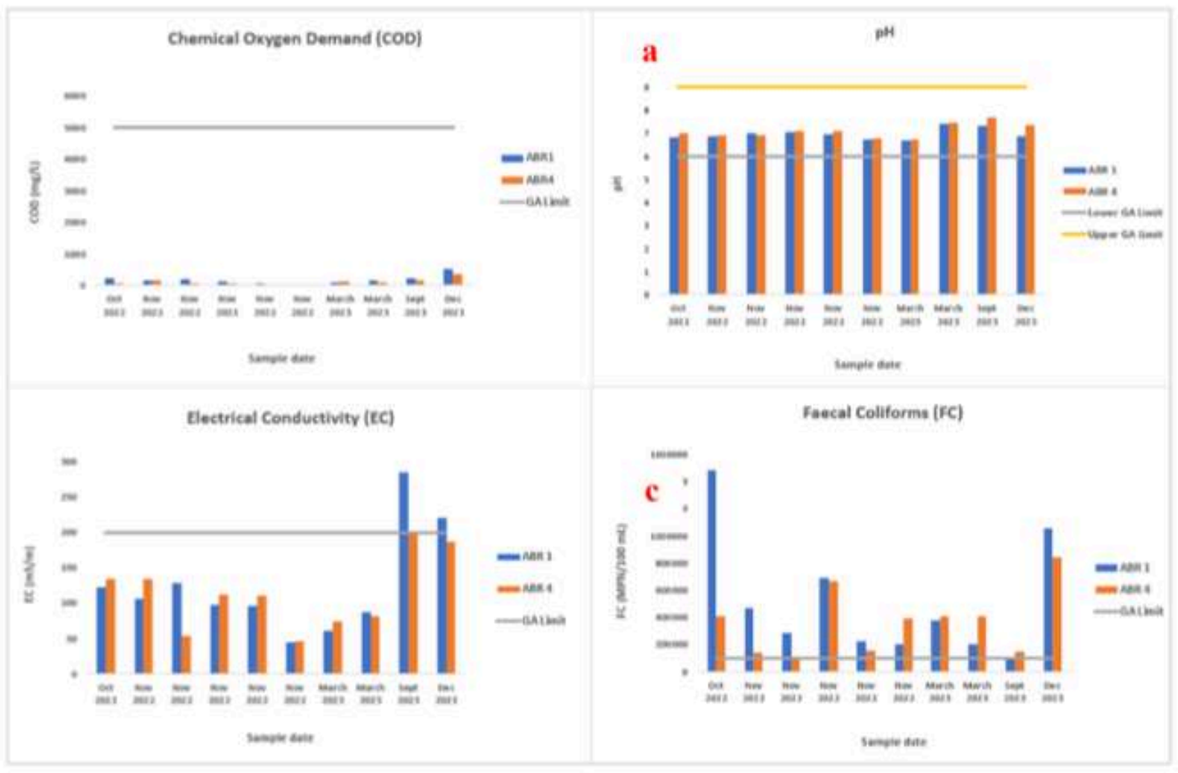

Figure 1.1 The results from the year-long sampling campaign at Sarasvati Primary School

A socio-technical analysis of solving the school sanitation crisis in South Africa: A case study of the BORDA-designed Decentralised Wastewater Treatment System (DEWATS)

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Figure 1.1 presents a summary of removal efficiency of the DEWATS for the four parameters. The average total COD (a) concentration of the feed wastewater entering the plant was 214.5 mg/L. After primary treatment in ABR1, the total COD of the wastewater was reduced to under 72.5 mg/L in the ABR4, with reduction between 66% to 33%. This suggests that the ABR is highly effective in reducing the COD through the microbial activities as well as the amount of time the substrate has been kept in the system. The pH (b) of the effluent falls within acceptable range of 6 to 7,5 for irrigation indicating the effective neutralization of the faecal matters during the treatment. EC (c) is compliance with a max of 221.5 and a min of 46.2 mS/m insuring that the effluent is suitable for reuse or safe discharge. No significant reduction is observed in the Faecal Coliforms (d) with only 6% of samples achieving compliance. This could be due to Lower temperatures which can slow down microbial activity in the system.

Significance of research

Although the treatment system is not considered a complete DEWATS (it's a biodigester with advanced septic tank and soak-away), it has proven to be efficient in reducing COD, maintaining pH and reducing EC, with some exceptions (care needs to be taken in monitoring FC. What is important is the reuse of the effluent, to add context to the efficiency of the system. By adding rainwater harvesting tanks, water consumption is reduced, thus saving an already poor school, money. With more context-specific research and data, BORDA-designed DEWATS can prove to be efficient small wastewater treatment systems, where budget, land and time are limited.

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Enhancing Methane Production and Phosphorus Recovery by Nitrogen Nanobubble Anaerobic Digestion Treating Waste Activated Sludge

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Abstract

Nitrogen nanobubble water (N_2-NBW), known for enhancing mass transfer, microbial enzyme activity, and the potential of phosphate precipitates, was evaluated to simultaneously improve methane production and phosphorus recovery from waste activated sludge (WAS) in this study. Biochemical methane potential (BMP) tests were conducted with different volumes of N 2 -NBW, measuring cumulative methane production, phosphate, ammonia, and magnesium concentrations. Results showed that N2-NBW significantly enhanced cumulative methane production (up to ~45% higher than control). Enhanced phosphorus release (~33%) and ammonia concentrations correlated with decreased soluble magnesium concentrations, suggesting struvite ($MgNH_4PO_4 \cdot 6H_2O$) formation, which was confirmed by X-ray diffraction (XRD), inductively coupled plasma-optical emission spectroscopy (ICP-OES), and scanning electron microscopy (SEM) analysis. This study demonstrates N_2-NBW as a promising method for improved anaerobic digestion (AD) efficiency and effective phosphorus recovery in WAS treatment.

Keywords: Nanobubble; Waste activated sludge; anaerobic digestion.

Waste activated sludge (WAS) is a byproduct of municipal wastewater treatment, presenting both disposal challenges and potential for resource recovery. Anaerobic digestion (AD) is a widely used biological process that addresses the challenges by reducing sludge volume and producing renewable biogas. Additionally, WAS contains a large amount of phosphorus, which is a non-renewable and limited resource essential for agricultural fertilizers. However, the efficiency of AD is often constrained by slow hydrolysis rates due to the complex extracellular polymeric substances (EPS) and microbial cell structures in WAS, limiting both methane production and phosphorus release.

To address these limitations, this study investigated the potential of nitrogen nanobubble water (N_2-NBW) as an additive to enhance both methane production and phosphorus recovery during AD treating WAS. N_2-NBW, characterized by its small size, high surface area, and stability, has been shown to improve mass transfer of substrates, microbial enzymatic activity, and substrate solubilization. Furthermore, it has the potential to facilitate the release of bound phosphorus in microbial cells and EPS in WAS and its recovery as struvite ($MgNH_4PO_4 \cdot 6H_2O$), a valuable fertilizer.

The primary objectives of this study were to evaluate the effect of different volumes of N_2-NBW on methane production, assess the phosphorus release potential in AD enhanced by N_2-NBW, and investigate the formation of struvite as a product for phosphorus recovery.

Biochemical methane potential (BMP) tests were conducted with five volumes of N2-NBW (0 (control), 20 (NB1), 30 (NB2), 40 (NB3), and 50% (NB4), expressed as LNBW/Lworking volume) on methane production, phosphorus release, ammonia concentration, and struvite formation from WAS.

The results demonstrated that cumulative methane production significantly increased with the addition of N_2-NBW, with the highest enhancement (~45% greater than control). Soluble chemical oxygen demand (SCOD)/ total chemical oxygen demand (TCOD) ratios were consistently higher in N 2 -NBW supplemented reactors, potentially indicating improved hydrolysis efficiency. Furthermore, phosphate release was notably enhanced, especially during Days 1-7, reaching peak phosphate concentrations (600 mg PO_4^{3-}-P/L), which was 33% higher than control. Subsequent sharp declines in soluble ammonia, magnesium, and phosphate concentrations after Day 7 in N 2 -NBW supplemented reactors were observed, indicating possible magnesium precipitation. After AD process, struvite formation was confirmed through X-ray diffraction (XRD), inductively coupled plasma-optical emission spectroscopy (ICP-OES), and scanning electron microscopy (SEM).

Overall, these results highlight the potential of N_2-NBW to improve methane production and phosphorus recovery from WAS, primarily by enhancing hydrolysis and substrate solubilization. The initial increase in soluble ammonia and phosphate concentration and subsequent decrease in soluble ammonia, phosphate, and magnesium concentrations further suggest effective phosphorus recovery via struvite precipitation.

In conclusion, N_2-NBW emerges as a promising, environmentally friendly approach to improve AD efficiency and phosphorus recovery in WAS treatment. Further studies are recommended to investigate the potential of different NBW types, such as air-NBW and CO_2-NBW, on phosphorus recovery, as well as the potential enhancement of struvite precipitation through additional magnesium supplementation in NBW treatments.

Enhancing Methane Production and Phosphorus Recovery by Nitrogen Nanobubble Anaerobic Digestion Treating Waste Activated Sludge

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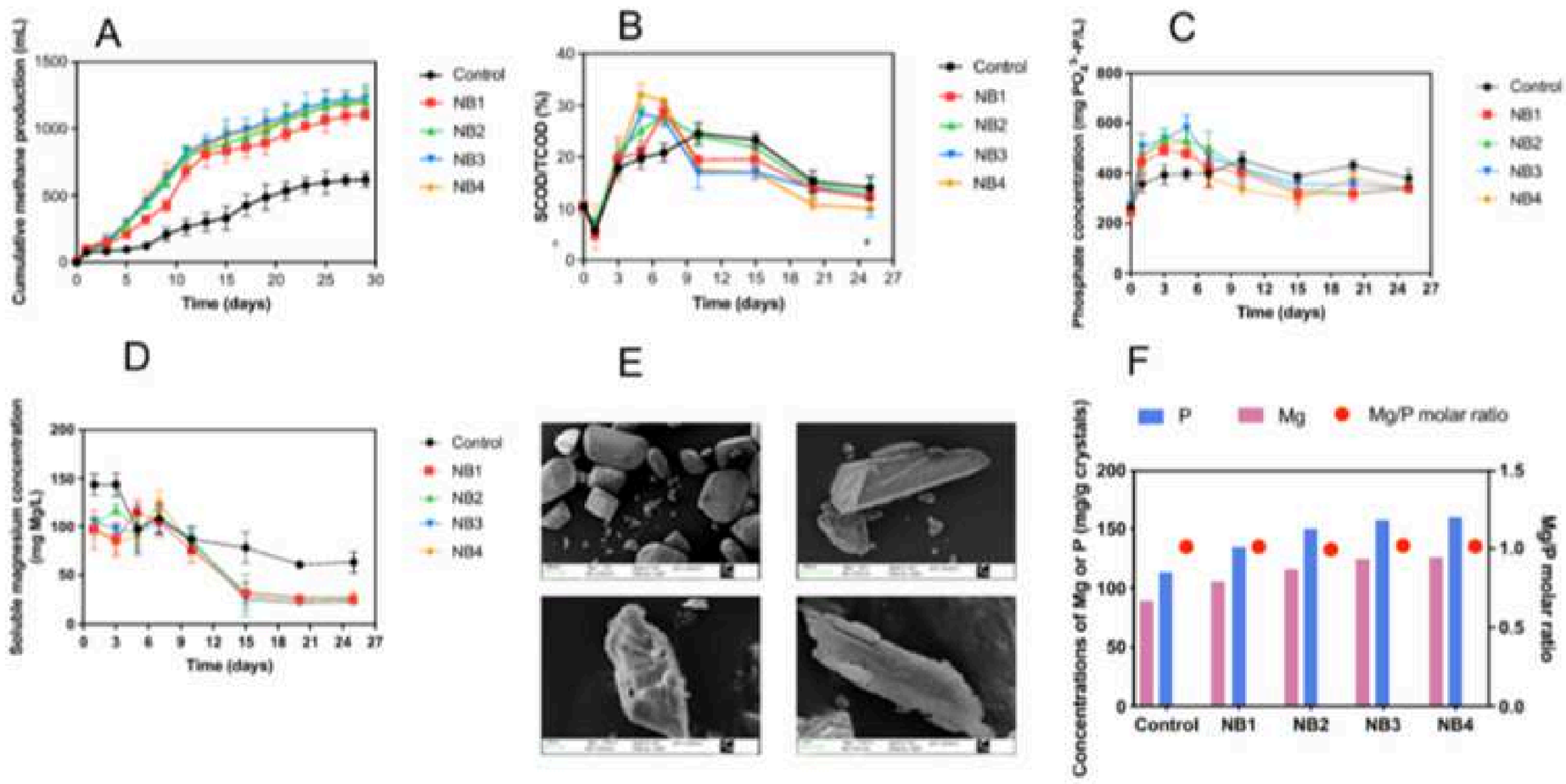

Fig. 1. Effect of different volumes of N2-NBW supplementation on AD performance: (A) cumulative methane production, (B) SCOD/TCOD ratios, (C) soluble phosphate concentrations, and (D) soluble magnesium concentrations. Struvite characteristics are shown in (E) SEM images and (F) ICP results of the formed crystals.

Enhanced Floating Wetlands for Nutrient and Cyanotoxin Removal in Eutrophic Waters

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Abstract

Eutrophication is a key environmental concern that affects water quality globally. This research aims to assess the efficacy of enhanced ecological floating wetlands combining Typha spp. with six types of substrates (different types of wood chips and wood biochar). These setups will be evaluated under different temperature settings (room and cold) simulating eutrophic water conditions in controlled mesocosms. We hypothesize that due to better sorption capacities, larger surface area, and ability to support growth of beneficial micro-organisms, biochar-based substrates might offer better nutrient removal in comparison to wood substrates. Furthermore, we anticipate that temperature will have a major impact on the structure and function of microbial communities favouring more resilient microbial taxa in colder environments. Additionally, cyanotoxin levels will be monitored to evaluate each substrate-plant system's ability to reduce toxic algal by-products. This study combines chemical monitoring of nutrient and cyanotoxin removal with microbial community characterization via 16S rRNA gene sequencing to achieve these objectives. Expected results include: 1) determining most efficient substrate-plant combinations for nutrient and cyanotoxin reduction under varying temperature conditions; 2) characterization of main microbial taxa and functional groups driving biogeochemical processes in floating wetlands; and 3) creating an ecological floating wetlands design that is scalable and optimized for field-scale use in eutrophic water bodies. This study looks to provide critical insights into interactions between substrate properties, plant performance, microbial dynamics, and environmental conditions which in turn would lead to advancement of design and application of nature-based solutions for enhancing water quality and to restoring aquatic ecosystems.

Keywords: Phytoremediation; enhanced ecological floating wetlands (EFW); eutrophication

Surface water quality is an important part of a multi-barrier approach to water security; water bodies across the globe have faced deterioration due to anthropogenic pollution. Discharge from domestic, agricultural, and industrial effluents deposit excess nutrients into waterbodies, causing eutrophication, which can severely impact the service uses of water bodies and long-term health of their aquatic system (Yao et al. 20221; Boeykens et al. 2017). This deterioration leaves communities that are dependent on local surface water reliant on expensive and high-energy water treatment technologies that the community does not always have capacity to run properly (Kumar et al. 2018). Therefore, there is a need for more sustainable, non-invasive, and community-driven approaches to water treatment and management for improved water security.

Bioremediation approaches for eutrophic water bodies can be low energy, low cost, and offer opportunities for community implementation and engagement. Many bioremediation strategies involving plants for nutrient removal (phytoremediation) such as constructed wetlands require significant areas of land. Studies have shown ecological floating beds can be a more efficient and convenient solution for in situ water treatment with simple management, however, the capacity of this treatment technology is limited since these designs typically rely entirely on the plant roots as the site for phytoremediation (Lu et al. 2015; Yuan et al. 2021). This project looks to optimize ecological floating wetlands for use in Alberta, Canada with plants and substrates that are native to the area in conditions that reflect the local climate. We anticipate that this study will identify the most effective combinations of substrate and plant species for reducing nutrients and cyanotoxins in floating wetland systems across a range of temperature conditions. We hypothesize that biochar-based substrates may outperform wood substrates in nutrient removal due to their higher sorption capacity, greater surface area, and enhanced support for beneficial microbial growth (Gwenzi 2025). Additionally, 16S rRNA gene sequencing is expected to reveal the key microbial taxa and functional groups involved in nutrient cycling and toxin degradation. These findings will inform the development of a scalable, field-ready ecological floating wetland design optimized for improving water quality in eutrophic aquatic environments.

Enhanced Floating Wetlands for Nutrient and Cyanotoxin Removal in Eutrophic Waters

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This study is situated as a part of a larger interdisciplinary water research project. Addressing water insecurity is a multifaceted problem that requires not only governance and policy changes but also technical solutions. Thus, effective water projects demand an interdisciplinary approach. While water characterization, treatment, and distribution are engineering problems, issues such as water access (who can access it and by what means), water consumption and related behaviours, and knowledge dissemination fall within the realm of social sciences (Kong et al. 2016). At this stage, this study is being designed with community-collaboration in mind and potential community implementation. Preliminary insights from the design of this study including challenges for designing lab scale research with community application in mind as well as the hypothesized impacts of EFW design on efficiency for this localized application. These results are relevant to interdisciplinary water research design and sustainable in situ treatment technologies for surface water remediation of water bodies facing nutrient pollution.

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Evaluating Digestate Replacement Strategies: Influence on Methane and H_2S Production in HSAD

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Abstract

This study explores the impact of varying digestate replacement ratios by weight basis (50%, 60%, and 70%) on methane and hydrogen sulfide (H 2 S) production during the operation of high-solids anaerobic digestion (HSAD) fed with source-separated organics (SSO). The digestate was replaced with aforementioned ratios and mixed with fresh feedstock at the start of new batch cycle to assess its effect on biogas yield and quality. Among the tested conditions, the 50% digestate replacement ratio resulted in the highest methane production (~218 L) during the 28- day batch operation, while both 60% and 70% replacements led to reduced methane yields. H 2 S concentrations showed a similar trend, with the 50% condition maintaining comparatively lower levels, potentially indicating a balance between microbial activity and inhibition. These findings provide insights into optimizing digestate reuse for improved HSAD efficiency.

Keywords: High-Solids Anaerobic digestion (HSAD); Digestate Replacement; Biogas; Hydrogen Sulphide (H2S)

Background

Optimizing the substrate-to-inoculum ratio also known as the food-to- microorganism ratio is essential for enhancing the performance and stability of anaerobic digesters [1,2]. During the start-up phase of HSAD systems, inoculum, such as biosolids, manure, or uncured compost is typically used as a seed. From the next cycles onwards, normally a portion of the digestate is replaced and combined with fresh feedstock [3]. Previous studies have shown that higher inoculum loading during start-up can significantly improve process stability by minimizing initial pH drops, reducing organic acid buildup, and shortening the lag phase [4,5]. Nonetheless, high substrate-to-inoculum ratios can lead to process inhibition due to volatile fatty acid (VFA) accumulation, ultimately leading to acidification [2]. Conversely, using excessive inoculum reduces the effective capacity of the digester, leading to higher capital costs since larger reactor volumes are needed to meet the target requirements. Objective: The objective of this study was to evaluate the effect of different digestate replacement ratios (50%, 60%, and 70%) on methane yield and H2S concentrations in biogas during batch- HSAD with percolate recirculation. The aim was to identify the most efficient replacement strategy to improve biogas production and quality while ensuring stable reactor performance.

Observations

Methane production was highest under the 50% digestate replacement condition, reaching a cumulative yield of ~218 L over 28 days. Both 60% and 70% replacement ratios resulted in lower methane yields (~158 L and ~125 L respectively), indicating that 50% inoculum provided the best balance between microbial activity and substrate availability. Regarding biogas quality, H2S concentrations were lowest under the 50% replacement condition, ranging between 185-741 ppm, while higher levels (393-816 ppm and 764-1397 ppm respectively) were observed at 60% and 70%. These trends suggest that proper digestate replacement not only enhances methane yield but also helps limit sulfide accumulation, likely due to improved microbial interactions and more favourable process conditions.

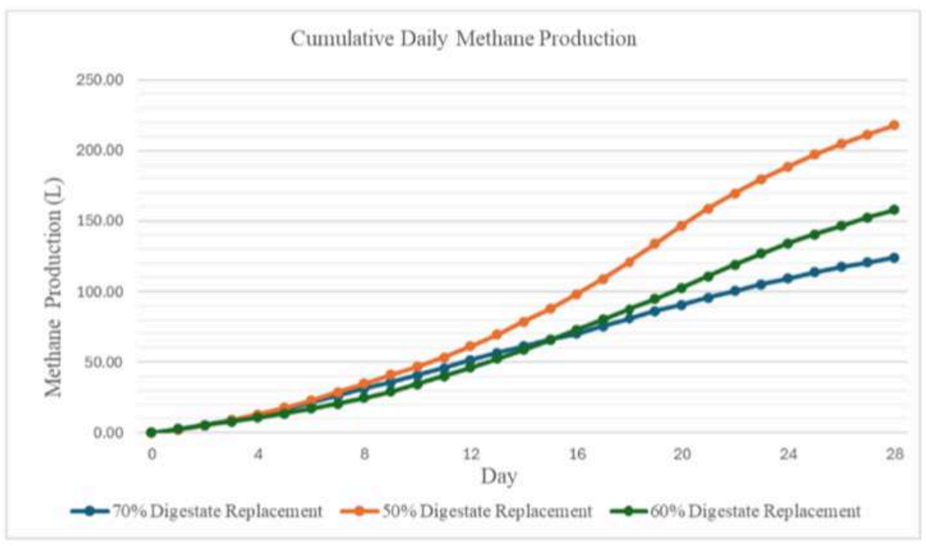

Figure 1.1. Cumulative methane production at different digestate replacement ratios

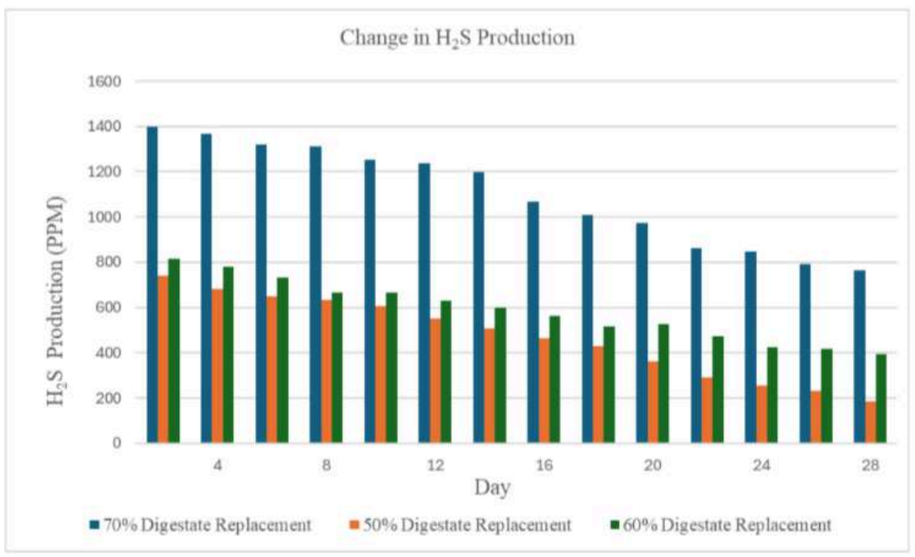

Figure 1.2. H2S production at different digestate

Evaluating Digestate Replacement Strategies: Influence on Methane and H_2S Production in HSAD

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