BOOK OF ABSTRACTS

12TH WESTERN CANADIAN SYMPOSIUM ON WATER QUALITY RESEARCH

June 17, 2025

Donadeo Innovation Centre for Engineering, University of Alberta, 9211 116 St NW, Edmonton, AB T6G 1H9

Supported by:

Canadian Association on Water Quality (CAWQ)

Faculty of Engineering, University of Alberta

Civil & Environmental Engineering and the School of Mining & Petroleum Engineering, University of Alberta

IWA YWP Canada Chapter

Acknowledgment of Traditional Territory

The University of Alberta is home to a diverse and welcoming community of over 1,900 Indigenous students from across the country, and Edmonton has the second-largest Indigenous population of any city in Canada. We celebrate our Indigenous heritage, including the ancestral lands on which our university campuses are located today, and we are proud to be the only university in Canada with a Faculty of Native Studies.

To acknowledge the traditional territory is to recognize its longer history, reaching beyond colonization and the establishment of European colonies, as well as its significance for the Indigenous peoples who lived and continue to live upon these lands, and whose practices and spiritualities were tied to the land and continue to develop in relationship with the land and its other inhabitants today.

The following statement acknowledges traditional territories on which the University of Alberta resides. All U of A conferences and public events held on our campuses are opened with an acknowledgment, and an acknowledgement may be included as part of written U of A documents such as websites, brochures or papers. Instructors may also wish to use an acknowledgement during the first class of the semester, or include an acknowledgement in their course outlines, as a sign of respect, to and commitment to the rich history of these lands.

Territorial Acknowledgment

English

"The University of Alberta, its buildings, labs and research stations are primarily located on the territory of the Néhiyaw (Cree), Niitsitapi (Blackfoot), Métis, Nakoda (Stoney), Dene, Haudenosaunee (Iroquois) and Anishinaabe (Ojibway/Saulteaux), lands that are now known as part of Treaties 6, 7 and 8 and homeland of the Métis. The University of Alberta respects the sovereignty, lands, histories, languages, knowledge systems and cultures of all First Nations, Métis and Inuit nations."

Français

"L'Université de l'Alberta, ses édifices, laboratoires et centres de recherche sont principalement situés sur le territoire des Néhiyaw (Cris), Niitsitapi (Pieds-Noirs), Métis, Nakoda (Stoney), Dénés, Haudenosaunee (Iroquois) et Anishinaabe (Ojibway/Saulteaux), des terres qui sont maintenant connues comme faisant partie des Traités 6, 7 et 8 et de la terre des Métis. L'Université de l'Alberta respecte la souveraineté, les terres, les récits, les langues, les systèmes de connaissance et les cultures de toutes les Premières nations, des Métis et des Inuits".

https://www.ualberta.ca/en/toolkit/communications/acknowledgment-of-traditional-territory.html

Welcome Message from Conference Chair

Dear Attendees,

Welcome to the 12th Western Canadian Symposium on Water Quality Research! The symposium aims to bring together academic researchers and practitioners from different areas of water quality engineering and management. As concerns about water and climate change grow, it's critical to develop innovative engineering solutions for the water and wastewater industries. These innovations can help us meet climate goals, manage resources more effectively, and bring economic benefits to our communities.

Supported by the Canadian Association on Water Quality (CAWQ), this symposium offers a great platform to share innovative research ideas and advancements in both conventional and emerging areas of sustainable water and wastewater treatment. Among the many water-related conferences and symposiums, this event stands out as one of the very few events specifically dedicated to supporting students and young water professionals. In that spirit, over 90% of the poster/oral presentation slots are reserved for graduate students, postdoctoral researchers, and early career professionals.

As one of the national leaders in water research and innovation, we are very pleased and honored to host this event at the University of Alberta again. Hosting this conference strongly aligns with UofA's strategic goal of advancing research in water and environmental sustainability. The last time we hosted this event on campus, in 2019, we welcomed participants from more than 10 Canadian universities. This year, we are equally excited by the keen response from across Canada and internationally.

On behalf of the organizing committee, thank you for joining us and contributing to this event. I want to take this opportunity to extend my sincere thanks to the Department of Civil and Environmental Engineering and the Faculty of Engineering for their generous support. My sincere appreciation goes to the scientific committee members, the local organizing committee, and our dedicated volunteers. Thanks to the Canadian Association on Water Quality (CAWQ) and the IWA YWP Canada Chapter for their support.

We look forward to many interesting and inspiring conversations. Thank you!

Sincerely,

Dr. Bipro Ranjan Dhar

Conference Chair and Vice-President CAWQ (Western)

Associate Professor, Environmental Engineering, University of Alberta
Canada Research Chair (Tier 2) in Microbial Electrocatalysis for Energy and Environment,
University of Alberta Engineering Research Chair (UAERC) in Environmental Biotechnology
Email: bipro@ualberta.ca

Scientific Committee Members

Dr. Chelsea Benally (University of Alberta)
Dr. Olubukola Alimi (University of Alberta)
Dr. Rasha Maal-Bared (CDM Smith)
Dr. Oliver Iorhemen (University of Northern British Columbia)
Dr. Seyed Mohammad Mirsoleimani Azizi (Stantec)

Local Organizing Committee Members/Volunteers

Dr. Sherif Ismail (University of Alberta)
Dr. Simran Kaur Dhillon (University of Alberta)
Tae Hyun Chung (IWA YWP/University of Alberta)
Anindya Amal Chakrabarty (University of Alberta)
Samiullah (University of Alberta)
Dr. Anqi Mou (University of Alberta)
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Monisha Alam (University of Alberta)
Romana Saila (University of Alberta)
Tamanna Haque (University of Alberta)
Mariastella Ferreri (UofA/ Mediterranea University of Reggio Calabria, Italy)

Conference Agenda

Start	End	Program	
8:00	8:45	**Registration (Electrical and Computer Engineering Research Facility (ECERF) W2-090)**	
8:45	9:15	**Opening Remark (ECERF W2-090)** **Moderator: Dr. Bipro Dhar** (Conference Chair) **Dr. Samer Adeeb** (Chair, Civil and Environmental Engineering, UofA) **Dr. Baiyu Zhang** (President, CAWQ) **Dr. Elsayed Elbeshbishy** (Immediate Past-President, CAWQ) **Hadi Mokarizadeh and Calvin Tae Hyun Chung** (IWA YWP)	
9:15	10:00	**Keynote (ECERF W2-090)** IntensiCarb: A Vacuum-Driven Technology for Intensification of Anaerobic Digestion and Resource Recovery **Dr. George Nakhla**, Western University, Canada	
10:00	10:15	Break	
10:15	11:05	**Session 1. Advanced Water and Wastewater treatment 1 (ECERF W2-090; Chair: Dr. Roopesh Syamaladevi)**	**Session 2. Emerging Contaminants: Fate, Transport and Mitigation 1 (ECERF W2-010, Chair: Dr. Xiaomeng Wang)**
10:15	10:30	**Invited Talk.** Prospects of Membrane Technology for the Treatment of Oil Sands Produced Water, **Dr. Mohtada Sadrzadeh**, University of Alberta	**Invited Talk.** PFAS in Wastewater Treatment: Understanding Fate, Uncovering Unknowns, and Advancing Removal, Dr. **Rania Hamza**, Toronto Metropolitan University
10:30	10:45	Energy Savings in heat Treated Mainstream Partial Nitrification (PN) Process, Dr. Niema Afroze, WSP Canada Inc.	Synergistic effect of thermal dewatering on the perfluoroalkyl and poly-fluoroalkyl substances (PFAS) removal via Electro-Fenton, Afrouz Yousefi, University of Alberta
10:45	11:00	Modelling the impact of sludge age and thermal hydrolysis pretreatment on the sewage sludge biodegradability and sidestream nitrogen removal, Amr Ismail, Toronto Metropolitan University	Unveiling the impacts of polycyclic musks as an emerging contaminant on aquatic organisms: Insights from a model organism—the zebrafish, Zhanika Gimeno, University of Alberta
11:00	11:15	Break	
11:15	12:00	**Keynote (ECERF W2-090)** Harnessing Sunlight for the Next-Generation Water Treatment **Dr. Frank Gu**, University of Toronto, Canada	
12:00	1:30	**(ECERF W2-090)** **Lunch Break, Poster, and Networking Session**	
1:30	2:30	**Session 3. GHG Emission, Climate Resilience, and Sustainability (ECERF W2-090; Chair: Dr. Oliver Iorhemen)**	**Session 4. Advanced Water and Wastewater treatment 2 (ECERF W2-**

			010; Chair: Dr. Chelsea Benally and Dr. Niema Afroze)
1:30	1:45	**Invited Talk.** Multi-Scale observations of GHG emissions in WWTP, **Dr. Elsayed Elbeshbishy**, Toronto Metropolitan University	**Invited Talk.** Challenges in the implementation of nanobubbles for wastewater treatment: a bench-scale study, **Dr. Rasha Maal-Bared**, CDM Smith
1:45	2:00	N_2O Emissions in Full-Scale Wastewater Treatment: Role of Flow Modes and Operational Conditions, Marwan AlSaleh, Toronto Metropolitan University	Enhanced dissolved organic matter (DOM) removal in process intensified biofiltration, Adedamola A. Ali, University of Northern British Columbia
2:00	2:15	Biogas upgrading and desulfurization via microbial electrosynthesis system, Tae Hyun Chung, University of Alberta	Algal Bacterial Granular Sludge: Exploring Algae's Role in Extracellular Polymeric Substances and Aerobic Granular Sludge, Nada Hosni, Toronto Metropolitan University
2:15	2:30	CO_2 Electro-methanogenesis in Microbial Electrosynthesis Systems with Modified Stainless-Steel Electrodes, Dr. Simran Kaur Dhillon, University of Alberta	Effect of initial phosphorus concentration, impregnation type, and media particle size distribution on phosphorus removal efficiency of biofilters using iron hydroxide-activated wood-based media, S. Hamidou, Université Laval
2:30	2:45	Integrating Anaerobic Digestion and Hydrothermal Liquefaction for Sewage Sludge Management: A Techno-Economic Analysis, Harveen Kaur Tatla, University of Alberta	Performance Evaluation of textile processing wastewater treatment plant with the retrofit of influent temperature decrease evaluation, Mohammed Mahfuz Ahmed, University of Technology Sydney, Australia
2:45	3:00	Break	
3:00	4:15	**Session 5. Circular Economy: Energy and Resource Recovery (ECERF W2-090; Dr. Rasha Maal-Bared and Dr. Seyed Mohammad Mirsoleimani Azizi)**	**Session 6. Emerging Contaminants: Fate, Transport and Mitigation 2 (ECERF W2-010; Chair: Dr. Olubukola Alimi and Hayat Reza)**
3:00	3:15	**Invited Talk.** Direct lithium extraction from Canadian oilfield brine, **Dr. Xiaomeng Wang**, Natural Resources Canada, CanmetENERGY Devon	Vacuum-Driven Intensification of Anaerobic Digestion vs. Thermal Hydrolysis Process: Ammonia Recovery and Enhanced Toxicity Resilience, Dr. Ali Khadir, Western University
3:15	3:30	Ozone and hydrogen peroxide pretreatment of hydrothermal	Novel green fabrication of stable hydrogel beads from industrial waste

		liquefaction aqueous from municipal sludge for enhanced downstream biological valorization, Nahian Rahman, University of British Columbia	lignin for efficient Pb (II) ion removal, Aurora Hu, University of Alberta
3:30	3:45	Enhancing Methane Production from Municipal Sewage Sludge by Combining Hydrothermal Pretreatment with a Novel Bioaugmentation Technology, Meagan Morrow, Toronto Metropolitan University	Using Biochar and Granular Activated Carbon to Counteract Nanoplastics in Sludge Dark Fermentation, Monisha Alam, University of Alberta
3:45	4:00	Optimization of curdlan biosynthesis in the granule matrix during wastewater treatment in aerobic granular sludge systems, Dr. Resty Nabaterega, University of Northern British Columbia	Degradation Dynamics of Mater-Bi and Crystalline PLA during Anaerobic Co-Digestion of Household Organic Waste and Wastewater Sludge, and Phytotoxicity Assessment of Digestate, Mariastella Ferreri, Mediterranea University of Reggio Calabria, Italy
4:00	4:15	Enhanced treatment of rice-washing wastewater and bioelectricity production in microbial fuel cells with ethanol supplementation, Kharisrama Trihatmoko, Nagaoka University of Technology, Japan	Impact of aged and non-aged polyethylene microplastics on antibiotic resistance genes propagation and microbial communities during primary sludge fermentation, Romana Saila, University of Alberta
4:15	4:30	Boosting Biogas Production and Phosphorus Recovery in Anaerobic Digestion using Nanobubbles, Dr. Anqi Mou, University of Alberta	Characterization of Polyethylene Microplastics Following Aerobic and Anaerobic Bio-Aging, Maha Dassouki Dit Tahan, Middle East Technical University, Türkiye
4:30	5:15	**(ECERF W2-090)** **Poster and Networking Session**	
5:15	5:30	**(ECERF W2-090)** **Closing Remark and Award Ceremony**	

Note. Speakers underlined will be considered for the Philip H. Jones Award

Poster Presentations (ECERF W2-090)

1. Effects of Amendments on the Anaerobic Bioremediation of Organohalides and Petroleum Hydrocarbons in Contaminated Soil and Groundwater, Sydney Kennedy-Flynn, University of Alberta
2. Evaluating the Effectiveness of Commercial Bioremediation Products on Petroleum and Chlorinated Hydrocarbons in Soil and Groundwater Under Sequential Aerobic–Anaerobic Conditions, Rachel Graham, University of Alberta
3. Enzymatic Indicators of Microbial Resilience to Temperature Shock in Planted and Unplanted Constructed Wetlands Treating Domestic Wastewater, Bridget Ataa Fosua, University of Northern British Columbia
4. Aquatic Methane Exposure Trials: A Novel Method, Abbey MacDonald, University of Alberta
5. Applying Nanobubbles for Boosting High-solids Anaerobic Digestion, Samiullah, University of Alberta
6. Long-term Optimization of High-solids Anaerobic Digestion for Process Intensification, Anindya Amal Chakrabarty, University of Alberta
7. Immune cell bioassays identify receptor-mediated inflammatory effects of Oil Sands Process Waters and Naphthenic Acids: Implications for water quality assessment, Sunanda Paul, University of Alberta
8. Examination of a demonstration pit lake using microbial toxicity and immunotoxicity cell-based assays, Nora Hussain and Marj Gem Bunda Fajunio, University of Alberta
9. Correlations Between Winter Parameters and Springtime Total Organic Carbon in the North Saskatchewan River, Sharafi Ferdaus, University of Alberta
10. Optimization-Based Estimation of Water Quality Index using Principal Component Analysis with Standalone and Hybrid Modeling Techniques, Ajaz Ahmad Mir, University of Alberta
11. Physicochemical Properties of Fat, Oil, and Grease (FOG) Deposits in Sewers: From Experimental Analysis to Mitigation Strategies, Xinzai Peng, University of Alberta
12. Optimization of micro-Fourier Transform Infrared Spectroscopy and Data Analysis Technique for Enhanced Detection of Microplastics in Environmental Samples, Ridwan Olaide Alabi, University of Alberta
13. Hydrothermal Liquefaction of Sludge for Biocrude Production with Integrated Anaerobic Digestion of Byproducts, Parisa Niknejad and Simran Kaur Dhillon, University of Alberta
14. Characterization and antibiofilm properties of Plasma-Activated Nanobubble Water, Prithviraj V, University of Alberta
15. Plasma-Activated Water Spray: An Effective Technique for Microbial Biofilm Elimination, Negar Ravash, University of Alberta
16. Plasma activated water mist: a promising surface disinfection technology, Shivani Sonkar, University of Alberta
17. Fat to Fuel: Optimizing Beef Tallow Anaerobic Digestion Using Nanobubble Water, Alsayed Mostafa, University of Alberta

Note. All poster presenters will be considered for the Best Poster Awards

KEYNOTE SPEAKER

Dr. George Nakhla
Professor, Western University, Canada
Salamander Chair in Environmental Engineering

IntensiCarb: A Vacuum-Driven Technology for Intensification of Anaerobic Digestion and Resource Recovery

IntensiCarb™ (IC) is an innovative vacuum-based process that intensifies anaerobic digestion (AD) by decoupling hydraulic and solids retention times, enhances solids-liquid separation, and enables ammonia recovery. Bench scale results demonstrated stable operation at organic loading rates up to six times higher than conventional AD, with improved methane yields and reduced reactor volumes. IC integration significantly decreased ammonia toxicity enriched high-growth rate methanogenic communities (e.g., *Methanosarcinaceae*), and enhanced system resilience. Techno-economic analysis across multiple facility sizes of 10, 50, and 250 MGS showed up to 75% volume and 43% footprint reduction, supporting the scalability and economic feasibility of the technology for full-scale implementation. The TEA indicated that the IC technology reduces life cycle costs by 22%-40%, depending on size and organic loading rate intensification. The process is currently under piloting in Canada with plans for piloting in the US.

E-mail: gnakhla@uwo.ca

KEYNOTE SPEAKER

Dr. Frank Gu
Professor, University of Toronto, Canada
Director, Institute for Water Innovation (IWI)
NSERC Senior Industrial Research Chair in Nanotechnology Engineering

Harnessing Sunlight for the Next-Generation Water Treatment

This presentation explores how sunlight-driven technologies are enabling the next generation of sustainable water treatment in the mining sector. The talk will highlight our recent work on solar-assisted water evaporation and reuse systems that reduce energy consumption and operational footprints in mine water management. Next, we present a hybrid treatment strategy that combines solar-powered physicochemical and biological methods to address complex contaminants in mine-impacted water. These approaches offer scalable, low-energy solutions to pressing environmental challenges. The talk will also introduce our recent e-mining initiative that supports the recovery and reuse of critical minerals from mine waste. By integrating solar-enabled treatment with circular resource recovery, our research team aims to advance academic work in partnership with industry, promoting sustainability and creating value for mining operations.

E-mail: f.gu@utoronto.ca

INVITED SEPAKERS

Multi-Scale Observations of GHG Emissions in WWTP

Dr. Elsayed Elbeshbishy, Professor, Civil Engineering,
Toronto Metropolitan University

Prospects of Membrane Technology for the Treatment of Oil Sands Produced Water

Dr. Mohtada Sadrzadeh, Professor, Mechanical Engineering,
University of Alberta

PFAS in Wastewater Treatment: Understanding Fate, Uncovering Unknowns, and Advancing Removal

Dr. Rania Hamza, Associate Professor, Civil Engineering,
Toronto Metropolitan University

Challenges in the implementation of nanobubbles for wastewater treatment: a bench-scale study

Dr. Rasha Maal-Bared

Principal Environmental Scientist, CDM Smith

Direct Lithium Extraction from Canadian Oilfield Brine

Dr. Xiaomeng Wang

Research Scientist, Natural Resources Canada

SESSION 1. ADVANCED WATER AND WASTEWATER TREATMENT 1

Prospects of Membrane Technology for the Treatment of Oil Sands Produced Water

Mohtada Sadrzadeh*, Mechanical Engineering, University of Alberta, Edmonton, Canada

Abstract

Membrane processes offer a promising alternative to energy- and material-intensive water treatment methods in the oil and gas industry, such as ion exchange and lime softening, by enabling higher separation efficiency and a smaller footprint. However, the low thermal stability and fouling susceptibility of polymeric membranes limit their application in high-temperature processes. Most commercial membranes are restricted to operations below 50 °C, making them less suitable for thermally integrated or energy-efficient systems. To address these limitations, the Advanced Water Research Lab (AWRL) has strategically focused on developing thermally stable thin-film composite (TFC) and thin-film nanocomposite (TFN) membranes. This includes tuning the polyamide chemistry using advanced monomers, incorporating functional additives, and embedding well-dispersed nanoparticles into the selective layer to enhance thermal and separation performance. These efforts have led to the synthesis of highly crosslinked, thermally robust membranes capable of maintaining stable flux and salt rejection under elevated temperatures. In particular, the use of novel monomers and optimized fabrication conditions has significantly improved membrane resilience and selectivity. AWRL has also tackled the major challenges of TFN fabrication, i.e., nanoparticle aggregation and poor polymer compatibility, through surface modification techniques that ensure uniform nanoparticle dispersion and integration. The resulting membranes demonstrate enhanced thermal stability, improved anti-fouling properties, and sustained performance in the treatment of complex, high-temperature wastewaters, including oil sands produced water.

*Presenting author. sadrzade@ualberta.ca

SESSION 1. ADVANCED WATER AND WASTEWATER TREATMENT 1

Energy Savings In Heat Treated Mainstream Partial Nitrification (PN) Process

Niema Afroze[1,2,*], George Nakhla[2,3], Mehran Andalib[4], Art Umble[5]

[1] WSP Canada Inc.
[2]Department of Civil and Environmental Engineering, Western University, London, ON.
[3]Department of Chemical and Biochemical Engineering, Western University, London, ON.
[4]EnviroSim USA. [5]Stantec, USA

Abstract

The energy savings in partial nitrification (PN) come from the lower oxygen requirements during the ammonia oxidation step. In conventional nitrification process, ammonia-oxidizing bacteria (AOB) oxidizes ammonia to nitrite, and then nitrite oxidizing bacteria (NOB) oxidizes the nitrite to nitrate. These processes consume oxygen. Compared to the conventional nitrification process, partial nitrification consumes less oxygen, thereby saving energy. Due to these advancements, partial nitrification has been widely adopted in side stream nitrogen removal. However, the widespread adoption of partial nitrification in mainstream systems faces challenges related to process stability and microbial competition. Therefore, to date, mainstream partial nitrification has been occurring in the vicinity of the lab and faces numerous challenges. In order to develop a promising means of achieving mainstream short-cut nitrification, this study evaluated the effect of thermal shock on nitrite accumulation using intermittent offline and continuous inline heat treatment of biomass in sequencing batch reactors (SBRs). The SBRs fed with municipal wastewater were operated at a solids retention time of 7 days and nitrogen loading rate of 0.04 gN/L/d to 0.08 gN/L/d without the application of pre-treatment. Contrary to literature studies that showed nitrite oxidizing bacteria suppression at temperature 60℃ to 80℃, nitrite accumulation was achieved when 20% of the biomass was heated for 2 hr at 47℃, as well as in continuously heated SBRs at 37℃ and 42℃. The continuously heated reactors at 37℃ and 42℃ produced a maximum nitrite accumulation ratio (NAR) of 0.59 and 0.79, respectively, whereas the intermittent offline heating at 47℃ -2hr produced a NAR of 0.37. Estimated energy demand for partial nitrification using return activated sludge heated at 50℃ -1hr, 55℃ -0.75hr, and 60℃ -0.67hr can be reduced by 14%, 19% and 22%, respectively, compared to complete nitrification in biological nitrogen removal systems.

*Presenting author. Niema.Afroze@wsp.com

SESSION 1. ADVANCED WATER AND WASTEWATER TREATMENT 1

Modelling the impact of sludge age and thermal hydrolysis pretreatment on the sewage sludge biodegradability and sidestream nitrogen removal

Amr Ismail[1,2,*], Elsayed Elbeshbishy[2], George Nakhla[1]

[1] Civil and Environmental Engineering Department, The University of Western Ontario, London, ON, Canada N6A 5B9.

[2] Department of Civil Engineering, Toronto Metropolitan University, Toronto, ON, Canada M5B 2K3.

Abstract

This study investigates the impact of thermal hydrolysis pretreatment (THP) on the characteristics of wastewater biosolids, methane production and anaerobic biodegradability, and recycled sidestream nitrogen loads as a function of the sludge age of the activated sludge (AS) system through a series of BioWin simulations of 3 different process configurations (i.e., MLE, MLE-MBR, and a Carrousel) at sludge ages of 5, 10, 15, 20, 30, and 60 d with and without the application of THP. BioWin's anaerobic digester and thermal hydrolysis unit were calibrated by adopting and identifying various operational parameters from the literature and through series of simulations to find the best fit. Thermal hydrolysis showed improvements of 181% in the hydrolysis rate of biosolids mixtures. Improvements in anaerobic biodegradability, which were mainly due to the conversion of endogenous products, ranged from 14% to 67% at sludge ages of 5–15 d. At sludge ages of 20–60 d, biodegradability improved by 59% to 67%, and 155% to 186% in the MLE-MBR and Carrousel configurations, respectively. At sludge ages of 15–60 d, methane production was relatively stable and insensitive to the biosolids composition. Despite the increase in the recycled nitrogen load by 42% to 127%, effluent ammonia concentrations remained unchanged even in the absence of sidestream treatment.

*Presenting author. amr.ismail@torontomu.ca

SESSION 2. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 1

PFAS in Wastewater Treatment: Understanding Fate, Uncovering Unknowns, and Advancing Removal

Rania Hamza*, Civil Engineering, Toronto Metropolitan University, Canada

Abstract

Per- and polyfluoroalkyl substances (PFAS) are highly persistent and structurally diverse contaminants that resist removal in conventional biological wastewater treatment systems. In light of their widespread presence in municipal and industrial effluents and their potential transformation into even more persistent perfluorinated end-products, this research synthesizes insights from four interconnected studies [1 - 4] to elucidate PFAS fate, reveal gaps in removal efficiency, and evaluate the performance of advanced biological treatment, specifically biofilm-based systems such as aerobic granular sludge (AGS), a form of mobile biofilm aggregate.

A comprehensive global meta-analysis across 161 wastewater treatment plants (WWTPs) revealed that PFAS removal is compound-specific, influenced by chain length, functional group, and influent source composition. Long-chain perfluorosulfonic acids (PFSAs, $C \geq 6$) and perfluorocarboxylic acids (PFCAs, $C \geq 7$) showed the highest affinity for removal due to hydrophobic and electrostatic interactions. However, WWTPs commonly exhibited negative or negligible removal efficiencies for most PFAS, especially in the case of short-chain analogs. A four-cluster behavior model was developed, segmenting PFAS into operationally distinct groups: C6–C10 PFCAs, C4/5/11/12 PFCAs, C4/6/8 PFSAs, and C10 PFSAs. Biofilm-based processes and membrane bioreactors showed improved removal compared to conventional activated sludge, while the addition of tertiary treatment often had negligible effects . Despite regulatory restrictions on PFOS and PFOA under Canada's Environmental Protection Act, these compounds remain prevalent in WWTP effluent and sludge, raising concerns over the adequacy of current national discharge standards (e.g., SOR/2012-139)

Building on these findings, laboratory-scale sequencing batch reactors (SBRs) were used to cultivate AGS and investigate its capacity to adsorb and tolerate PFAS. Four PFAS - PFPeA, PFOA, PFBS, and PFDS - were selected to represent the full behavioral range identified in the meta-analysis. Two reactors were operated: one inoculated with return activated sludge (R1-CTRL), and the other acclimatized to PFAS from the granulation phase (R2-PFAS). Over 247 days, the R2-PFAS reactor maintained superior settleability, granule stability, and nutrient removal (COD, ammonia, phosphate > 95%) even at PFAS concentrations up to 500 $\mu g\ L^{-1}$. In contrast, R1-CTRL exhibited biomass loss and deterioration in sludge structure upon PFAS exposure. Molecular profiling revealed unique microbial adaptations in R2-PFAS, including the enrichment of PFAS-tolerant taxa such as Methylobacillus, which emerged exclusively in the PFAS-exposed reactor.

PFAS removal efficiency was strongly compound-dependent and improved substantially with AGS acclimatization. PFDS was nearly completely removed (>99%) in both reactors. For PFPeA, PFBS, and PFOA, removals ranged from −71% to 93% in R1-CTRL and from −17% to 100% in R2-PFAS. Adsorption kinetics further confirmed AGS' superior affinity, with distribution coefficients (Kd) up to an order of magnitude higher than AS. Maximum Kd values for PFDS reached ~71000 in AGS, compared to ~11000 in AS. The granule structure and enriched extracellular polymeric substances (EPS), particularly hydrophobic proteins, contributed significantly to the enhanced adsorption.

These findings establish biofilm-based systems, particularly mobile biofilm aggregates such as AGS, as a robust microbial architecture for PFAS separation in wastewater treatment. AGS demonstrated superior adsorption capacity, structural resilience, and effluent quality under elevated PFAS loads, with acclimatization during granulation enhancing both microbial tolerance and compound-specific removal. However, even in optimized systems, PFAS are not mineralized but partitioned into biosolids, confirming that biological treatments function primarily as separation, not destruction, units. The persistence of regulated compounds like PFOS and PFOA in effluent and sludge highlights the limitations of end-of-pipe approaches and underscores the need for upstream interventions. Effective PFAS management must integrate source control through industrial pretreatment, restriction of non-essential uses, and adoption of the essential-use framework. Without coordinated efforts to limit inputs across supply chains, treatment technologies alone will remain containment strategies, not points of control.

References

1. Ilieva, Z., Salehi, R., Aqeel, H., Li, Y., Sühring, R., Liss, S. N., & Hamza, R. (2025). Strength under pressure: Aerobic granular sludge (AGS) dynamics in sequencing batch reactors exposed to per- and polyfluoroalkyl substances (PFAS). Journal of Hazardous Materials, 491, 137903.

2. Ilieva, Z., Sühring, R., Bastos, N., Ezzahraoui, F.-Z., & Hamza, R. (2025). Adsorption dynamics of four per- and polyfluoroalkyl substances (PFAS) onto activated sludge (AS) and aerobic granular sludge (AGS). Journal of Environmental Chemical Engineering, 13(3), 116377.

3. Ilieva, Z., Hamza, R. A., & Sühring, R. (2023). The significance of fluorinated compound chain length, treatment technology, and influent composition on per- and polyfluoroalkyl substances removal in worldwide wastewater treatment plants. Integrated Environmental Assessment and Management, 20(1), 59–69.

4. Ilieva, Z., Hania, P., Sühring, R., Gilbride, K., & Hamza, R. (2023). Impact of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) on secondary sludge microorganisms: Removal, potential toxicity, and their implications on existing wastewater treatment regulations in Canada. Environmental Science: Processes & Impacts, 25(10), 1604–1614.

*Presenting author. rhamza@torontomu.ca

SESSION 2. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 1

Synergistic effect of thermal dewatering on the perfluoroalkyl and poly-fluoroalkyl substances (PFAS) removal via Electro-Fenton

Afrouz Yousefi[1*], Mohamed Gamal El-Din[2], Mohtada Sadrzadeh[1]

[1] Department of Mechanical Engineering, 10-367 Donadeo Innovation Center for Engineering, Advanced Water Research Lab (AWRL), University of Alberta, Edmonton, AB T6G 1H9, Canada.

[2]Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, T6G 1H9, Canada.

Abstract

The ubiquitous presence of poly- and perfluoroalkyl (PFAS) is a severe concern because of their bioaccumulation and persistence in the environment because of strong C−F bonds (485 kJ/mol) that are recalcitrant towards thermal, chemical, and biological decomposition. The predominance of PFAS having toxicological effects can be quite hazardous to the environment, wildlife, and human beings, especially children [1]. Efforts are continuously pursued to investigate the complete mineralization of PFAS to detect and destroy these chemicals from the environment. Of all the many methods used, advanced oxidation processes can remove emerging contaminants from wastewater with complete degradation; however, the slow kinetics of the degradation process and extensive energy input hinder further commercialization [2,3].

We developed a hybrid process, comprising electro-Fenton as an advanced oxidation process, and membrane distillation (MD), to simultaneously degrade organic PFAS pollutants and extract pure water from the mixture. In this study, environmentally persistent perfluorooctanoic acid (PFOA) as an emerging contaminant, was used to study the effectiveness of the electro- Fenton/membrane distillation hybrid system. The PFOA degradation studies were conducted in two modes: electro-Fenton and electro-Fenton coupled with membrane distillation. The experiments have been done at pH=3 and a temperature of 60- 20 °C (feed side and cold side of MD). High-performance liquid chromatography with ultraviolet detection (HPLC-UV), Ion- chromatography (Measuring Fluoride ion concentration), total organic carbon (TOC) decay, mineralization current efficiency (MCE), and specific energy consumption (SEC) were evaluated for a single EF and hybrid EF-MD processes. Moreover, the effect of current density on the degradation and mineralization efficiency was investigated.

In the Electro Fenton process, increasing the current density from 50 to 500 A/m² resulted in a notable improvement in TOC removal, rising from zero to 70%. In the hybrid process of EF/MD, Dewatering the feed solution not only elevates the feed concentration but also enhances electrolyte conductivity. Consequently, the MD/EF system demonstrates superior performance compared to the standalone EF process, particularly at the lower current density of 50 A/m². Notably, there is no mineralization in the EF process at this lower current density. However, through the integration of membrane distillation with Electro Fenton and subsequent feed solution dewatering, mineralization

is significantly augmented, achieving a 42% TOC removal rate. Furthermore, our assessment of PFOA concentration over the 6 hours of operation reveals a remarkable outcome: within the initial two hours, employing current densities of 300 and 500 A/m², we achieved a PFOA removal rate exceeding 95%. Moreover, the calculated specific energy consumption (SEC) reveals that thermal dewatering of the solution substantially decreases energy consumption per gram of TOC, aligning with our research objective to minimize energy consumption for the mineralization of these toxic substances.

Keywords: Per and poly-fluoroalkyl substances (PFAS), Membrane distillation, PFOA removal, Advanced oxidation

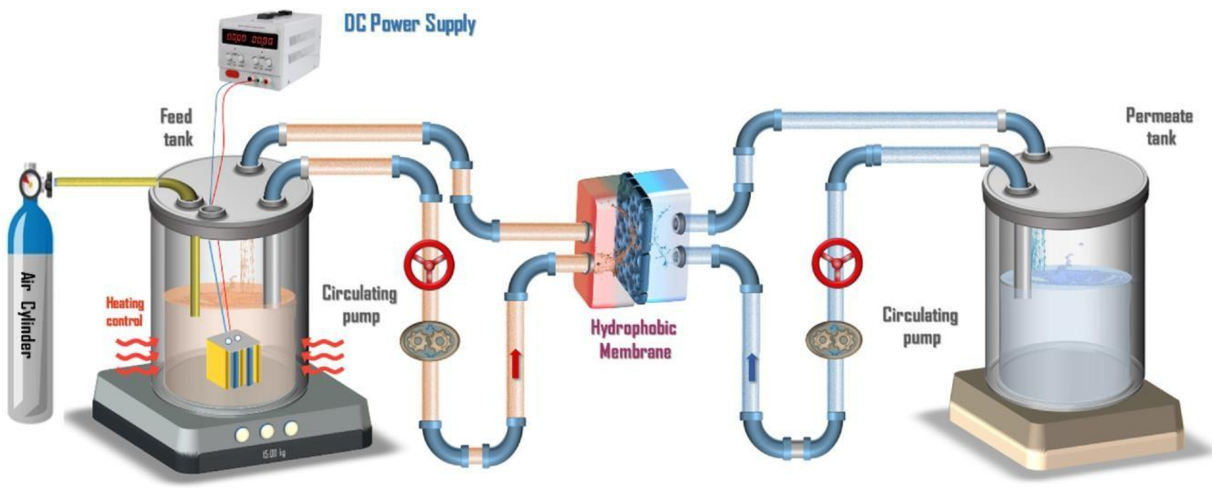

Fig. 1. Schematic of the hybrid EF/BDD-MD setup.

The heated feed container, equipped with a titanium cathode and a BDD anode connected to a DC power supply, is continuously aerated. A cold permeate container on a digital mass balance tracks mass changes from thermal dewatering. The PTFE membrane's active side interfaces with the hot feed solution containing sodium sulfate, iron heptahydrate, and PFOA, while its opposite side is exposed to a cold DI water stream.

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*Presenting author. afrouz@ualberta.ca

Session 2. Emerging Contaminants: Fate, Transport and Mitigation 1

Unveiling the impacts of polycyclic musks as an emerging contaminant on aquatic organisms: Insights from a model organism—the zebrafish

Zhanika Gimeno[1*], Drew Olsen[1], Lingling Yang[2], Mohamed Gamal El-Din[2], Keith Tierney[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB.

[2]Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB.

Abstract

In a world obsessed with smelling good, fragrances permeate people's day-to-day lives, whether that be through products such as personal care products, detergents, or household cleaning products. As the rate of using scented products continues to rise, knowing what is used to create these fragrances is important. Unfortunately, in both Canada and the US, the formulas creating the distinct smells are considered proprietary by the manufacturers and are thereby exempted from the typical regulatory need to list the specificities of the makeup. Consequently, this lack of transparency has raised concerns regarding the potential environmental impacts associated with these undisclosed ingredients. Furthermore, these fragrances ultimately find their way into wastewater treatment plants and subsequent effluent, leading to the release of a concoction of trace fragrance compounds polluting aquatic environments and solidifying their status as an emerging contaminant.

Among the major fragrance groups utilized by manufacturers, polycyclic musks (PM) currently dominate the industry and are predominantly found in waters around the world. While less toxic than its predecessor (nitro musks), PMs still exhibit concerning characteristics that are not yet fully understood. Within the PMs, tonalide (AHTN) is one of the most commonly used followed by traseolide (ATII). Of these two, AHTN is the more prominent and well-researched PM, while ATII remains understudied despite the latter exhibiting toxicity comparable to that of the more extensively studied AHTN. This knowledge gap underscores the urgency of investigating the potential ecological implications associated with these lesser-known PMs. Therefore, the main objective of our project is to better characterize the effects of PMs on non-target organisms, using zebrafish (*Danio rerio*) as a model organism.

Based on the results from our preliminary LC50 research, AHTN shows the highest toxicity among the six PMs, with ATII closely following. Additionally, AHTN, being a well-researched and characterized PM, was used as a reference for comparative analysis. Given the conflicting evidence in previous studies regarding PMs' potential as estrogen-disrupting compounds (EDC), we included EE2 as a positive control. EE2 is a widely documented and thoroughly characterized EDC known to impair embryonic development. The three selected compounds, ATII, AHTN, and EE2, were introduced individually to embryonic zebrafish at four various concentrations along with DMSO as a vehicle control. Combinations of ATII + EE2 and AHTN + EE2 were investigated to determine the chemosensitization effect of PMs. The exposure duration spanned seven days, during which genetic, developmental, morphological, and behavioural endpoints were taken.

Among the endpoints measured, heart rate differed significantly between the exposed groups and the control at higher concentrations, underscoring the potential impact of acute exposures during critical stages of early development. Additionally, results from the light-dark test, used to assess behavioural changes in thigmotaxis, revealed a notable shift between the initial and second dark phases—suggesting an increased preference for border-dwelling behavior over time. Collectively, these findings highlight the unintended effects that polycyclic musks may have on non-target aquatic organisms and emphasize the need for increased research and regulatory transparency regarding their classification as emerging contaminants.

*Presenting author. gimeno@ualberta.ca

SESSION 3. GHG EMISSION, CLIMATE RESILIENCE, AND SUSTAINABILITY

Multi-Scale observations of GHG emissions in wastewater treatment plant

Elsayed Elbeshbishy*

Department of Civil Engineering, Toronto Metropolitan University, Toronto, Canada

Abstract

Accurate monitoring and quantification of methane (CH4) emissions from wastewater treatment plants (WWTPs) is essential for regulatory compliance, process optimization, and the development of effective GHG mitigation strategies. Few previous studies applied individual CH4 sensing techniques (e.g., ground sensors and satellite imaging) to quantify CH4 emissions from wastewater treatment and biogas facilities. However, there are no systematic investigations that employed or evaluated the feasibility of adopting multiple sensing techniques to monitor and quantify CH4 emissions from full-scale WWTPs. In the current presentation, the hands-on experience for using multi-sensing monitoring, such as ground sensors, a handheld Optical Gas Imaging (OGI) camera, and drone-based sensors from different treatment processes, will be discussed. In addition, the importance of monitoring CH4 emissions and tailoring practical mitigation strategies for effective CH4 emissions reduction in wastewater treatment processes will be highlighted.

*Presenting author. elsayed.elbeshbishy@torontomu.ca

SESSION 3. GHG EMISSION, CLIMATE RESILIENCE, AND SUSTAINABILITY

N_2O Emissions in Full-Scale Wastewater Treatment: Role of Flow Modes and Operational Conditions

Marwan Al Saleh[1*], Mostafa Khalil[1], Ahmed AlSayed[2], Ahmed Elsayed[1], Mohamed Sherif Zaghloul[3], Farokh Laqa Kakar[4], Katherine Y. Bell[4], Shannon Cavanaugh[4], Ahmed Al-Omari[4], Elsayed Elbeshbishy[1]

[1]Department of Civil Engineering, Toronto Metropolitan University, Toronto, Canada.

[2]Department of Civil and Environmental Engineering, McCormick School of Engineering, Northwestern University, USA.

[3]Department of Civil and Environmental Engineering, United Arab Emirates University, Sheik Khalifa Bin Zayed St - ’Asharij, Abu Dhabi.

[4]Brown and Caldwell, Walnut Creek, California, USA.

Abstract

In response to the detrimental effects of global warming, developing countries committed to reduce their GHG emissions aiming at Net-zero emissions by the year 2050. With the ongoing decarbonization of the energy sector, more attention has been recently paid to direct GHG emissions. Wastewater treatment plants contribute to Direct or Scope 1 emissions through the direct non-biogenic emissions from bioprocesses. Due to its 300 times higher global warming potential, Nitrous oxide (N_2O) is considered the main source of GHG emissions at WWTPs. It was estimated to account for about 90% of all GHG emissions. Accordingly, more research and industrial efforts have focused on quantifying, predicting, and understanding direct N_2O emissions from WWTPs.

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, see Figure 1 for more information.

Over six months, liquid samples were collected from 13 locations within the conventional WWTP. These locations are distributed as follows: nine locations along the selected aeration tank shown in Figure 1, the other locations are influent, effluent, and RAS. A sampling schedule of 2-3 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. Key parameters such as NH3, NO2-, NO3-, sCOD, TCOD, TN, TP, TSS, VSS, DO, pH, and temperature were measured to understand the nitrification and denitrification processes under each flow mode. Additionally, two Unisense sensors were used to monitor and record N_2O liquid concentration every 30 seconds. Moreover, two microbial analysis samples were collected from locations (2&6) at each sampling event to identify microbial community changes across the different flow modes.

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. 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 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. However, $NO_3^-$and NO_2^- accumulation in plug flow and semi-plug flow modes suggest incomplete nitrification and/or denitrification, further contributing to N_2O emissions.

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 NH3 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.

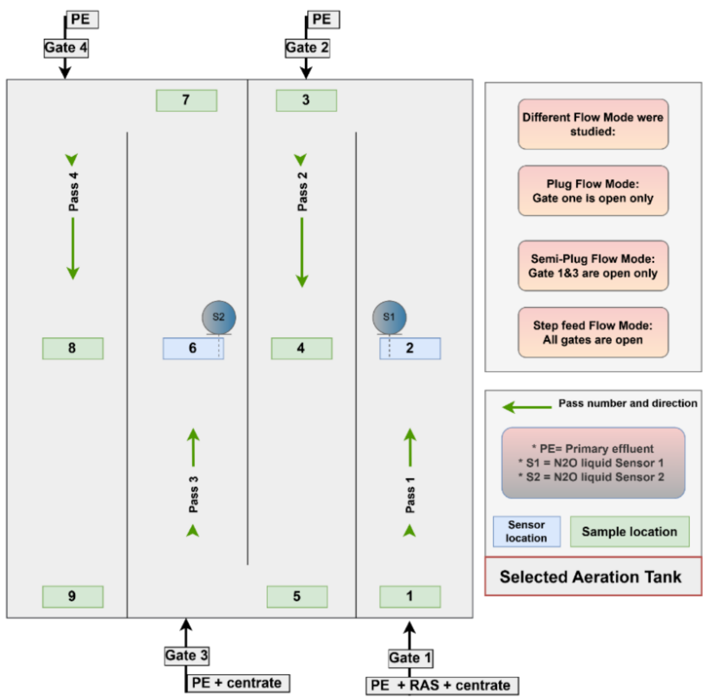

Figure 1. The layout of the selected tank indicates liquid sampling locations and sensor placements.

*Presenting author. marwan.alsaleh@torontomu.ca

SESSION 3. GHG EMISSION, CLIMATE RESILIENCE, AND SUSTAINABILITY

Biogas upgrading and desulfurization via microbial electrosynthesis system

Tae Hyun Chung*, Simran Kaur Dhillon, Anindya Amal Chakrabarty, Bipro Ranjan Dhar

Department of Civil and Environmental Engineering, University of Alberta,
9211-116 Street NW, T6G 1H9, Edmonton, AB, Canada.

Abstract

The urgent need for renewable energy alternatives stems from increasing fossil fuel demand, climate change concerns, and greenhouse gas emissions. Biogas offers a promising substitute, with a global potential of roughly 29.5 GW of electricity. Raw biogas typically contains around 60% methane, 40% CO_2, and impurities like H2S, which lower its heating value. To meet pipeline injection or vehicle fuel standards, methane content must exceed 95% and H_2S must be removed. Conventional upgrading technologies, such as water scrubbing, pressure swing adsorption, and chemical absorption, require large facilities, significant energy inputs, high capital and operational costs, and skilled personnel.

In this regard, microbial electrosynthesis systems (MESs) emerge as a promising alternative for efficient biogas upgrading and desulfurization, merging microbial metabolism with electrochemistry to convert CO_2 into biomethane and remove H2S. To date, several studies have been published on the application of MES biogas upgrading but they have not comprehensively provided insights on real biogas upgrading simultaneously with desulfurization. Additionally, no studies have thoroughly investigated the optimization of MES for biogas purification. Therefore, in this study, we tested different cathode and membrane materials to optimize MES for both biogas upgrading and desulfurization processes.

Initially, four dual-chambered H-cell type MES reactors were set up and equipped with a fixed anode (platinized titanium fiber felt, Pi-Ti) combined with different cathodes (stainless steel or carbon felt) and proton-exchange membranes (Nafion™ 117 or Nafion™ 212) as indicated in Table 1. MES reactors were operated with a growth buffer medium containing either bicarbonate as a carbon source or CO_2 derived from various gas compositions, such as CO_2-rich gas (70% CO_2, 30% N_2), synthetic biogas (59% CH_4, 41% CO_2), and real biogas (64±1% CH_4, 36±1% CO_2, 214±6 ppmv H_2S) obtained from an AD reactor fed with agricultural wastes. It was determined that the MES configuration with a stainless steel cathode and Nafion™ 117 (denoted as MES-#2) exhibited optimal performance with a bicarbonate growth medium in terms of CO_2 conversion to methane, achieving a maximum methane production of 268.5±19.5 LCH_4/m^3 (Fig. 1a). This performance is potentially due to the nature of stainless steel cathodes, which catalyze the hydrogen evolution reaction more effectively than carbon-based cathodes, resulting in more kinetically efficient methanogenic biocathodes and enhanced hydrogenotrophic methanogenesis. When MES-#2 was subjected to a recirculation of gaseous CO_2 (e.g., CO_2-rich gas, synthetic biogas) it achieved approximately 100% CO_2 conversion to biomethane within 3 days.

Due to its outstanding performance, MES-#2 was further tested with real biogas. MES-#2 was capable of upgrading real biogas (>99% methane) in 3 days (Fig. 1b) while significantly removing H2S (reducing levels from 214 ppmv to <1 ppmv) via catalytic activities of sulfide-oxidizing bacteria (*Thiobacillus*) enriched in the biocathode. Therefore, using MES, successful biogas upgrading can be achieved even with real biogas, potentially replacing natural gas and offering a sustainable and renewable energy alternative. Furthermore, with ongoing enhancements and adaptations, MES is poised to advance towards broader field applications, potentially transforming biogas upgrading practices and contributing significantly to sustainable energy solutions.

Table 1. Concise summary of MES reactor configuration.

MES reactor name	**Anode**	**Cathode**	**Separator**
MES-#1	Pi-Ti	Carbon Felt	Nafion™ 117
MES-#2	Pi-Ti	Stainless Steel	Nafion™ 117
MES-#3	Pi-Ti	Carbon Felt	Nafion™ 212
MES-#4	Pi-Ti	Stainless Steel	Nafion™ 212

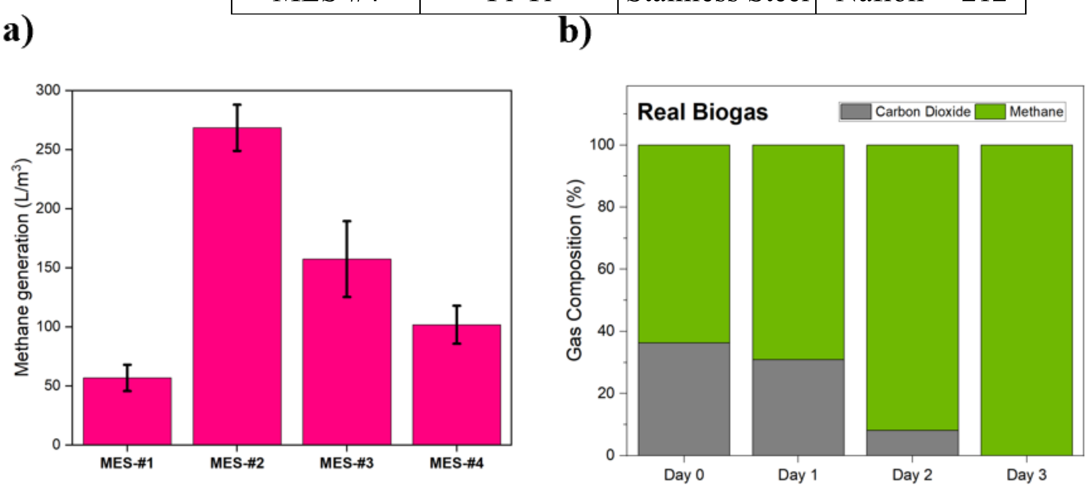

Figure 1. MES performance showing: (a) methane production from bicarbonate medium; and (b) real biogas upgrading performance of MES-#2

*Presenting author. thchung@ualberta.ca
Presenting author is a Young Water Professional

SESSION 3. GHG EMISSION, CLIMATE RESILIENCE, AND SUSTAINABILITY

CO_2 Electro-methanogenesis in Microbial Electrosynthesis Systems with Modified Stainless-Steel Electrodes

Simran Kaur Dhillon*, Tae Hyun Chung, Bipro Ranjan Dhar

Department of Civil and Environmental Engineering, University of Alberta, 9211-116 Street, NW, T6G 1H9, Edmonton, AB, Canada.

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 an 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 CH4 generation in a shorter time compared to the 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 [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]. 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.

Findings

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. 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.

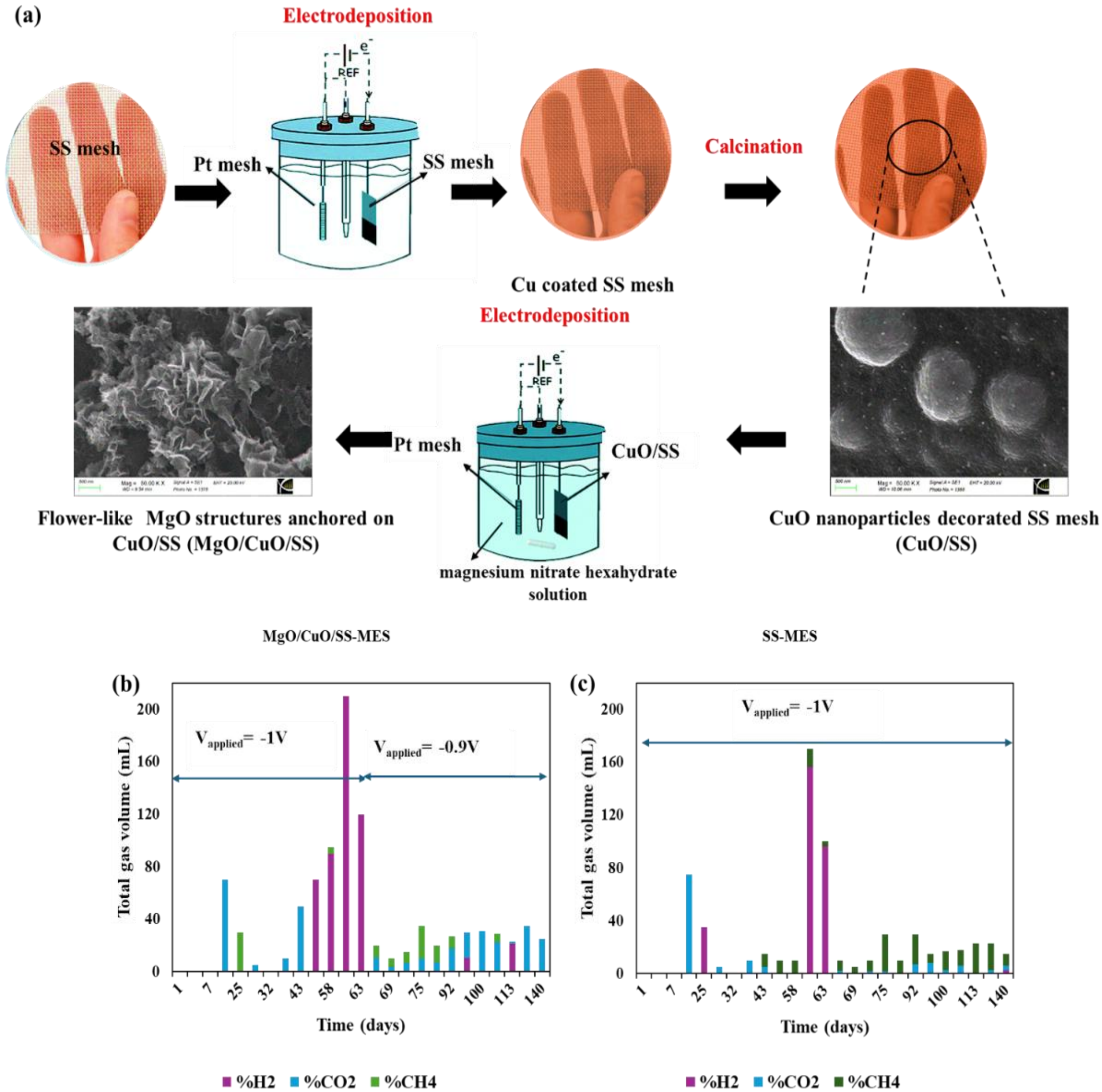

Fig. 1 (a) Schematics of the MgO/CuO/SS composite cathode synthesis procedure; gas composition in MES with (b) MgO/CuO/SS (MES-1) and (c) SS cathode (MES-2), respectively.

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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*Presenting author. skdhill3@ualberta.ca
Presenting author is a Young Water Professional

SESSION 3. GHG EMISSION, CLIMATE RESILIENCE, AND SUSTAINABILITY

Integrating Anaerobic Digestion and Hydrothermal Liquefaction for Sewage Sludge Management: A Techno-Economic Analysis

Harveen Kaur Tatla[1*], Sree Eagalapati[1], M.A. Khan[1], Bipro Ranjan Dhar[2], Rajender Gupta[1]

[1] Department of Chemical and Materials Engineering, University of Alberta, Edmonton, AB, Canada

[2] Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada

Abstract

The growing need for sustainable and economically viable solutions for sewage sludge management has led to the exploration of integrated waste-to-energy systems. This study presents a comprehensive techno-economic analysis (TEA) of three system configurations for processing 1.1 million tons of primary sludge annually, with a focus on evaluating their feasibility, cost-effectiveness, and energy performance. Our findings highlight the complex trade-offs involved in integrating advanced technologies such as hydrothermal liquefaction (HTL), anaerobic digestion (AD), and methanation. While these technologies significantly enhance biomethane yield and create new revenue streams through the production of biocrude and hydrochar, they also introduce higher operational costs due to increased electricity demands and maintenance requirements. Among the evaluated scenarios, the integrated AD-HTL configuration demonstrated the most promising economic performance, achieving the lowest levelized cost of energy (LCOE) at $11.4/GJ. This was primarily due to the diversified income generated from both biocrude and hydrochar, illustrating the value of multi-output strategies in waste-to-energy systems. The results underline how integrating complementary processes can lead to enhanced financial returns while maximizing energy recovery from sludge.

Sensitivity analysis further revealed that optimizing key process parameters, such as biogas and biocrude yields, can significantly reduce the LCOE, suggesting that ongoing refinement and process optimization are critical for economic success. Notably, the inclusion of energy-intensive units like the electrolyzer and HTL reactor points to the pivotal role electricity pricing plays in overall system viability. Consequently, transitioning toward renewable energy sources for power input could be a game-changer, simultaneously reducing costs and boosting sustainability.

Environmental considerations were also integral to the analysis. The emissions profile of each configuration showed that lowering the carbon intensity of electricity is crucial for aligning economic performance with climate objectives. A more sustainable electricity mix would not only improve the environmental footprint but also support the long-term economic resilience of these systems. Therefore, this study demonstrates the potential of integrated AD-HTL systems to serve as both economically viable and environmentally sustainable solutions for large-scale sewage sludge processing.

*Presenting author. htatla@ualberta.ca

SESSION 4. ADVANCED WATER AND WASTEWATER TREATMENT 2

Challenges in the implementation of nanobubbles for wastewater treatment: a bench-scale study

Rasha Maal-Bared*

CDM Smith

Abstract

Utilities are striving to find innovative ways to meet regulatory limits in a more cost-effective and sustainable manner. Nanobubbles (NBs, also known as ultrafine bubbles) are gas-filled cavities with a volume equivalent diameter of less than 1 μm. This allows NBs to be highly stable, have a high surface area-to-volume ratio, high negative zeta potential, low buoyancy, and the ability to generate radicals, which could contribute to physical, chemical and biological water treatment processes. We conducted a two-week study at a wastewater treatment plant in the United States to investigate the impacts of NB on wastewater treatment. Results showed that the only variable that was statistically significantly different by ANOVA between NB and conventional aeration was true color. Results for total COD (tCOD), total suspended solids (TSS) and turbidity were not statistically significantly different between treatments. The impacts of industrial discharge on treatment efficiency were explored, highlighting differences in performance when industrial discharge was received and the challenges associated with NBs implementation without process controls.

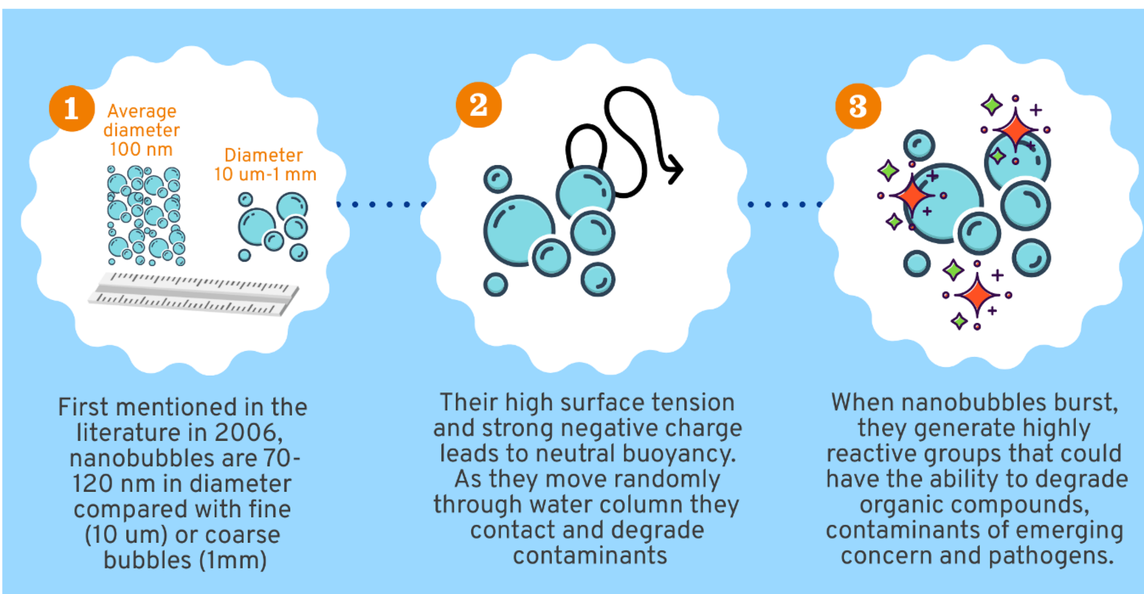
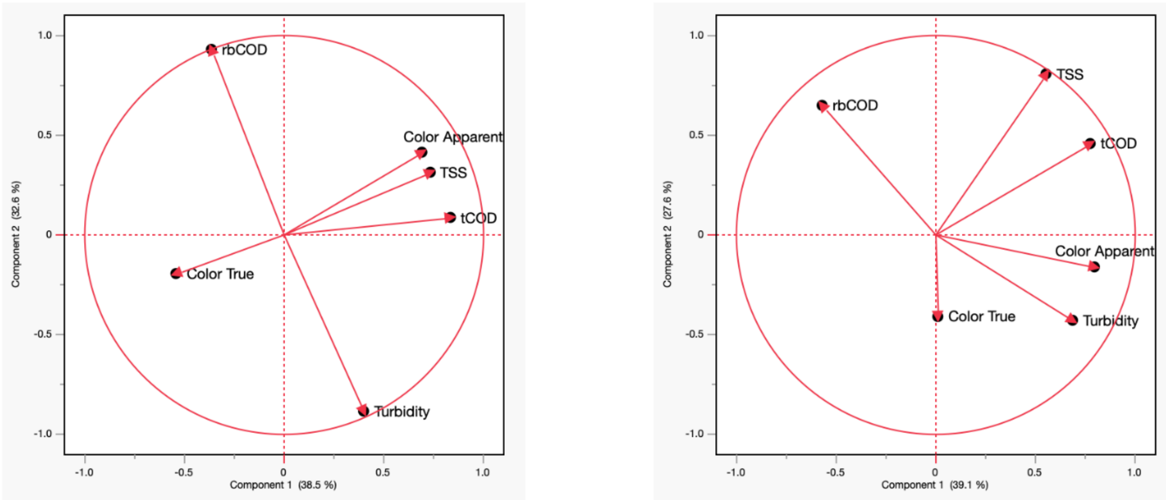


Figure 1. Properties of nanobubbles.



Conventional **Nanobubbles**

Figure 2. Principal Component Analysis for pooled wastewater properties after nanobubble and conventional treatment.

*Presenting author. maalbaredr@cdmsmith.com

SESSION 4. ADVANCED WATER AND WASTEWATER TREATMENT 2

Enhanced dissolved organic matter (DOM) removal in process intensified biofiltration

Adedamola Adesomi Ali*, Ronald W. Thring, Oliver Terna Iorhemen

School of Engineering, University of Northern British Columbia, 3333 University Way, Prince George, BC, V2N 4Z9, Canada.

Abstract

The occurrence of wildfire events results in the runoff of ashes and unburnt carbon into surface water bodies, contributing to increased turbidity, total suspended and dissolved solids, and elevated levels of dissolved organic matter (DOM) in the receiving water bodies. DOM plays a critical role in influencing water quality and ecosystem health, necessitating efficient removal mechanisms in water treatment processes. Process-intensified biofiltration emerges as an innovative solution, offering enhanced DOM removal through optimized operational strategies and advanced design configurations. By leveraging biological processes and engineering advancements, this approach not only improves treatment efficiency but also contributes to sustainable and adaptive water management practices. 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 simulated by amending raw water with 0.5 g/L of bottom ash and increasing the DOC concentration by the addition of sodium acetate and sodium propionate. The simulated wildfire-impacted raw water was pretreated using aeration and a roughing filter.

With a DOC influent concentration of 20 mg/L, the biofilters operated at an empty bed contact time (EBCT) of 15 min, a hydraulic loading rate (HLR) of 2.8 m/h, and temperature ranging between 17 – 21 °C. The biofilters achieved DOC removal efficiencies of up to 65 % (roughing filter), 80 % (sand), 85 % (GAC), and 83 % (sand and GAC) as seen in Figure 1 below.

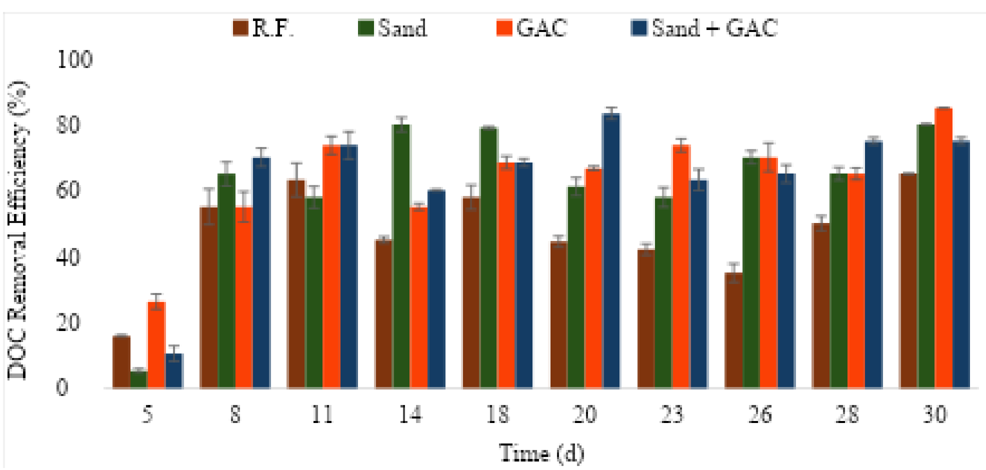


Figure 1:DOC removal in process intensified biofilters

Additionally, turbidity was effectively removed, with the lowest effluent turbidity of 0.64 NTU achieved by the GAC biofilter. The maximum UV absorbance across all biofilters was 0.04 cm^{-1} (92 % transmittance). The findings also indicated a decrease in dissolved oxygen (DO) levels within roughing filter and biofilter effluents, thereby confirming the activity and presence of microorganisms in both the pretreatment and biofiltration systems. The roughing filter was noted to have the highest DO reduction. Alkalinity of the treated water ranged between 289 – 362 mg/L. The results of this investigation demonstrate that GAC media in a biofilter more effectively degrades pollutants. Furthermore, this study shows that process-intensified biofiltration effectively enhances DOM removal, highlighting its potential as a sustainable and efficient water treatment method.

*Presenting author. alia3@unbc.ca

SESSION 4. ADVANCED WATER AND WASTEWATER TREATMENT 2

Algal Bacterial Granular Sludge: Exploring Algae's Role in Extracellular Polymeric Substances and Aerobic Granular Sludge

N. Hosni*, R. Hamza

Department of Civil Engineering, Toronto Metropolitan University, 350 Victoria St, Toronto, ON M5B 2K3.

Abstract

Aerobic Granular Sludge (AGS) systems have emerged as an alternative to Conventional Activated Sludge (CAS) systems by utilizing dense, self-aggregated microbial granules. AGS provides a higher rate of removal of organic matter (85%), nitrogen (59%), ammonia (99%), and phosphorus (80%) in a sequencing batch reactor (SBR) with a multistage cycle of aerobic, anoxic, and anaerobic zones. However, AGS requires substantial airflow and energy consumption, with a 5.4L SBR needing a superficial air velocity (SAV) of typically 1.2-3.2 cm/s for 120 minutes during the aerobic 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). Integrating algae into Aerobic Granular Sludge (AGS) forms an Algal-Bacterial Granular Sludge (ABGS) system, offering opportunities for energy savings and a symbiotic relationship between the algae and bacteria. The algae produce oxygen through photosynthesis for the microbial bacteria's growth while simultaneously capturing the carbon dioxide released by the bacteria.

AGS was cultivated in a Plexiglas column-type SBR at a volume of 4.8 L and a volumetric exchange ratio (VER) of 50%, resulting in an 8-h hydraulic retention time (HRT). The operational cycle lasted four hours and was repeated six times daily, with five sequential phases: influent addition, anaerobic reaction, aerobic reaction, settling, and effluent discharge. Air was introduced from the bottom through a fine air bubble diffuser using an air pump during aeration. An airflow meter was used to control the airflow at about 2.3cm/s with the dissolved oxygen (DO) range of 6-8 mg O_2 L^{-1}. The reactor was fed a synthetic acetate-based wastewater containing the requirements for the growth of microorganisms. After maturation, the algae species *Scenedesmus obliquus* was added with LED lights to create a light-to-dark ratio of 12 hours on/off, providing the environment for algal growth. This research aimed to better understand Extracellular polymeric substance (EPS) secretions during the addition of ABGS when compared to an AGS system.

Analysis was conducted weekly to examine the biomass characteristics of Mixed Liquor Suspended Solids (MLSS), Mixed Liquor Volatile Suspended Solids (MLVSS), and Sludge Volume Index (SVI), following (APHA, 2012). System performance was assessed for Chemical oxygen demand (COD), ammonia, phosphorus, nitrate, and nitrite in 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 and ABGS. Biweekly testing monitored protein and polysaccharide secretions on tightly bound and loosely bound EPS. Preliminary results have shown that the addition of algae enhances the removal of pollutants with a decrease in aeration rate reaching as low as 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.

*Presenting author. nhosni@torontomu.ca

SESSION 4. ADVANCED WATER AND WASTEWATER TREATMENT 2

Effect of initial phosphorus concentration, impregnation type, and media particle size distribution on phosphorus removal efficiency of biofilters using iron hydroxide-activated wood-based media

S, Hamidou[1]*, Y, LeBihan[2], P, Lessard[1]

[1]Department of Civil Engineering and Water Engineering, Université Laval, Pavillon Adrien-Pouliot, 1065 avenue de la Médecine, G1V 0A6, Québec, Québec, Canada
** Investissement Québec, 333 rue Franquet, G1P 4C7, Québec, Québec, Canada

Abstract

In response to regulatory requirements for phosphorus discharge limits, research conducted at Investissement Québec in collaboration with Université Laval has focused on developing a passive treatment system called Techno-P. The system is based on biofiltration units packed with iron hydroxide–impregnated activated lignocellulosic media, designed to enhance sorptive interactions and optimize phosphorus retention. The objective of this study was to evaluate the influence of impregnation type, media particle size distribution, and initial phosphorus concentration on the phosphorus removal efficiency of the Techno-P process.

The experimental setup consisted of 5 biofilters (C1 to C5), each with a one-meter-high packed bed and a diameter of 15 cm, filled with iron hydroxide activated yellow birch wood chips. These filters were operated for 461 days and fed with synthetic wastewater (municipal and industrial) containing various phosphorus concentrations. Biofilters C1, C2, C3, and C5 were initially operated at 5 mg P/L, while C4 received 20 mg P/L until day 347. From day 347 to 461, phosphorus concentration was increased to 100 mg P/L for C1, C2, C3, and C5. For C4, concentrations varied from 200 mg P/L (day 347 - 373) to 150 mg P/L (day 374 - 387), then to 50 mg P/L (day 388 - 461).

Only biofilter C1 contains surface-impregnated media, while the remaining four biofilters were filled with depth-impregnated media. Particle sizes ranged from 2-12.5 mm (C1, C2, C4, C5) to 1-6 mm (C3). All filters were operated under anaerobic conditions and fed via immersion at hydraulic loading rates of 100 and 200 L/m²/day using peristaltic pumps. Precipitate analyses were performed using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX).

The results for phosphorus removal are presented in Figure 1. Phosphorus removal efficiency reached 99.9% in biofilter C2 (depth-impregnated, coarse media), compared to 99.6% in C1 (surface-impregnated, coarse media) and 98.6% in C3 (depth-impregnated, fine media). Although overall efficiencies remained high and stable, a significant difference emerged under high phosphorus loading (100 mg P/L) between C2 and C3, as well as between C1 and C2, indicating the impact of media granulometry and impregnation method under stress conditions. In addition, biofilter C4, which received the highest phosphorus concentrations, exhibited lower removal efficiency (94.0%) compared to biofilter C5 (98.2%) operating under lower phosphorus inputs.

Precipitate analysis revealed the presence of vivianite ($Fe_3(PO_4)_2 \cdot 8H_2O$) in biofilters C1, C2 and C3, and iron phosphate ($FePO_4$) in all biofilters, confirming phosphorus immobilization via mineral formation.

These findings demonstrate that iron hydroxide-activated, wood-based anaerobic biofilters are effective in removing phosphorus from wastewater. They also highlight the influence of media characteristics, phosphorus concentration, and impregnation depth on phosphorus removal performance, particularly under stress conditions, and provide valuable insights for the design and optimization of biofiltration systems in wastewater treatment.

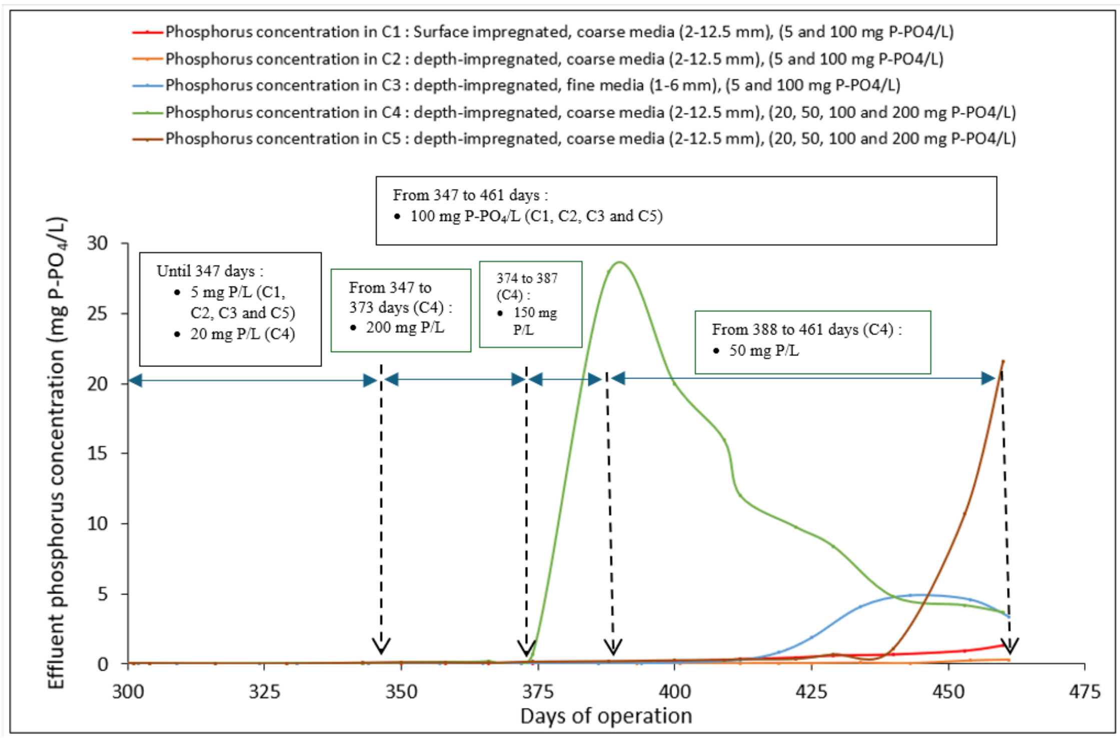


Figure 1: Total phosphorus concentrations in the effluent.

*Presenting author. soureyatou.hamidou.1@ulaval.ca

SESSION 4. ADVANCED WATER AND WASTEWATER TREATMENT 2

Performance Evaluation of textile processing wastewater treatment plant with the retrofit of influent temperature decrease evaluation.

Mohammed Mahfuz Ahmed*[1], Mozakkir azad[2], IMM Serajul Haque[3], Nadim Reza Khandaker[4]
[1]Department of Civil and Environmental Engineering, University of Technology Sydney, Australia.
[2]Department of Environmental Science and Engineering, Jatiya Kabi Kazi Nazrul Islam University, Trishal, Mymensingh-2220, Bangladesh.
[3]Department of civil and environmental engineering, University of Surrey, UK.
[4]Department of Civil Engineering, Bangladesh Army University of Science and Technology, Khulna, Bangladesh.

Abstract

The rapid expansion of Bangladesh's textile dyeing sector has intensified water pollution challenges, necessitating innovative solutions for sustainable wastewater management. This study evaluates the efficacy of effluent treatment plants (ETPs) through a case study at SQ Group, a textile mill in Gazipur, Dhaka, focusing on retrofitting a cooling tower to optimize treatment performance. By analyzing water quality parameters across key processing stages and assessing the cooling tower's impact, the research demonstrated that reducing influent temperature by 8°C enhanced biochemical oxygen demand (BOD) removal efficiency from 75% to 85%, improving dissolved oxygen levels critical for aquatic ecosystems. Additionally, the retrofit reduced monthly energy consumption by 5.6% (from 27,596 kWh to 26,040 kWh), yielding potential annual savings of 18,000 kWh and lowering reliance on non-renewable energy sources (natural gas, coal, and diesel), and thereby curbing CO_2 emissions. Effluent samples post-treatment complied with Bangladesh's Environmental Quality Standards (EQS) for pH, total suspended solids (TSS), and chemical oxygen demand (COD), underscoring the system's alignment with national regulations and ISO 14001 environmental management standards. Despite high upfront costs, the cooling tower proved pivotal in advancing energy efficiency and operational sustainability. The findings highlight that strategic ETP upgrades, coupled with ethical management practices, can mitigate industrial pollution while fostering economic viability. This study provides a replicable framework for reducing ecological footprints in resource-intensive industries, offering actionable insights for policymakers and textile manufacturers to harmonize industrial growth with environmental stewardship in Bangladesh and similar contexts.

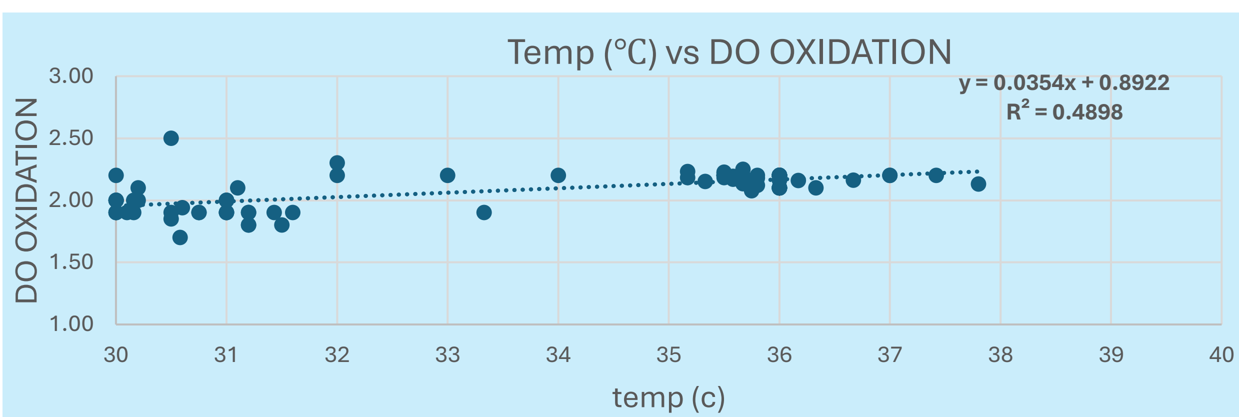
Keywords: Effluent treatment plant (ETP), Cooling tower retrofit, BOD removal, Energy efficiency, Textile wastewater, Sustainable industrial practices.

Edmonton, AB T6G 1H9

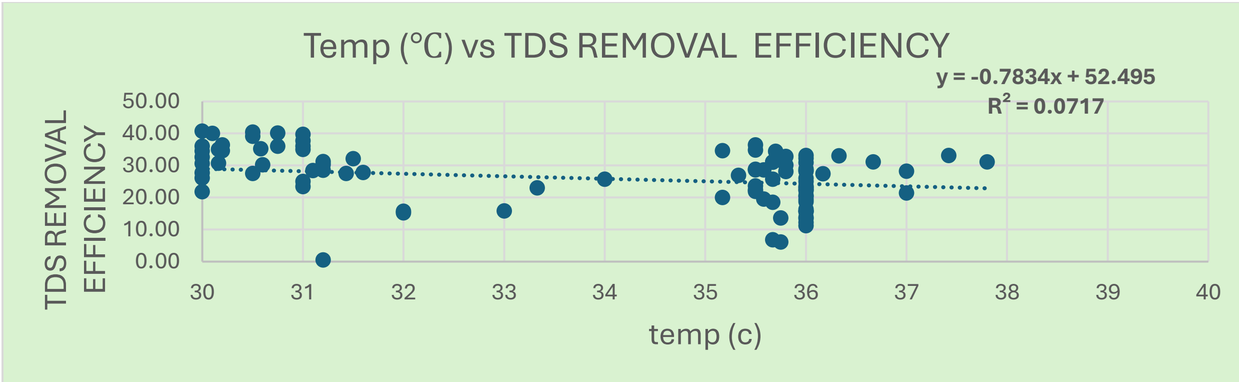
Month	Date	Temp (℃) OXIDATION	DO OXIDATION	TDS REMOVAL EFFICIENCY	TSS REMOVAL EFFICIENCY	COD REMOVAL EFFICIENCY	BOD REMOVAL EFFICIENCY
	1	37.8	2.13	31.16	81.82	83.21	80.21
	2	35.8	2.18	32.87			
	3	35.8	2.20	30.15			
	4	35.7	2.15	34.44	81.82	82.98	67.82
	5	35.8	2.12	28.18			
	6	35.33	2.15	26.97			
	7	36.33	2.10	33.08			
	8	35.67	2.13	31.01	77.78	86.81	81.11
	9	35.75	2.15	6.12			
	10	29.67	2.17	1.77			
	11	35.67	2.18	31.10			
N	12	35.17	2.23	34.62			
O	13	35.75	2.08	13.67	75.00	84.92	78.02
V	14	35.67	2.17	6.79			
E	15	35.5	2.20	34.85			
M	16	35.58	2.17	28.62			
B	17	35.5	2.22	28.84	81.82	76.00	81.25
E	18	35.5	2.23	28.59			
R	19	35.67	2.25	25.77			
	20	35.5	2.18	36.41			
	21	35.5	2.20	21.96			
	22	35.58	2.19	19.53	70.00	77.59	69.32
	23	35.67	2.20	18.57			
	24	35.5	2.20	22.41			
	25	35.5	2.20	23.66			
	26	35.17	2.18	20.05	81.82	82.08	79.05
	27	36	2.16	22.35			
	28	36.17	2.16	27.42			
	29	36.67	2.16	31.16			
	30	37.42	2.20	33.13			

Fig 4.1: Graph between temperature and removal effectiveness month of November

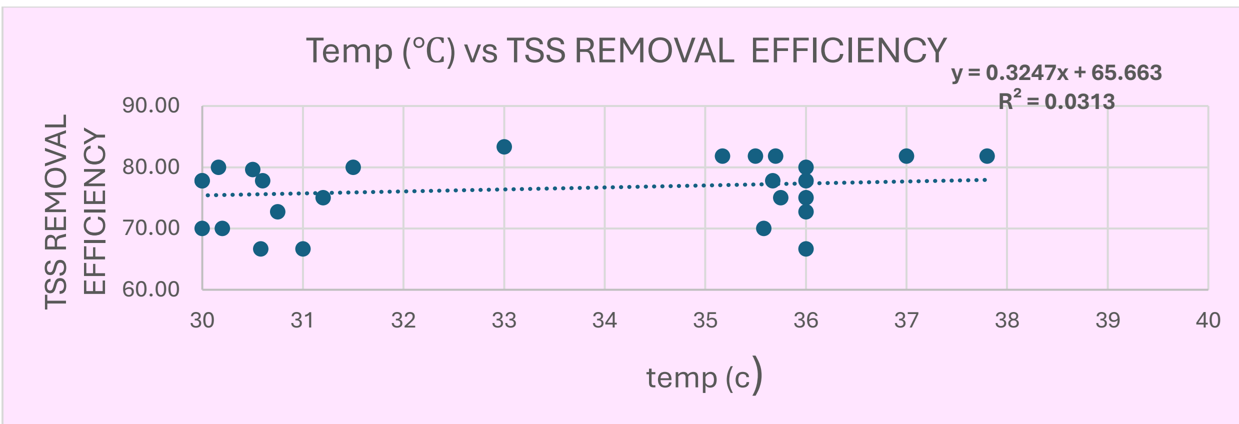
Figure and Table



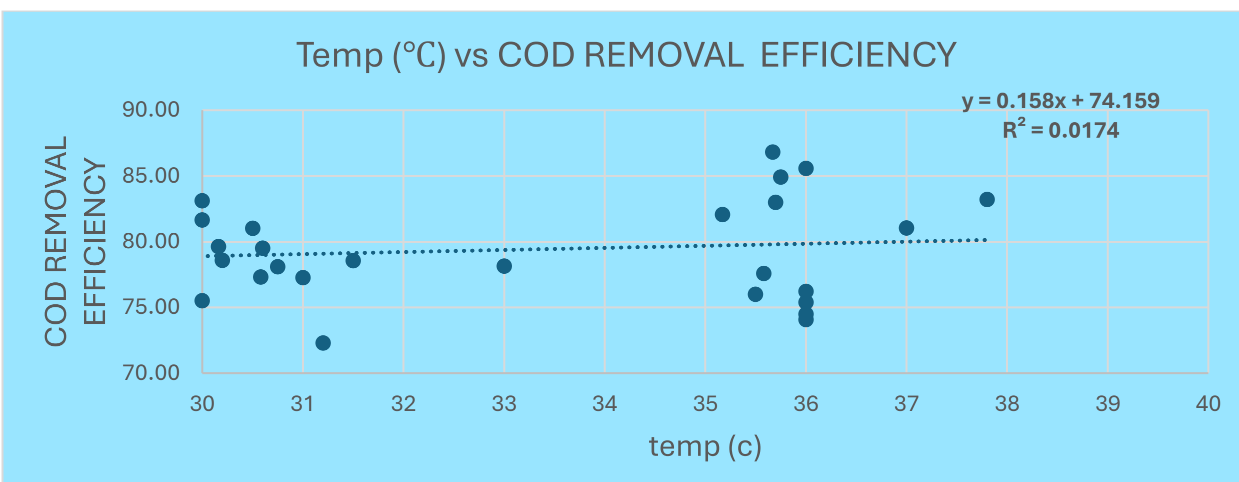
Graph 4.1: Temp (℃) vs. DO OXIDATION



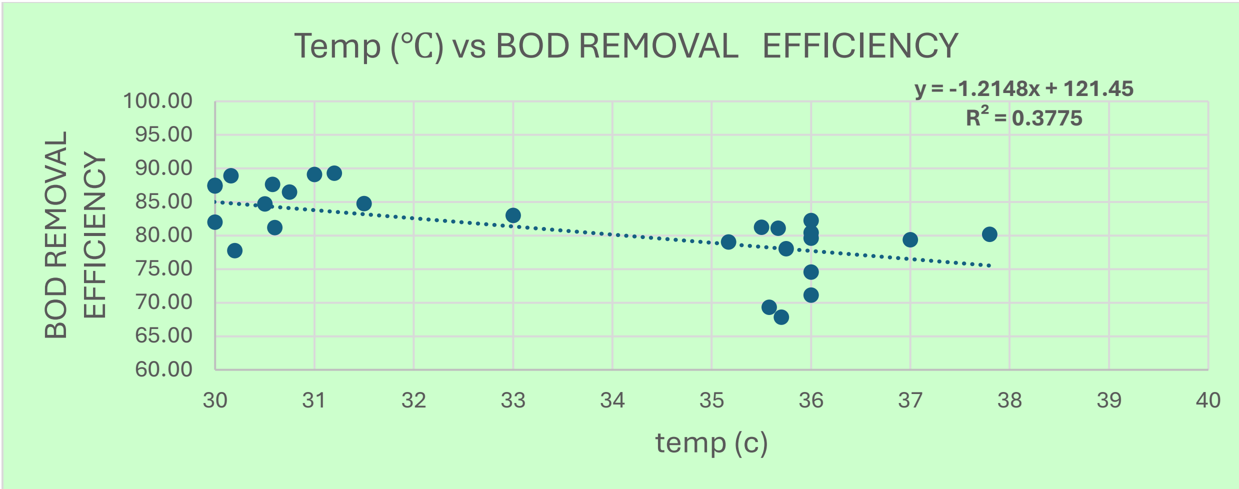
Graph 4.2: Temp (℃) vs TDS REMOVAL EFFICIENCY



Graph 4.3: Temp (℃) vs TSS REMOVAL EFFICIENCY



Graph 4.4: Temp (℃) vs COD REMOVAL EFFICIENCY



Graph 4.5: Temp (℃) vs BOD REMOVAL EFFICIENCY

*Presenting author. engr.md.mahfuzahmed@gmail.com

SESSION 5. CIRCULAR ECONOMY: ENERGY AND RESOURCE RECOVERY

Direct lithium extraction from Canadian oilfield brine

Xiaomeng Wang*[1], Natasha Numedahl[1], Chunqing Jiang[2]

1. Natural Resources Canada, CanmetENERGY Devon
2. Natural Resources Canada, Geological Survey of Canada

Abstract

Lithium, one of the critical and strategic minerals, is often found in elevated concentrations in some of the wastewater streams from oil and gas operations. However, most of these wastewater streams are eventually disposed of in either surface ponds and/or deep underground wells. In Canada, examples of these oilfield wastewater streams are hydraulic fracturing flowback and produced water. The average concentration of lithium in Canadian oilfield brine is about 40 ppm. Extracting lithium from oilfield brine offers a sustainable solution that would promote the efficient use of resources, reduce waste and environmental impacts, enabling the development of a circular economy and reducing the cost of oilfield brine disposal.

Over the years, ionic liquids (ILs) with metal binding functional groups have found applications for liquid-liquid extraction and the separation of metal ions, due to their favorable properties such as negligible vapor pressure, low flammability, and high thermal stability. In this study, we applied IL technology for lithium extraction from hydraulic fracturing flowback water and produced water. Our results show the IL extraction efficiency for a single extraction (1x) is 72 ± 16% on average and the stripping efficiency for a single stripping (1x) is 71 ± 26% (based on 55 trials). The highest single extraction efficiency is 97% when using newly synthesized IL systems. In addition, ILs can be recycled and reused for Li extraction. Thus, overall operational costs can be further reduced. Therefore, extracting lithium using ILs from industrial wastewater offers a sustainable solution that addresses concerns over critical mineral resource scarcity and wastewater management. It is hoped that the oilfield wastewater after Li extraction may be safely released into the environment.

*Presenting author. xiaomeng.wang@nrcan-rncan.gc.ca

Ozone and hydrogen peroxide pretreatment of hydrothermal liquefaction aqueous from municipal sludge for enhanced downstream biological valorization

Nahian Rahman*, Anmol Parajuli, Cigdem Eskicioglu

UBC Bioreactor Technology Group, School of Engineering, The University of British Columbia, Okanagan Campus, 1137 Alumni Avenue, Kelowna, British Columbia V1V 1V7, Canada

Abstract

Wastewater sludge, the primary byproduct of water resource recovery facilities (WRRFs), poses challenges, due to its high volume and contaminants including per- and poly-fluoroalkyl substances, metals, pathogens and microplastics. Anaerobic digestion (AD) is the common sludge treatment method. However, it presents limitations, including extended retention period (20 days), large bioreactors, and high biosolids (~50%) requiring final disposal. Hydrothermal liquefaction (HTL) offers a compact alternative to AD by converting sludge to biocrude oil at high temperatures (250–400°C) and pressures (4–22 MPa), efficiently destroying pollutants. However, around 80% of HTL byproduct is an aqueous phase (HTL_{aq}), containing recoverable resources (C, N) and recalcitrant compounds inhibiting its downstream biological treatment. The lack of treatment option for HTL_{aq} is the bottleneck for implementing HTL.

This study explored hydrogen peroxide (H_2O_2), and ozone (O_3) pretreatment of HTL_{aq} to detoxify and improve its biodegradability. Chemical oxygen demand (COD), total phenolics, volatile fatty acids (VFA), total ammonium nitrogen, N-heterocyclics, etc. were measured to optimize pretreatment before biodegradability assessments via biochemical methane potential (BMP) and biochemical oxygen demand (BOD) assays. The HTL of dewatered sludge (20% total solids) was conducted using 1-L Parr® 4570 reactor at 350°C/168 bar/15 minutes to maximize production. Sludge combined primary and secondary sludges at 50:50% by vl. from a local WRRF. Aerobic and anaerobic inocula were obtained from the from the same plant. After HTL reactor cooled down, HTL_{aq} was obtained and filtered via 0.45 µm membrane.

Pretreatment at dosages of 0.25, 0.50, and 0.75 g H_2O_2/g COD of HTL_{aq} followed quenching with Na_2CO_3 to eliminate residual H_2O_2. The highest COD removal (18%) occurred with 0.75 g H_2O_2/g COD, while the 0.25 g H_2O_2/g COD with Na_2CO_3 quencher showed 27% removal of N-heterocyclics. The lowest dosage (0.25 g H_2O_2/g COD) with Na_2CO_3 resulted in 63% and 16% increases in cumulative methane yield under thermophilic and mesophilic conditions compared to non-pretreated HTL_{aq} (Figure 1a). The aerobic biodegradability index (BOD/COD ratio) also increased from 0.75 to 0.85.

Ozone pretreatment was more effective than H_2O_2. In the dissolved ozone range of 0.03 0.18 g O_3/g COD, the highest dose (0.18 g O_3/g COD) resulted in 43% COD reduction, 72% removal of total phenolics, and 69% removal of N-heterocyclics, while preserving VFA. The optimal ozone doses were identified as 0.14 g O_3/g COD for AD and 0.18 g O_3/g COD for aerobic treatment. At 0.14 g O_3/g

COD, pretreatment enhanced specific cumulative methane yields by 98% and 89% improvement under mesophilic and thermophilic conditions (Figure 1b). The dose of 0.18 g O_3/g COD increased the aerobic biodegradability index by 90%.

Across both pretreatments, the improvement of the biodegradability index is ranked as aerobic > mesophilic anaerobic > thermophilic anaerobic. Future studies should focus on verification of the ozone pretreatment improvements for HTLaq from sludge under continuously-flow HTL and AD operation.

*Presenting author. pro1910nahin@gmail.com

SESSION 5. CIRCULAR ECONOMY: ENERGY AND RESOURCE RECOVERY

Enhancing Methane Production from Municipal Sewage Sludge by Combining Hydrothermal Pretreatment with a Novel Bioaugmentation Technology

Meagan Morrow [1*], Abir Hamze[1], Elsayed Elbeshbishy[1]

[1] Department of Civil Engineering, Toronto Metropolitan University, 350 Victoria Street, Toronto, ON M5B2K3, Canada

Abstract

Anaerobic digestion (AD) is a biological process where microorganisms, in a contained system without oxygen, degrade organic material to produce methane-rich biogas. The biogas can be utilized as electricity, heat, or fuel. This is a viable process for converting municipal sewage sludge into biogas. The wastewater treatment process generates large quantities of municipal sewage sludge, especially in large-scale facilities. AD offers a pathway to manage and valorise this resource. However, AD of raw municipal sewage sludge without pretreatment, due to the large and complex macromolecules present in the raw feedstock, results in low biodegradation and low biogas yields.

This study has evaluated a novel pretreatment approach. This approach combines hydrothermal pretreatment (HTP) with bioaugmentation technology. The bioaugmentation technology applied is the Ydro Process®, which is owned by Hydrotech Environmental L.P. and Tradeworks Environmental Inc., located in Mississauga, ON, Canada. This research evaluates the biochemical methane potential (BMP) of municipal sewage sludge subjected to the following conditions: hydrothermal pretreatment at 70°C (HTP 70) and 170°C (HTP 170), YDRO (standalone), and combinations of YDRO with HTP 70 and HTP 170. BMP assay tests were conducted in triplicates under mesophilic conditions. This study gathered insights on cumulative biogas and methane production, feedstock biodegradability, and the impact of pretreatment conditions on viscosity, solubilization, foaming propensity, and extracellular polymeric substances (EPS).

The results indicate that pretreatment with YDRO in combination with HTP 170 resulted in the highest cumulative biogas production (1108 mL), the highest methane yield of 257 mL/g COD added, and highest biodegradability of 67%. This condition also achieved the highest degree of solubilization.

The study also explores the impact of novel pretreatment methods on extracellular polymeric substances (EPS) in municipal sewage sludge. EPS components, including proteins and polysaccharides, were measured for soluble (S-EPS), loosely bound (LB-EPS), and tightly bound (TB-EPS) fractions. Compared to the raw feedstock, YDRO in combination with HTP 170 released the largest quantity of S-EPS (178% increase) by reducing the fractions of LB-EPS and TB-EPS. HTP 170 performed secondly (142% increase in S-EPS), followed by YDRO alone (71% increase in S-EPS). This suggests that YDRO alone surpasses HTP 70 in terms of releasing S-EPS from LB-EPS and TB-EPS fractions.

Based on these findings, future full-scale applications of YDRO in combination with hydrothermal pretreatment could enhance biogas recovery from municipal sewage sludge. Further research could investigate long-term process stability and economic feasibility under continuous operation.

*Presenting author. meagan.morrow@torontomu.ca

SESSION 5. CIRCULAR ECONOMY: ENERGY AND RESOURCE RECOVERY

Optimization of curdlan biosynthesis in the granule matrix during wastewater treatment in aerobic granular sludge systems

Adedoyin Adekunle*, Resty Nabaterega, Oliver Terna Iorhemen

School of Engineering, University of Northern British Columbia, 3333 University Way, Prince George, BC, V2N 4Z9, Canada

Background

Curdlan, an insoluble linear microbial exopolysaccharide, has numerous applications including food additive, stabilizer, thickening agent, and some of its derivatives serve as drug delivery polymer (Yang et al., 2016). However, the low conversion rate of glucose in curdlan production increases its overall production costs (Yuan et al., 2021). Considering the increasing areas of application of curdlan, it is inevitable for its demand to rise. Currently, the global market value of curdlan is over 37 million US dollars, which is projected to grow to 57 million US dollars by 2030 at a of 7.3% during the forecast period (QY Research, 2024). Therefore, an imperative need to recover curdlan from low-cost waste sources such as waste granules from aerobic granular sludge (AGS) wastewater systems. AGS biotechnology, which has been extensively studied for wastewater treatment over the past two decades, has the potential for curdlan recovery. However, due to minimal research on this, issues regarding recovery techniques, quantification, optimization of production, and large-scale applications remain subjects of concern.

Objective

This research aimed to optimize the biosynthesis of curdlan in aerobic granule matrix while maintaining efficient wastewater treatment in AGS-based wastewater treatment systems.

Methodology

In this study, 9 experimental runs (Table 1) were conducted to study the impact of carbon-to-nitrogen (C/N) ratio (carbon measured as chemical oxygen demand – COD), feeding strategy, and organic loading rate (OLR) on treatment efficiency and curdlan biosynthesis AGS systems.

Results and discussion

The COD removal efficiency was promising, exceeding 91% in all runs. Phosphorus and ammonia-N removal efficiencies were mostly high, reaching up to 96% and 100%, respectively. Among the nine runs (Table 1), R3 (C/N - 10, 30 min feeding/30 min resting, OLR-2.1 kg COD/m³·d) and R4 (C/N - 30, 10 min pulse feeding/50 min resting, OLR-2.1 kg COD/m³·d) showed the most promising results, with curdlan yields of 74 and 69 mg curdlan/g biomass after 30 d, respectively (Figure 1). The high OLR (2.1 kg COD/m³·d) favoured higher curdlan yields in these reactors.

Table 1: Combinations of experimental factors for each run

Experimental Runs	C/N ratio	Feeding strategy	OLR – kg COD/m³·d
R1	20	60 min feeding	2.1
R2	30	60 min feeding	1.5
R3	10	30 min feeding; 30 min resting phase	2.1
R4	30	10 min pulse feeding; 50 min resting phase	2.1
R5	10	10 min pulse feeding; 50 min resting phase	1.5
R6	20	30 min feeding; 30 min resting phase	1.5
R7	10	60 min feeding	0.8
R8	20	10 min pulse feeding; 50 min resting phase	0.8
R9	30	30 min feeding; 30 min resting phase	0.8

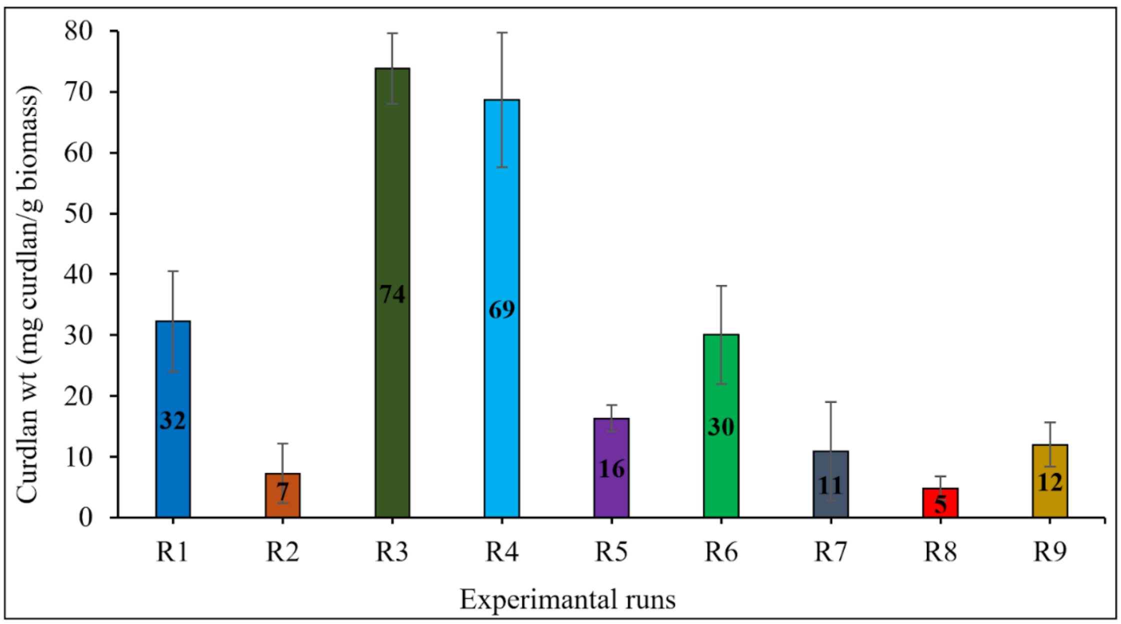


Figure 1: Curdlan gel extracted from AGS biomass on day 30 for the 9 experimental runs.

R1 (C/N-20, 60 min feeding, OLR-2.1 kg COD/m³·d); R2 (C/N-30, 60 min feeding, OLR-1.5 kg COD/m³·d); R3 (C/N-10, 30 min feeding/30 min resting, OLR-2.1 kg COD/m³·d); R4 (C/N-30, 10 min pulse feeding/50 min resting, OLR-2.1 kg COD/m³·d); R5 (C/N-10, 10 min pulse feeding/50 min resting, OLR-1.5 kg COD/m³·d); R6 (C/N-20, 30 min feeding/30 min resting, OLR-1.5 kg COD/m³·d); R7 (C/N-10; 60 min feeding, OLR-0.8 kg COD/m³·d); R8 (C/N-20; 10 min pulse feeding/50 min resting, OLR-0.8 kg COD/m³·d); R9 (C/N-30; 30 min feeding/30 min resting, OLR-0.8 kg COD/m³·d).

Pearson correlation analysis revealed a significant positive correlation between OLR and curdlan recovery, while no correlation was observed between C/N ratio, feeding strategy, and curdlan production. Mean effect analysis revealed that 2.1 kg COD/m³·d OLR, C/N ratio of 10, and feeding strategy of 30 min feeding/30 min resting phase were the optimal levels for curdlan production in this study.

Conclusions and recommendations

This study provides valuable insights into the impact of selected factors on curdlan biosynthesis and recovery from AGS biosolids. These findings may enhance the sustainability of AGS treatment technology in the wastewater industry and create opportunities for curdlan recovery from wastewater treatment systems. However, more research on the purification and quantification of curdlan extract using suitable characterization methods such as chemical composition analysis, molecular weight determination, and thermal gel formation properties is recommended. Additionally, since the current study was conducted using synthetic municipal wastewater in a controlled laboratory environment, future research should confirm the findings using real wastewater from industrial or municipal sources.

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SESSION 5. CIRCULAR ECONOMY: ENERGY AND RESOURCE RECOVERY

Enhanced treatment of rice-washing wastewater and bioelectricity production in microbial fuel cells with ethanol supplementation

Kharisrama Trihatmoko*, Takahiro Watari**, Thu Huong Nguyen***, David Simpson****, Mami Kainuma*****, Masashi Hatamoto******, Takashi Yamaguchi*******

* Department of Science of Technology Innovation, Nagaoka University of Technology, Niigata 940-2188, Japan, s215001@stn.nagaokaut.ac.jp

** Department of Civil and Environmental Engineering, Nagaoka University of Technology, Niigata 940-2188, Japan, watari@vos.nagaokaut.ac.jp

*** Graduate School of Engineering, Kyoto University, Kyoto 615-8540, Japan, huongnguyen.thu1030@gmail.com

**** Watasumi Co., Ltd., Okinawa 904-0495, Japan, david@watasumi.com

***** Biological Systems Unit, Okinawa Institute of Science and Technology, Okinawa 904-0495, Japan, mami.kainuma@oist.jp

****** Department of Civil and Environmental Engineering, Nagaoka University of Technology, Niigata 940-2188, Japan, hatamoto@vos.nagaokaut.ac.jp

******* Department of Science of Technology Innovation/Department of Civil and Environmental Engineering, Nagaoka University of Technology, Niigata 940-2188, Japan, ecoya@vos.nagaokaut.ac.jp

Background

Rice-washing wastewater (RWW) remains an underutilized resource for bioelectricity generation via microbial fuel cells (MFCs). However, its high chemical oxygen demand (COD) (2,000 to 13,000 mg·L^{-1}) can inhibit MFC performance by suppressing exoelectrogens' growth. Ethanol has emerged as a promising additive to promote exoelectrogenic activity, though excessive concentrations may exert toxic effects on microbial communities (Paz-Mireles, 2019).

Objectives

This study investigated the influence of ethanol concentration and varying COD levels on the performance of starch-based wastewater in MFCs, aiming to gain insights into effective conditions for industrial-scale applications.

Methodology

Batch treatments of RWW were conducted using six single-chamber air-cathode microbial fuel cells (SCAC-MFCs), labelled R1 to R6. Prior studies have demonstrated that 0.07% ethanol supplementation can improve MFC, yet its effectivity for enhancing RWW treatment remains unclear (Pan, 2017). Based on these findings, R1, R2, and R3 were operated at a COD of 2,900 mg·L^{-1} with ethanol concentrations of 0%, 0.07%, and 0.15% (v/v), respectively. Additionally, R4, R5, and R6 were operated at a higher COD of 8,000 mg·L^{-1} with the same ethanol concentrations to assess performance under concentrated conditions (Lóránt, 2021). All experiments were conducted in duplicate over 34 days at 25°C with an external resistance of 1,000 Ω. Prior to the experiments, each SCAC-MFC was inoculated with 100 mL of anaerobic sludge and 100 mL of RWW, followed by a 30-day acclimation period.

Results and discussion

After 34 days, R2 (0.07% ethanol, moderate COD) achieved the highest COD removal efficiency (89%), consistent with previous findings (Pan, 2017). In contrast, R5—operated at the same ethanol concentration but with higher initial COD—achieved lower organic removal (80%), along with a higher ethanol degradation rate (177.8 mgCOD·L^{-1}·d^{-1}) and increased methane production (6.0 mgCODmethane·$gCODremoved^{-1}$). Microbial analysis revealed a 2.5-fold increase in *Clostridium sensu stricto* 1 (exoelectrogens) in R2, while R5 exhibited a 2.3-fold increase in *Methanosaeta* (acetoclastic methanogens). These findings suggest that 0.07% ethanol effectively promotes exoelectrogenic activity for enhanced organic removal in SCAC-MFCs treating RWW. However, under elevated COD conditions, methanogens appear to outcompete exoelectrogens for ethanol, shifting the metabolic pathway towards methanogenesis. Despite this, R5 recorded the highest power density (879.05 mW·m^{-2}), indicating that moderate ethanol supplementation also has potential to enhance both organic removal and energy recovery under high-strength wastewater conditions.

Conclusion

This study demonstrated that ethanol supplementation significantly influences organic removal and bioelectricity generation in SCAC-MFCs treating rice-washing wastewater (RWW). At moderate COD (2,900 mg·L^{-1}), 0.07% ethanol enhanced exoelectrogenic activity (*Clostridium sensu stricto* 1), leading to the highest COD removal. However, under high COD conditions (8,000 mg·L^{-1}), methanogens (*Methanosaeta*) became dominant, reducing treatment efficiency and redirecting ethanol metabolism toward methane production.

Recommendations

For industrial applications involving high-strength wastewater, integrating an ethanol fermentation pretreatment capable of continuously supplying low-dose ethanol may mitigate ethanol depletion by methanogens and enhance both treatment efficiency and energy recovery in MFC systems.

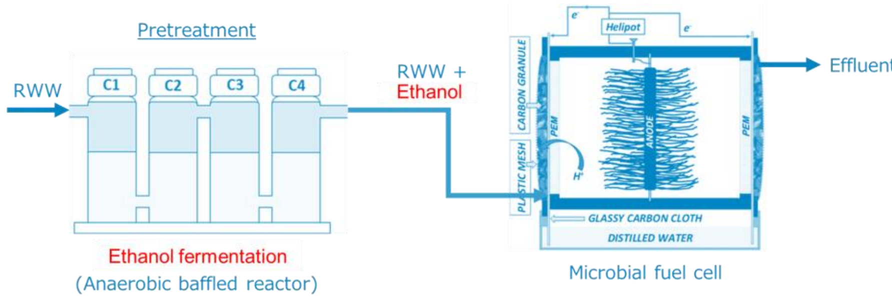

Fig. 1. Recommended process

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*Presenting author. s215001@stn.nagaokaut.ac.jp

SESSION 5. CIRCULAR ECONOMY: ENERGY AND RESOURCE RECOVERY

Boosting Biogas Production and Phosphorus Recovery in Anaerobic Digestion using Nanobubbles

Anqi Mou*, Tae Hyun Chung, Anindya Amal Chakrabarty, Samiullah, Bipro Ranjan Dhar

Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, T6G 1H9, Canada.

Abstract

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 N_2-NBW (0 (control), 20 (NB1), 30 (NB2), 40 (NB3), and 50% (NB4), expressed as $L_{NBW}/L_{working\ volume}$) 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) 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.

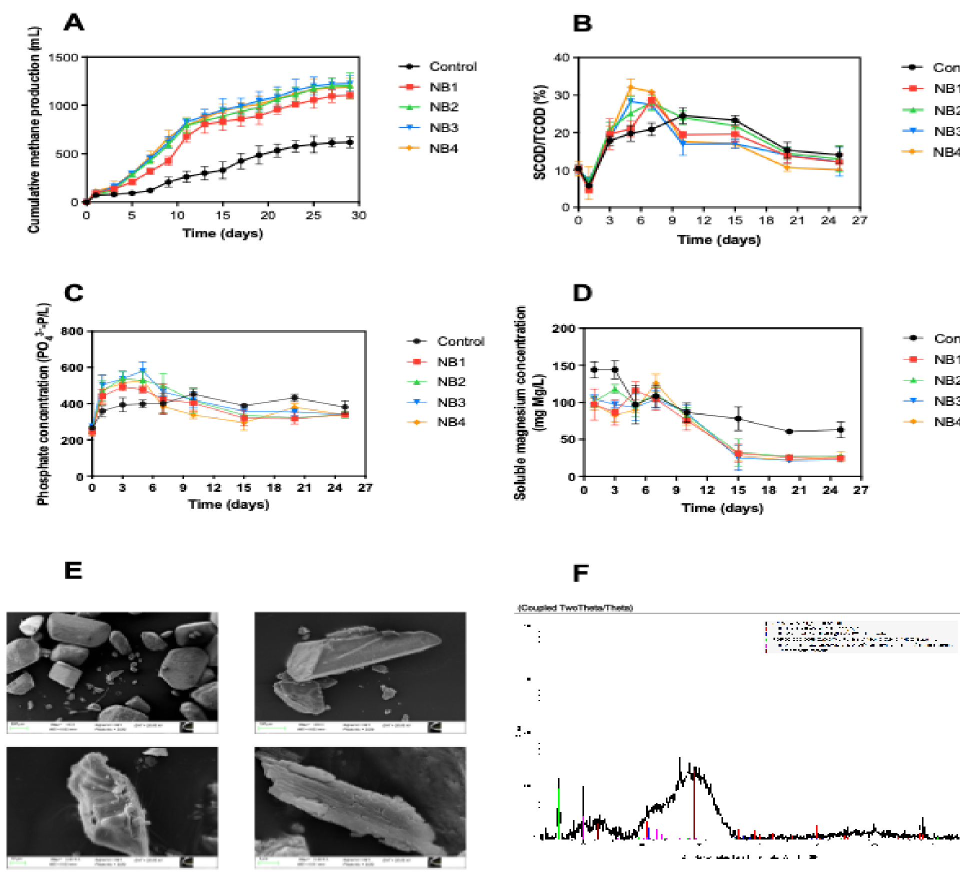

Fig. 1. Effect of different volumes of N_2-NBW supplementation on AD performance: (**A**) cumulative methane production, (**B**) SCOD/TCOD ratios, (**C**) soluble phosphate concentrations, and (**D**) soluble magnesium concentrations. Struvite characteristics are shown in (**E**) SEM images and (**F**) XRD patterns of the formed crystals.

*Presenting author. mou@ualberta.ca.

SESSION 6. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 2

Vacuum-Driven Intensification of Anaerobic Digestion vs. Thermal Hydrolysis Process: Ammonia Recovery and Enhanced Toxicity Resilience

Ali Khadir*, Eunkyung Jang[2], Domenico Santoro[2], John Walton[2], Ahmed Al-Omari[3], Christopher Muller[3], Katherine Y. Bell[4], Wayne Parker[5], George Nakhla[1]

1. Western University, London, Ontario, Canada
2. USP Technologies, London, Ontario, Canada
3. Brown and Caldwell, Andover, MA, USA
4. Brown and Caldwell, Nashville, TN, USA
5. University of Waterloo, Waterloo, Ontario, Canada

Abstract

Conventional anaerobic digesters (AD) are limited to low OLR and ammonia toxicity [1]. While AD intensification technologies like thermal hydrolysis can boost digester loading and methane production, high ammonia concentrations pose challenges due to long acclimatization times and potential toxicity to methanogens. The IntensiCarb™ (IC) system, which employs an ex-situ vacuum for liquid–solid separation, and recovers ammonia in the condensate without pH adjustment, as well as intensifies AD, has the potential to be a significant game-changer (Figure 1a). This study aims to assess the capability of IC to handle high OLR (6 times that of conventional AD) and examine its role in ammonia toxicity mitigation and recovery, while also comparing the resistance of IC biomass to that of conventional AD.

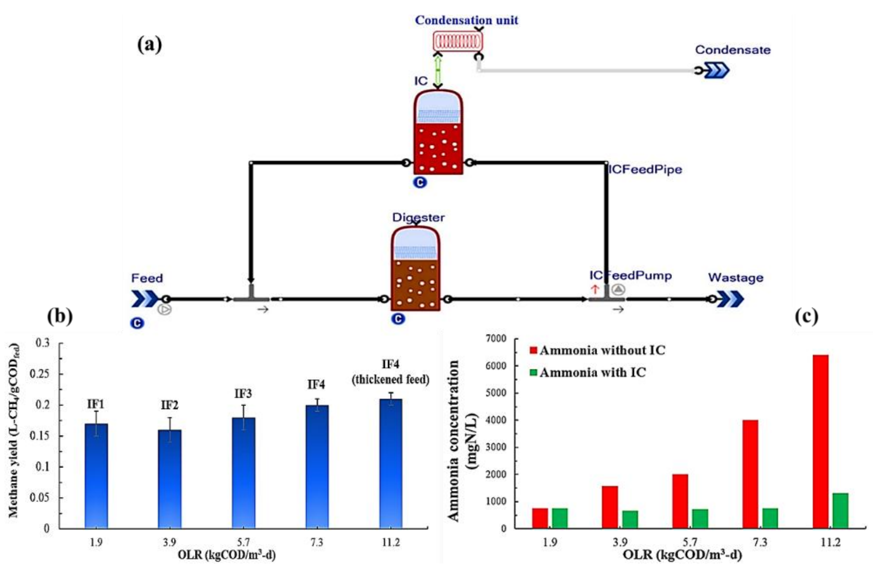

Figure 1. IC-technology Sidestream (a), methane yield (b) and ammonia concentration (c).

MATERIALS AND METHODS

Lab-scale completely mixed mesophilic anaerobic digesters (1.8 L working volume) and a vacuum rotary evaporation unit (Ecodyst, USA). Feed was 50/50 (v/v) of primary sludge and thickened waste-activated sludge from the Greenway wastewater treatment plant (London, ON) with following characteristics: TCOD=39.4 g/L, TKN=2.1 gN/L, ammonia=300 mgN/L, TS=3.4% and VS=2.6%. The operational conditions are listed in Table 1. Although SRT was 20 d in all digesters, HRT varied within 5-20 d. Intensifaction factor, F, is equal to SRT/HRT. The ammonia recovery in the IC was achieved with the evaporation unit.

Table 1 Steady-state performance of the digesters

	Unit	IF1	IF2	IF3	IF4	IF4 (thickened feed)
HRT	**d**	20	10	6.7	5	5
SRT	**d**	20	20	20	20	20
OLR	**kgCOD/m^3-d**	1.70 ± 0.3	3.47 ± 0.6	5.1 ± 0.8	7.3 ±0.8	11.3 ± 1.1
Daily condensate	**mL**	0	90	182	270	270
Daily waste	**mL**	90	90	90	90	90

RESULTS AND DISCUSSION

Figure 1b shows the steady-state methane yield for the 5 reactors operated at OLR of 1.9 to 11.2 kgCOD/m^3-d. Methane yield varied within 0.17-0.20 L-CH_4/gCOD$_{fed}$ (45%-50% COD removal), indicating that IC technology allowed processing 6 times the OLR of a conventional AD. The stable operation of the IC is attributed to (i) methanogenic community shift and (ii) mitigation of ammonia toxicity and recovery. Microbial analysis revealed that in the control reactor, *Methanosaeta* (low growth rate and Monod half-saturation concentration) was dominant, whereas the faster-growing *Methanosarcinaceae* was dominant in the IC. Figure 1c shows the comparison between the theoretical and the measured digestate ammonia concentrations. At OLR > 7.3 kgCOD/m^3-d, theoretical ammonia concentrations exceed 4,000 mgN/L, well above inhibition levels. IC recovers 43%-46% of total digester influent TKN fed as ammonia in a clean solution, maintain the ammonia concentration at low levels. Ammonia batch inhibition tests showed K_i value for IC (5.6 gN/L) was three times higher than for conventional digester (1.9 gN/L), attributed to methanogens community.

CONCLUSIONS

Ammonia recovery and enrichment of *Methanosarcina* allowed 6 times OLR of conventional digesters, significantly reducing digester volumes, enhances digester stability, and recovers ammonia.

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*Presenting author. akhadir@uwo.ca

Session 6. Emerging Contaminants: Fate, Transport and Mitigation 2

Novel green fabrication of stable hydrogel beads from industrial waste lignin for efficient Pb (II) ion removal

Xiwen Hu,[ab] Muhammad Amirul Islam,*[ab] Aria Khalili,[ab] Amir Aghaei,[ab] Jae-Young Cho[b] and Mohtada Sadrzadeh *[a]

a Department of Mechanical Engineering, 10-367 Donadeo Innovation Center for Engineering, Advanced Water Research Lab (AWRL), University of Alberta, Edmonton, AB, T6G 1H9, Canada. E-mail: sadrzade@ualberta.ca; maislam@ualberta.ca

b Quantum and Nanotechnologies Research Centre, National Research Council Canada, 11421 Saskatchewan Drive, Edmonton, AB, T6G 2M9, Canada.

Abstract

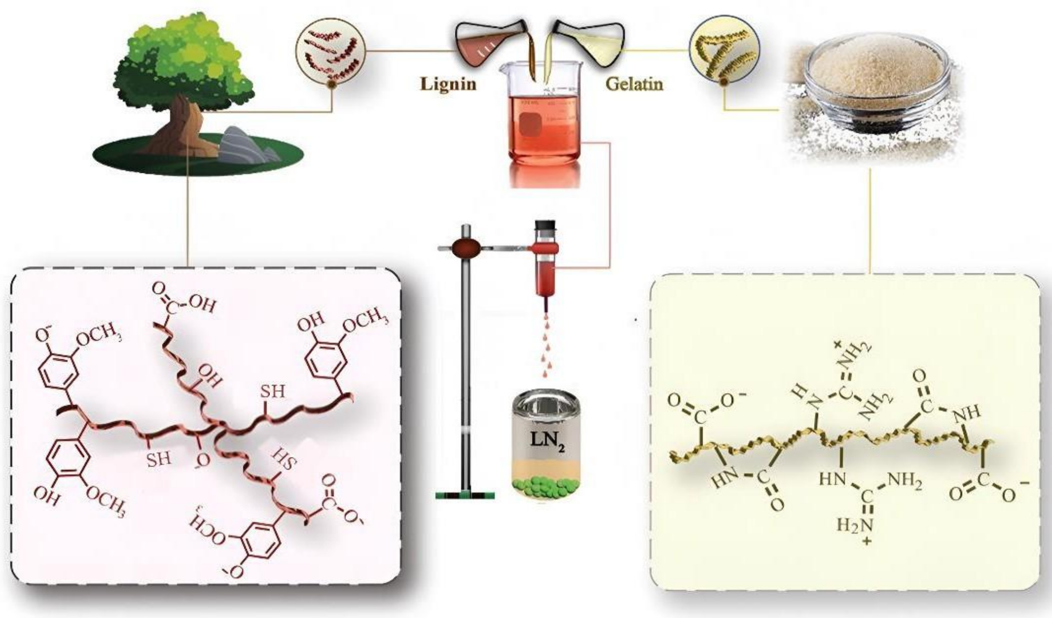
The increasing levels of toxic lead (Pb) contamination in aquatic systems—originating from battery waste, industrial effluents, aging infrastructure, and mining activities—pose serious risks to both environmental and human health. Pb(II) ions are associated with neurological, developmental, and organ damage. Among various treatment methods, adsorption stands out for its efficiency, cost-effectiveness, minimal energy requirements, and lack of harmful byproducts. This study aims to develop a sustainable, high-performance adsorbent for Pb(II) removal using biopolymer hydrogel beads composed of gelatin (GE) and sulfur-rich kraft lignin (SKL)—a chemically and thermally stable byproduct of the pulp and paper industry. SKL's rich functional groups (–OH, –COOH, –SH, $-OCH_3$) enable strong coordination and electrostatic interactions with metal ions, while GE provides a biocompatible, moldable matrix with high surface area and reactive sites.

We implemented an eco-friendly fabrication process using liquid nitrogen (LN_2) for rapid droplet freezing, overcoming the limitations of traditional slow or non-green gelation methods. This approach allows bead formation from low-viscosity biopolymer solutions with tunable SKL-to-GE ratios. LN_2-induced quenching forms beads with a dense outer skin and highly porous core, created by internal ice crystal formation and Marangoni flow effects—enhancing both structural stability and metal ion accessibility.

The optimal composition achieved a Pb(II) adsorption capacity of 155 mg g^{-1}—3.5 times higher than that of GE-only beads, which disintegrated after three cycles. The SKLGE beads retained structural integrity over ten adsorption–regeneration cycles under both acidic and basic conditions. A 0.1 g bead dosage removed 96% of Pb(II) from a 50 mL solution at 100 mg L^{-1}. Additionally, crosslinking with 1 mM EDC increased the adsorption capacity by 32% and improved long-term stability without introducing toxic reagents. Cryo-SEM characterization confirmed the impact of rapid freezing and swelling–deswelling behavior on porosity and skin morphology.

These results highlight the synergistic effect of SKL incorporation and EDC crosslinking in creating robust, reusable hydrogel beads. The fabrication process is rapid, scalable, and compatible

with low-concentration polymer solutions, offering a green and cost-effective route for wastewater remediation. By repurposing industrial byproducts, this work contributes to circular economy goals. Future work will explore adsorption performance for other toxic metal ions, assess real wastewater conditions, and optimize column-based systems for continuous water treatment.



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*Presenting author. xh1@ualberta.ca

SESSION 6. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 2

Using Biochar and Granular Activated Carbon to Counteract Nanoplastics in Sludge Dark Fermentation

Monisha Alam*, Simran Kaur Dhillon, Sherif Ismail, Bipro Ranjan Dhar

Department of Civil and Environmental Engineering, University of Alberta, Edmonton,

AB T6G 1H9, Canada

Background:
Dark fermentative hydrogen production is a promising pathway for sustainable energy recovery from municipal sewage sludge [1,2]. However, the presence of emerging pollutants such as polystyrene nanoplastics (PsNPs) in sludge poses a significant barrier by inducing oxidative stress [3,4] and inhibiting microbial activity [5]. These challenges compromise hydrogen yields and the overall efficiency of anaerobic processes [3].

Objectives:
This study aimed to evaluate and compare the efficacy of two carbonaceous materials: biochar (BC) and granular activated carbon (GAC) - in enhancing biohydrogen production during the dark fermentation of wastewater sludge, both in the presence and absence of PsNPs. It also sought to understand their impact on microbial communities, reactive oxygen species (ROS) generation, and sludge toxicity, along with sludge dewaterability.

Methodology:
Batch experiments were conducted using primary sludge as the substrate and a pretreated sludge mixture of digested and fermented primary sludge as the inoculum. PsNPs were added at 0.3 mg/L to simulate contamination, while BC and GAC were tested at 5 g/L and 10 g/L dosages. Hydrogen generation was monitored over 9 days. Analytical parameters included volatile fatty acid (VFA) profiles via high performance liquid chromatography (HPLC), ROS quantification through fluorescence assays, sludge toxicity using Microtox® tests, microbial community analysis through 16S rRNA sequencing, and sludge dewaterability using capillary suction time (CST).

Results:
The cumulative biohydrogen production from the control and amended batches have been shown in **Fig. 1**. In the absence of PsNPs, 5 g/L BC yielded a 22.4% increase in hydrogen production compared to the control. PsNPs alone caused an 80.6% reduction in hydrogen output. Notably, the addition of BC and GAC to PsNPs-contaminated systems significantly recovered hydrogen yields by up to 61.9% and 64.3%, respectively. Similarly, BC and GAC alleviated PsNPs-induced suppression of VFAs, with VFA concentrations nearly restored to control levels. ROS levels in PsNPs-amended sludge were more than double the control, but BC and GAC effectively reduced oxidative stress, with BC performing slightly better. Toxicity was reduced by over 40% with the inclusion of BC and GAC, and microbial diversity particularly *Firmicutes* and *Clostridium*, was enriched in conductive materials- amended systems. Dewaterability improved by up to 45% with GAC in the PsNPs-exposed sludge.

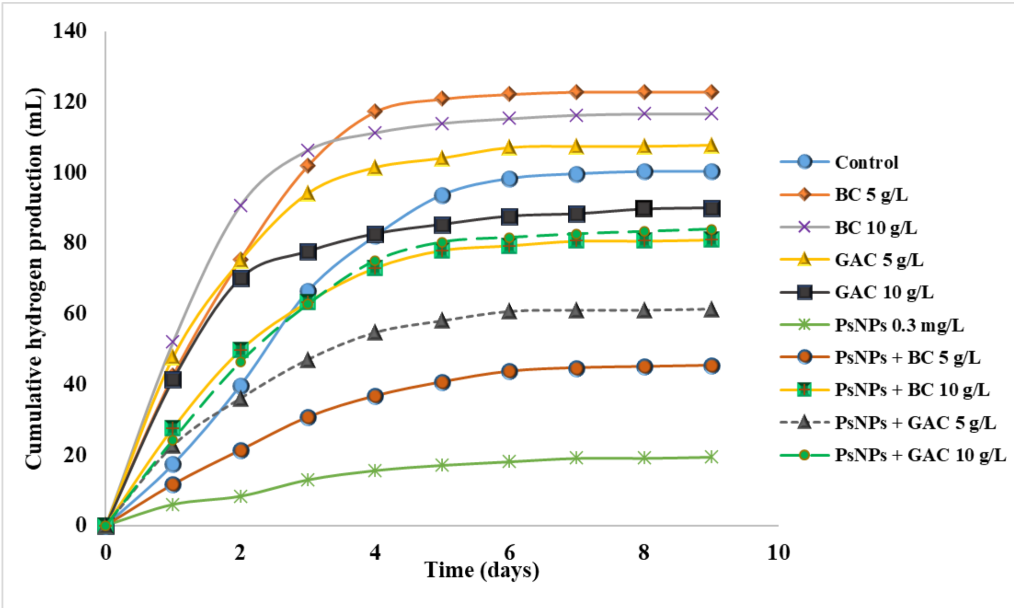

Fig. 1. Cumulative hydrogen production in the control, and batches amended with biochar (BC), granular activated carbon (GAC) and polystyrene nanoplastics (PsNPs)

Discussion:
The findings demonstrate that BC and GAC can mitigate the adverse effects of PsNPs by adsorbing the particles, decreasing ROS generation, and stabilizing microbial communities. BC's superior performance at lower concentrations is likely due to its larger macropore structure and functional groups that support microbial activity. GAC's high surface area and pore volume enhance PsNPs adsorption but may also adsorb hydrogen at higher dosages, slightly limiting its benefit at 10 g/L in uncontaminated conditions.

Conclusions:
Carbonaceous amendments, especially BC at 5 g/L and GAC at 10 g/L, are effective in restoring biohydrogen production and improving system stability in PsNPs-contaminated sludge. They offer a low-energy, scalable strategy for enhancing dark fermentation under realistic wastewater treatment scenarios.

Recommendations:
Future work should explore long-term continuous systems, economic feasibility, and the optimization of additive dosages. Additionally, advanced techniques for real-time monitoring of NPs behavior in sludge are recommended to further refine these remediation strategies.

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*Presenting author: monisha@ualberta.ca

SESSION 6. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 2

Degradation Dynamics of Mater-Bi and Crystalline PLA during Anaerobic Co-Digestion of Household Organic Waste and Wastewater Sludge, and Phytotoxicity Assessment of Digestate

Mariastella Ferreri*, Altea Pedullà, Paolo S. Calabrò

Mediterranea University of Reggio Calabria, Department of Civil, Energy, Environmental and Materials Engineering, Via Zehender, Località Feo di Vito, I-89124 Reggio Calabria, Italy

Presenting author: mstella.ferreri@unirc.it

Abstract

The increasing adoption of biodegradable bioplastics like Mater-Bi (MB) and Crystalline Polylactic Acid (CPLA) as alternatives to traditional plastics has raised critical questions about their degradation behavior, environmental impacts, and influence on the anaerobic digestion (AD) process. Despite being promoted as biodegradable, their real environmental impact and behavior during waste management remain uncertain and often controversial. This study aimed to assess the degradation dynamics of MB and CPLA during anaerobic co-digestion (AcoD) of organic fraction of municipal solid waste (OFMSW) and thickened sewage sludge, combined with abiotic degradation tests and phytotoxicity evaluation of the resulting digestate.

Experiments were conducted in lab-scale reactors with varying bioplastic concentrations (0%, 2%, 4%, 8% w/w), operated under mesophilic (35°C) and semi-continuous feeding conditions. The system allowed for daily monitoring of key process parameters, including methane production, pH, volatile fatty acids (VFAs), and the FOS/TAC ratio, a stability indicator that reflects the balance between acids accumulation and the buffering capacity of the digester. Complementary abiotic tests were performed at pH 6, 7, and 8 to separate chemical from biological degradation pathways. Phytotoxicity was evaluated using broccoli (*Brassica oleracea var. italica*) plants irrigated with digestate-water mixtures, measuring morphological traits and biomass yields.

MB showed faster degradation than CPLA under anaerobic conditions, with 23% vs. 15% mass loss after six weeks. However, abiotic tests suggested that most of the MB mass loss (25.8% at pH 6 in five weeks) resulted from chemical hydrolysis, not microbial action. CPLA exhibited low abiotic degradation (0.8–0.9%), confirming a slow but mostly biotic breakdown. SEM-EDX analysis indicated minimal structural changes post-treatment, raising concerns about microplastic formation due to fragmentation without full mineralization.

In terms of process performance, reactors with the highest MB content (8%) showed signs of instability at higher OLR (3 gVS/L·d), including VFA accumulation (up to 8300 mg/L), low pH (<6.5), and methane yield drop. Conversely, CPLA-fed reactors remained stable, though with modest methane yield increases (up to 11.9%). Digestate phytotoxicity mirrored these findings: higher MB concentrations negatively impacted plant growth and biomass, while CPLA showed neutral effects. Notably, diluted digestate mitigated adverse outcomes.

This is among the first studies to integrate AcoD, abiotic testing, and phytotoxicity assessment of commercial bioplastics under semi-continuous conditions. The findings reveal critical limitations in current bioplastic degradation under AD and highlight potential risks of process inhibition and soil contamination. Therefore, strategies should prioritize (i) developing bioplastics with higher anaerobic biodegradability, (ii) optimizing AcoD conditions for waste streams with unavoidable bioplastic content, and (iii) pre-application screening of digestate for agronomic safety. The study also supports rethinking end-of-life bioplastic management within circular economy models.

*Presenting author. mstella.ferreri@unirc.it

SESSION 6. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 2

Impact of aged and non-aged polyethylene microplastics on antibiotic resistance genes propagation and microbial communities during primary sludge fermentation

Romana Saila*, Bipro Ranjan Dhar

Civil and Environmental Engineering, University of Alberta, 116 Street NW, Edmonton, AB T6G 1H9, Canada

Abstract

Due to increased use and improper disposal, plastics, especially microplastics (<5 mm), have become ubiquitous and are considered emerging pollutants (Wei et al., 2019). Microplastics (MPs) experience physical, chemical, and biological aging processes in the natural environment while changing their physiochemical properties (Azizi et al., 2023). Although MPs are ubiquitous, wastewater treatment plants (WWTPs) are considered a significant route for MPs to enter the environment (Wei et al., 2019). Besides microplastics, WWTPs contain bacteria and antibiotic residues from different sources, such as households, hospitals, and pharmaceutical industries (Liu et al., 2019). Being hydrophobic in nature, MPs adsorb antibiotics from the surrounding environment and exercise selective pressure while interacting with bacterial communities that increase the rate of horizontal gene transfer (HGT) among different bacteria (Azizi et al., 2023; Liu et al., 2019). During treatment, more than 90% of MPs are removed from the effluent but trapped inside the solid sludge (Li et al., 2020). Therefore, investigating the impact of MPs on antibiotic resistance genes (ARGs) propagation and microbial communities during sludge fermentation has become significant. Hence, this study focused on exploring the impact of aged and non-aged polyethylene microplastics (PEMPs) in primary sludge fermentation, targeting the propagation of ARGs and associated microbial consortia.

For the experiment, 2 g/L of aged and non-aged PEMPs were added to the mixture of primary sludge (substrate) and fermented primary sludge (inoculum) to investigate the effects of MPs during primary sludge fermentation at 37 ± 1ºC under initial pH condition 10. Humic acid and alginic acid, 20 mg/L each, were mixed into the microplastic solution and left for two weeks to initiate the aging process. ARGs and microbial consortia analyses were accomplished to assess the possible impacts.

The results (Fig.1(a)) illustrated that the relative abundance of ARGs increased in aged MPs samples concerning the control and non-aged microplastics groups. The total concentration of ARGs increased by 6.6-fold and 2.6-fold in exposure to aged microplastics compared to the control and non-aged microplastic batches. Furthermore, concentrations of different types of ARGs (results not shown) also increased in the aged microplastics group than in its non-aged counterparts. Microbial community analysis (Fig. 1(b)) indicated that aged and non-aged microplastics changed the microbial community structure. Few microbes at the genus level, namely *Atopostipes*, *Bifidobacterium*, *Granulicatella*, *Coprococcus*, *Sporanaerobacter*, and *vadinCA02* disappeared after exposure to aged microplastics. Notably, the microbial communities such as *Achromobacter*, *Candidatus Microthrix*, which are capable of degrading recalcitrant compounds (Fan et al., 2020; Marzec-Grządziel & Gałązka, 2023), were eliminated in the aged MPs group as well, indicating the toxic effects of aged microplastics on

microorganisms. Toxicity induced by the aged MPs generates reactive oxygen species (ROS), which destroy the cell membranes and eventually enhance ARGs transmission by promoting the HGT among microbial communities (Mohammad Mirsoleimani Azizi et al., 2023).

The findings underscore the adverse impact of aged PEMPs on microbial communities and manifest that both aged and non-aged microplastics enhance ARGs transmission to the environment, reinforcing the emergency of addressing microplastic contamination from an engineering and policy-making perspective.

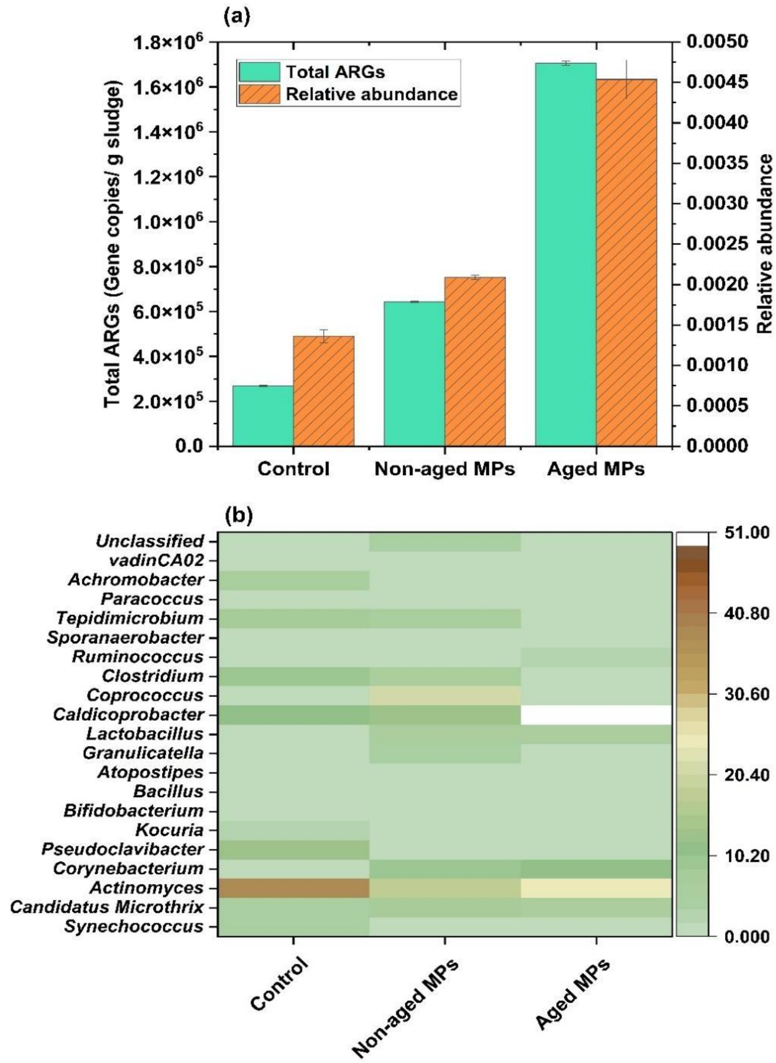

Fig. 1: (a) Total concentration and relative abundance of ARGs; (b) Relative abundance of microbial communities at genus level in the control, aged and non-aged microplastic batches.

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Presenting author. saila@ualberta.ca

SESSION 6. EMERGING CONTAMINANTS: FATE, TRANSPORT AND MITIGATION 2

Characterization of Polyethylene Microplastics Following Aerobic and Anaerobic Bio-Aging

Maha Dassouki Dit Tahan*, Melek Canbulat Ozdemir, F. Dilek Sanin, İpek İmamoğlu
Department of Environmental Engineering, Middle East Technical University, 06800 Ankara, Türkiye

Abstract

Microplastics such as high-density polyethylene (HDPE) and low-density polyethylene (LDPE) can undergo physical and chemical changes during wastewater treatment and examining these changes helps clarify their environmental fate and potential impacts. This study focuses on the characterization of HDPE and LDPE following bio-aging under mesophilic anaerobic and aerobic digestion conditions. The structural, chemical, and morphological transformations of MPs were assessed using Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), and light and scanning electron microscopy (SEM). FTIR analyses revealed distinct differences in the extent of aging between HDPE and LDPE. While HDPE, containing UV-stabilizers, exhibited no significant changes in its carbonyl index (CI), LDPE samples demonstrated bio-aging with increased CI, particularly under aerobic conditions. New absorption bands, including O–H and ester C=O stretching, along with increased intensity of polysaccharide-associated peaks, signaled microbial alterations on LDPE surfaces. However, variability in CI among anaerobic LDPE batches suggested heterogeneity in microbial interactions. DSC measurements indicated minor and statistically insignificant changes in the crystallinity and melting temperature of both HDPE and LDPE, confirming limited alteration in polymer structure post-aging. SEM and light microscopy corroborated FTIR findings by revealing increased surface roughness and discoloration in aged MPs. Overall, bio-aging led to observable surface-level transformations in MPs, more pronounced in additive-free LDPE than in HDPE. These modifications have implications for the sorption behavior and environmental interactions of MPs post-treatment. The study highlights the importance of understanding polymer-specific aging processes to assess MP fate and risk in wastewater treatment plants and subsequent environmental compartments.

Acknowledgement

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*Presenting author. maha.dassouki@torontomu.ca

POSTER SESSION

Effects of Amendments on the Anaerobic Bioremediation of Organohalides and Petroleum Hydrocarbons in Contaminated Soil and Groundwater

Sydney Kennedy-Flynn[1]*, Miles Dyck[1], Ania Ulrich[2], Petr Kuznetsov[2], Sampurna Nandy[2]

[1]Department of Renewable Resources, University of Alberta
[2]Department of Civil and Environmental Engineering, University of Alberta

Abstract

Organohalide and petroleum hydrocarbons are commonly found in soil and groundwater at contaminated oil and gas industrial sites. Specifically, tetrachloroethylene (PCE) and its daughter compounds (trichloroethylene, dichloroethylene, and vinyl chloride) along with co-contaminants benzene and toluene pose numerous health risks to humans and wildlife. The objective of this research is to evaluate the effectiveness of biostimulant amendments in increasing the rate of dechlorination of PCE and its daughter compounds in the presence of benzene and toluene.

Soil and groundwater were taken from two sites in Edmonton, Alberta. The first site is a Brownfield industrial site historically used for chemical storage, while the second is a commercial site historically involved in auto repair and oilfield services. Microcosms were prepared with soil and groundwater from the sites to make a slurry and then spiked with benzene, toluene, and PCE. Triplicate microcosms were left untreated or treated with biostimulants-ERDENHANCED™, or lactate. The microcosms have been kept in an anaerobic chamber to maintain reducing conditions, and regular GC measurements of concentrations of contaminants and other gases (methane, carbon dioxide, ethene) were done by headspace injection. qPCR for bacterial species *Dehalococcoides* and 16s microbial sequencing were performed to examine community shifts throughout the experiment. Microcosms have been re-spiked and re-amended to examine repeatability. Results will be used to test the hypothesis that the addition of ERDENHANCED™ or lactate increases the rate of dechlorination of PCE and its daughter compounds vs non-amended microcosms, regardless of the presence of benzene and toluene.

*Presenting author. kennedyf@ualberta.ca

Evaluating the Effectiveness of Commercial Bioremediation Products on Petroleum and Chlorinated Hydrocarbons in Soil and Groundwater Under Sequential Aerobic–Anaerobic Conditions

Rachel Graham*, Miles Dyck, PhD, Pag, Dr. Ania C. Ulrich, PhD, Peng
University of Alberta

Abstract

Remediation of petroleum hydrocarbon (PHC) and organohalide compound (OHC) contamination in soil and groundwater remains a significant environmental challenge in Canada, particularly at brownfield and urban commercial sites. This study investigates the effectiveness of three commercially available amendments—BioLogix (bioaugmentation), TPHENHANCED, and ERDENHANCED (biostimulation)—in degrading benzene, toluene, and tetrachloroethene (PCE) under sequential aerobic-anaerobic conditions. Using microcosms prepared with field- sourced soil and groundwater from two contaminated sites in Edmonton, Alberta, we have undertaken a 16-month incubation involving an initial 4-month aerobic phase followed by a 12- month anaerobic phase. Treatments have been evaluated for contaminant degradation and microbial community shifts. Preliminary results demonstrate a reduction in target contaminants, particularly with combined biostimulation and bioaugmentation strategies. These findings offer insight into the optimization of in-situ remediation approaches and have direct application for sustainable and cost-effective site rehabilitation across Canada.

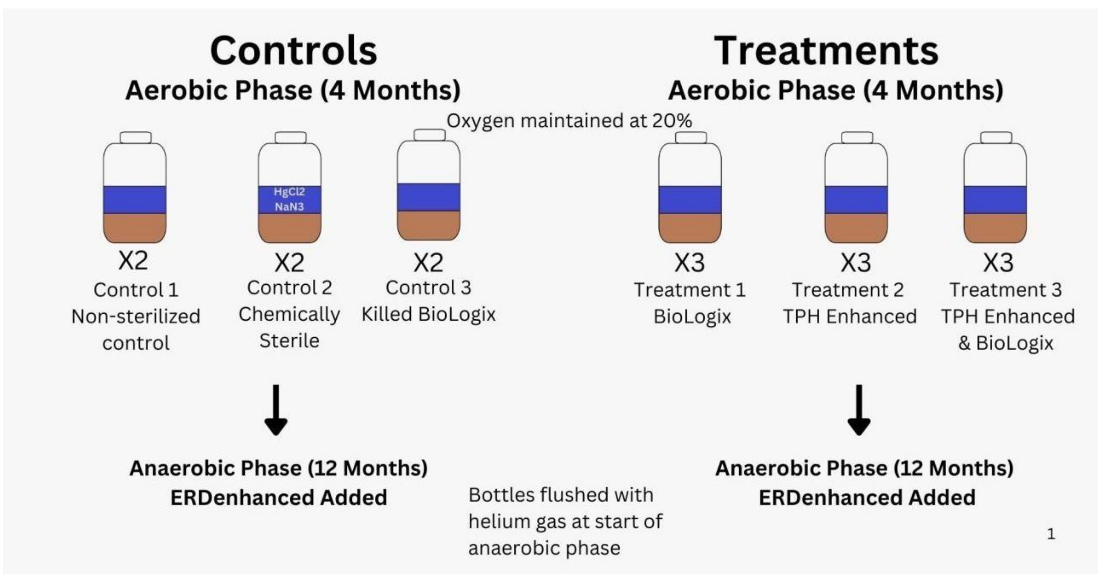

Figure 1. Treatment and controls

*Presenting author. rgraham4@ualberta.ca

POSTER SESSION

Enzymatic Indicators of Microbial Resilience to Temperature Shock in Planted and Unplanted Constructed Wetlands Treating Domestic Wastewater

Bridget Ataa Fosua*, June Garcia-Becerra[a], and Deborah Roberts[a]

University of Northern British Columbia

Abstract

Temperature fluctuations significantly affect microbial activity and nutrient removal efficiency in constructed wetlands (CWs), particularly in cold climates. These changes can compromise the long-term performance and stability of treatment systems. This study investigates the resilience and recovery pattern of microbial communities in CWs treating domestic wastewater, with a focus on how enzymatic activity responds to temperature shock. Enzyme activity was used as a functional indicator of microbial activity and adaptability. This work addresses a critical knowledge gap in understanding how sudden temperature variations, which are increasingly common due to climate change, impact the biological processes that underpin nutrient removal.

This study employed microcosm horizontal subsurface flow wetlands, both planted with *Carex utriculata* and unplanted, and monitored them through alternating warm and cold cycles. Key enzymatic activities, including nitrate reductase, urease, phosphatase, and β-glucosidase, were measured using colorimetric assays. These activities were correlated with concentrations of pollutants such as nitrate (NO_3^-), ammonium (NH_4^+), phosphate (PO_4^{3-}), and Chemical Oxygen Demand (COD), to evaluate treatment efficiency.

The synthetic wastewater was prepared using tap water, filtered concentrate from dog food, and urea fertilizer to simulate domestic wastewater nutrient levels. The influent was maintained at COD ~500 mg/L (ranging between 450-600 mg/L), NH_4^+-N (urea) at 50 mg/L, and phosphorus at 6.2 mg/L, maintaining a COD: N:P ratio of 100:10:1. Systems were operated in batch mode, with a hydraulic retention time (HRT) of three days before sampling. Preliminary findings from a 60-day trial conducted in a greenhouse at 24°C yielded unexpected results (Fig.1). Contrary to expectations, unplanted systems marginally outperformed planted ones in terms of COD removal, achieving average removal rates of 168.52 mg/L/day and 163.04 mg/L/day, respectively. Removal efficiencies ranged from 93-99% for unplanted and 84-98% for planted systems. These results suggest that microbial processes in unplanted systems may be more robust than previously assumed under warm, steady-state conditions. However, effluent concentrations of NO_3^-, NH_4^+, and PO_4^{3-} were consistently lower in planted systems compared to unplanted ones, indicating that vegetation enhances nutrient removal through synergistic mechanisms such as root oxygenation, microbial stimulation, and nutrient uptake. Enzymatic assays further revealed elevated activities of urease, nitrate reductase, phosphatase, and β-glucosidase in planted systems, highlighting stronger microbial potential, resilience, and functional stability in the presence of vegetation.

Future studies of this research will be conducted in a cold room at 5°C to evaluate enzymatic responses under temperature stress. These investigations will help clarify the role of vegetation in maintaining system functionality during seasonal temperature shifts. Ultimately, this study contributes to the design of more resilient and efficient CW systems capable of withstanding climate-induced variability, particularly in cold regions.

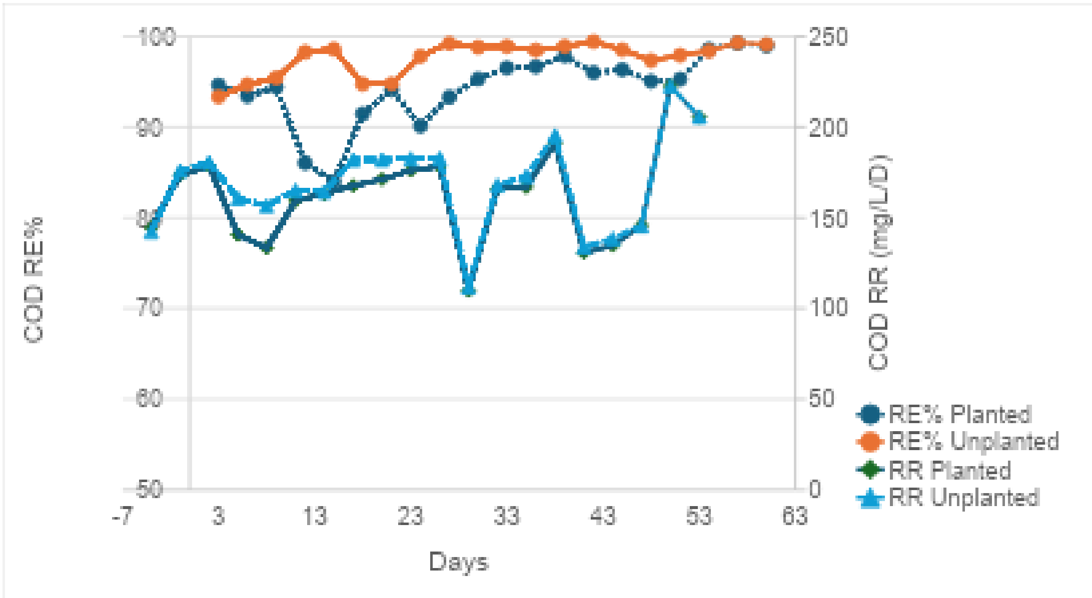

Fig.1 COD Removal Efficiency (%) and removal rate (RR) of planted and unplanted systems

*Presenting author. ataa@unbc.ca

POSTER SESSION

Aquatic Methane Exposure Trials: A Novel Method

Abbey MacDonald*, and Keith Tierney
University of Alberta

Abstract

Methane is an ever increasing presence in the environment, however while the role it plays as a greenhouse gas has been studied extensively, little is known about its interactions with aquatic organisms. While methane has always been present in water sources due to the multitude of natural sources such as coal seams or microbial activity, there has been an alarming increase as a result of anthropogenic activity in the last few decades. Specifically with cases like crude oil processing, methane is getting introduced into these water sources at a high rate, and as this gas is considered non toxic and biologically inert there has been little concern for the organisms inhabiting these spaces. This study aims to discover how methane exposure is affecting these aquatic ecosystems using the model organism, *Danio rerio*.

Approaching this study, the biggest hurdle was creating a system that would be capable of maintaining steady levels of methane without pressurizing the embryos undergoing the exposure trials. Due to its low presence in the atmosphere, methane requires low temperatures and high pressure to remain in solution as it will want to escape almost immediately. However, embryonic zebrafish require warm temperatures and cannot be kept in a highly pressurized environment. To circumvent this, a novel setup was developed and trialled over the course of 9 months that allowed for methane exposure to occur in the
absence of both low temperatures and high pressure.

The first step was ensuring the container maintained a steady water temperature, and that embryos were sufficiently protected during experimentation. After multiple attempts, we settled on a 1L glass beaker of embryo media (EM) that would be housed within a fumehood on a heated stir plate. Methane exposure occurred through the use of flow controller devices, allowing for a steady release of gas through an airstone placed at the bottom of the beaker. The fume hood acts as a safeguard against methane accumulation within the lab, and the heated stir plate maintains a steady temperature while mixing the EM and methane. To protect the embryos from getting swept up in the mixing or bubbling gas, a stainless steel tea strainer was hung from the top of the beaker with the embryos inside.

Once the setup was finalized, we began preliminary trials to assess performance and reliability. With 3 replicates, we tested 5 different flow rates of methane and logged the results over 5 day exposure trials for each group. Hatching rate was recorded on day 4, with control embryos achieving 100% success. The embryonic exposure trials resulted in a consistent dose dependent response to the methane concentration, with increased flow rate yielding more pronounced

differences across all replicated trials. Methane exposure resulted in a decreased hatching success as the dose increased. While developmental delays were noted, the lack of embryonic mortality during these trials demonstrated that the setup itself poses no harm to the fish. Moving forward, this setup will allow for insight into the outcomes of environmentally relevant levels of methane on aquatic organisms.

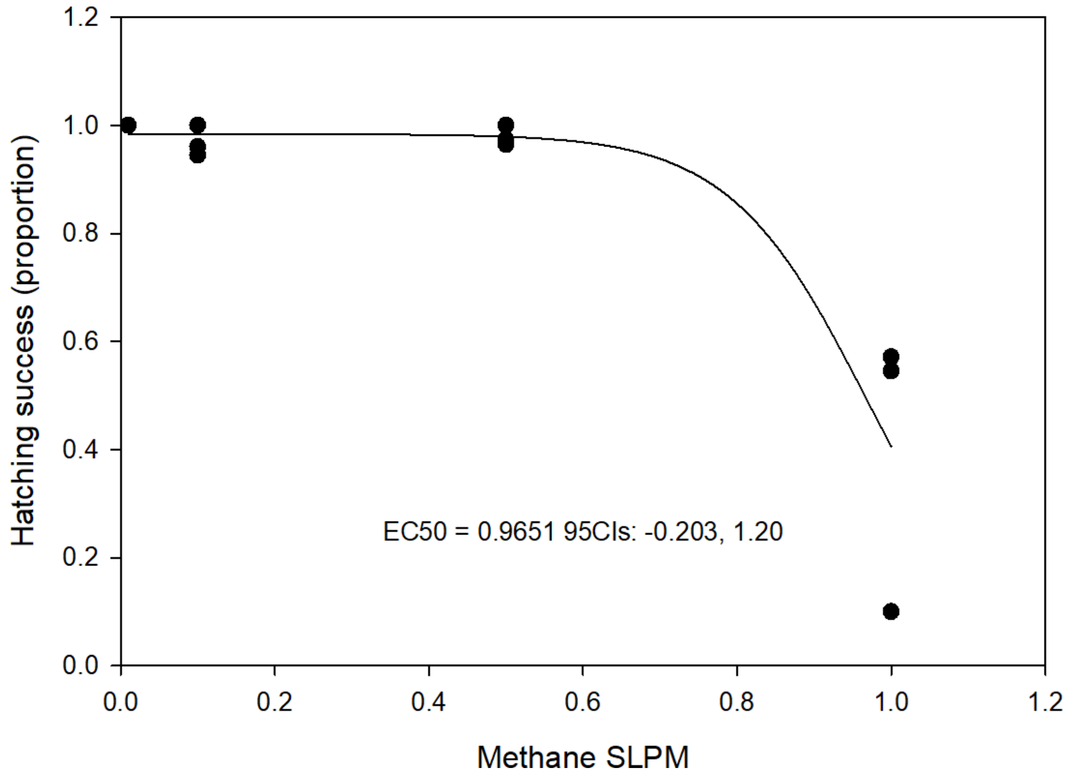

Figure 1. Dose response curve for the hatching success of 5 different standard litres per minute (SLPM) flow rates of methane exposure in embryonic zebrafish. This graph depicts the amount of embryos that successfully hatched by day 4 of the exposure trial. The EC50 value is 0.9651 (95% Cl -0.203 to 1.20).

*Presenting author. almacdon@ualberta.ca

POSTER SESSION

Applying Nanobubbles for Boosting High-solids Anaerobic Digestion

Samiullah, Anindya Amal Chakrabarty, Samruddhi Shekhar Sali, Tae Hyun Chung, Sherif Ismail, Bipro Ranjan Dhar

Abstract

This study investigates the effect of nitrogen nanobubble water (NBW) supplementation on the performance of high-solid anaerobic digestion (HSAD) of source-separated organics (SSO), with a focus on enhancing methane production and reducing hydrogen sulfide (H_2S) concentration in biogas. NBW addition increased the methane yield from 120 L to 170 L over the digestion period, while H_2S levels decreased by 66.67%. These improvements are likely due to enhanced mass transfer and increased microbial diversity in the NBW-treated medium compared to the control. These findings suggest that NBW has strong potential to optimize HSAD efficiency and improve biogas quality.

Keywords: High Solid Anaerobic digestion (AD); Nanobubble water; Hydrogen Sulfide (H_2S)

Background: Anaerobic digestion (AD) has drawn significant attention as a sustainable biogas production technology, providing a viable bio-energy source. Due to the high methane content, biogas produced can be utilized for thermal and electricity generation in cogeneration plants, injected into natural gas grids, or upgraded to renewable natural gas (RNG), contributing to reduced greenhouse gas emissions and decreased reliance on fossil fuels [1].

Objective: Biogas quality is often compromised by undesirable by-products, particularly hydrogen sulfide (H_2S), leading to serious equipment corrosion and other environmental concerns [2]. Here, NBW has shown the potential to enhance anaerobic digestion (AD) efficiency through improved mass transfer and microbial activity [3]. However, its impact on HSAD remains largely unexplored. Therefore, in this study, we investigate NBW supplementation as a strategy to enhance methane production and biogas desulfurization in HSAD.

Observations: Effect of nanobubble water on methane yield

The NB reactor exhibited higher cumulative methane production (~170 L) 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 yield. 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].

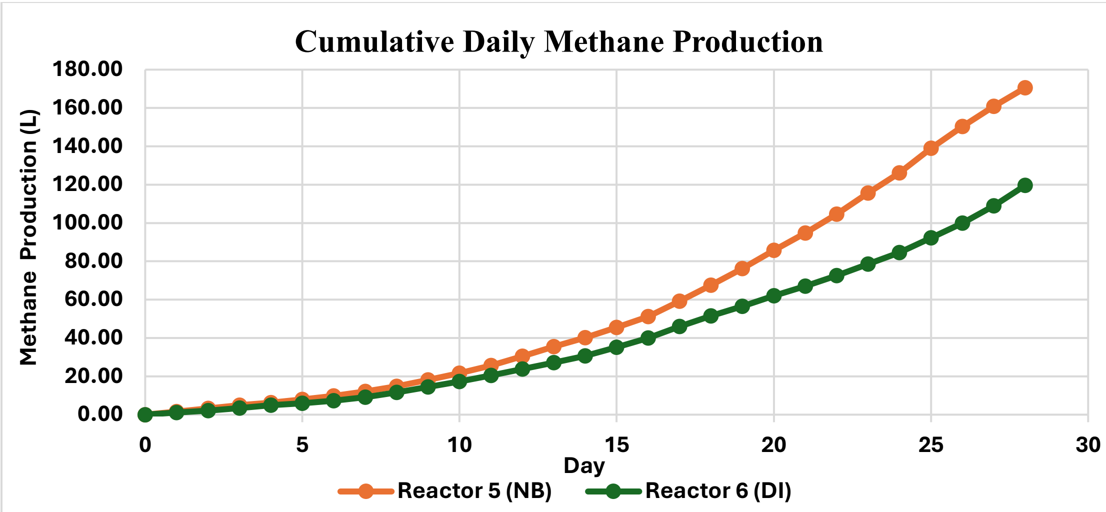

Figure 1.1. Cumulative methane production from the HSAD.

Hydrogen sulfide content in biogas

The NB reactor showed a sharper decline in H_2S concentration 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 enhances biogas desulfurization, likely by improving mass transfer and promoting sulfide-oxidizing bacterial activity. Maintaining low H_2S levels is essential for improving biogas energy efficiency and usability [5].

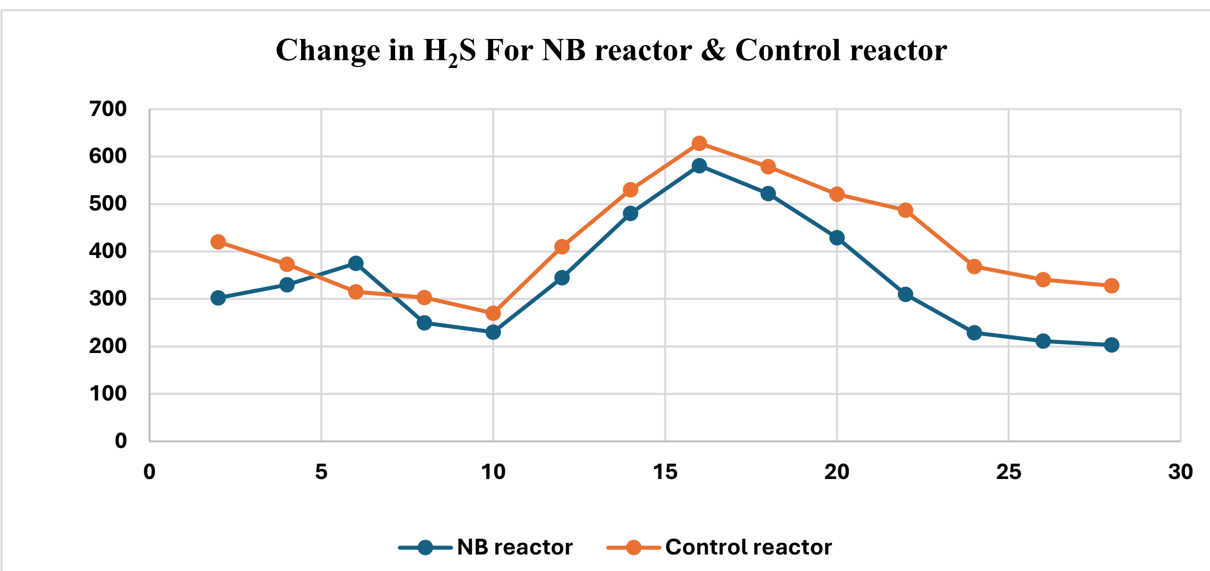

Figure 1.2. H_2S concentration in NB reactor and control reactor.

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*Presenting author. samiull1@ualberta.ca

Poster Session

Long-term Optimization of High-solids Anaerobic Digestion for Process Intensification

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

Department of Civil and Environmental Engineering, University of Alberta, 9211-116 Street, NW, Edmonton, AB, Canada T6G 1H9

Abstract

The high-solids anaerobic digestion (HSAD) represents an attractive option for the bioconversion of source-separated organics (SSO) to biogas that can meet on-site heat and electricity needs or be upgraded to renewable natural gas. Thus, the adoption of HSAD technologies can assist waste management industries in shifting to a circular economy approach. Compared to conventional wet-type digesters (<15% total solids, total solids (TS)), HSAD systems (usually operated at 20-40% TS) can provide several benefits, including a smaller digester footprint, lower heating cost, higher volumetric methane productivities. However, various operational challenges still limit HSAD systems from being widely applied in solid waste management facilities. For instance, optimizing substrate-to-inoculum ratios (also called food-to-microorganism ratios) is critically important to achieving process intensification and stable operation of digesters. During start-up, HSAD systems are usually seeded with inoculum (e.g., biosolids, manure, uncured compost, etc.). After start-up, a portion of the digestate is usually recycled as an inoculum for the following batch cycle and mixed with fresh feedstock. Increasing the amount of inoculum during start-up has been widely reported to provide higher process stability (with less initial pH drop, lower accumulation of organic acids, and shortened lag phases). However, providing more inoculum leads to a loss of volume capacity of the digester; thus, it is economically not suitable due to an increase in capital investments due to increased digester size to provide a target capacity. Most of the literature studies have reported an optimum substrate-to-inoculum or mixing ratio of feedstock and inoculum based on a single batch cycle study. To address this research gap, this study explores the impact of varying digestate replacement ratios on HSAD of SSO. This poster will present key findings from this study.

*Presenting author. anindya3@ualberta.ca

POSTER SESSION

Immune cell bioassays identify receptor-mediated inflammatory effects of Oil Sands Process Waters and Naphthenic Acids: Implications for water quality assessment

Sunanda Paul[a*], Asna Latif[b], Isaac Sánchez-Montes[c], Mohamed Gamal El-Din[c], Amit P Bhavsar[b], James L Stafford[a]

[a]Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada

[b]Department of Medical Microbiology and Immunology, Faculty of Medicine & Dentistry, University of Alberta, Edmonton, AB, Canada

[c]Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada

Abstract

Oil sands process-affected waters (OSPW) are complex mixtures of organic and inorganic compounds, including naphthenic acids (NAs), which have been associated with inflammatory effects. In this study, we prepared a mixture of commercial NAs (cNAs) as surrogates for OSPW-derived NAs to examine their immunotoxic effects. Using macrophage cell lines, we observed significant induction of proinflammatory cytokine secretion, including interleukin (IL)-1β, interleukin (IL)-6, and monocyte chemoattractant protein (MCP)-1, following exposure to OSPW and cNAs. Pharmacological inhibition of Toll-like receptor 4 (TLR4) and its co-receptor MD2, significantly reduced the cytokine secretion responses, indicating a TLR4/MD2-dependent mechanism. We further validated these findings using human embryonic kidney (HEK293) cells expressing human TLR4/MD2/CD14 (hTLR4) and HEK293-null2 cells. Based on IL-8 secretion levels, we showed that only the hTLR4 cells were activated following OSPW and cNA exposures and that these responses were also suppressed by TLR4 inhibitors. Finally, we also used Jurkat TLR reporter cells to investigate whether cNAs induce TLR4-dependent NF-κB signaling. As expected, Jurkat reporters expressing TLR4 (NF-κB::eGFP::TLR4) confirmed that cNA exposure significantly activates NF-κB signaling in a dose-dependent manner. We then expanded our analysis to include Jurkat reporter cells expressing TLR5 and the TLR2/6 heterodimer. Notably, neither OSPW nor cNAs induced detectable eGFP expression levels in these cells, suggesting that OSPW and cNA-induced pro-inflammatory effects are specific to the TLR4 receptor complex. Overall, these results provide mechanistic evidence for TLR4-dependent sensing of NAs, and highlights the utility of immune cell based bioassays in evaluating the immunotoxic potential of organic pollutants in environmental samples.

*Presenting author. sunanda1@ualberta.ca

POSTER SESSION

Examination of a demonstration pit lake using microbial toxicity and immunotoxicity cell-based assays

Nora AS Hussain[1*], Marj Gem B Bunda-Fajunio[1*], Sunanda Paul[1], Kareem F Moghrabi[1], Muhammad Arslan[2], Muhammad Usman[2], Liming Sun[2], Lingling Yang[2], Mohamed Gamal El-Din[2], and James L Stafford[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB

[2]Department of Civil and Environmental Engineering, University of Alberta, Edmonton AB

Abstract

Alberta tailings ponds contain over one trillion liters of oil sands process-affected water (OSPW), a toxic by-product of the petroleum extraction process. OSPW is retained onsite for reuse and eventual integration into natural watersheds after decontamination. However, OSPW currently lacks a standardized treatment protocol, as its chemical constituents vary depending on several factors such as ore origin, extraction methods, and management of the clay and sediment mixture released from the bitumen ore (i.e., tailings). One proposed treatment strategy is the creation of a demonstration pit lake (DPL) which focuses on the dewatering of tailings prior to deposition within a constructed lake system. Dewatered tailings have reduced volume, exhibit structural stability, and retain less contaminants in the pore water. This potential remediation approach is being monitored through several interdisciplinary collaborations. Our investigations into the biological effects of this treatment regimen included the establishment of cell bioassays to evaluate cytotoxicity and immunotoxicity in two distinct matrices – surface water and expressed pore water – collected from three spatially separated zones within the system over a five month period in 2024. Bacterial and immune cell-based models showed consistent and significant differences in biological effects between the two matrices. For example, expressed pore water showed greater toxicity across all the zones, characterized by diminished bacterial viability (9.25x maximum fold reduction) and significantly increased immunotoxic effects. Overall, these findings highlight the effectiveness of cell-based assays to discern environmentally relevant differences in a spatiotemporally informed manner from complex field samples.

*Presenting author. nahussai@ualberta.ca; bundafaj@ualberta.ca

POSTER SESSION

Correlations Between Winter Parameters and Springtime Total Organic Carbon in the North Saskatchewan River

Sharafi Ferdaus[1], Monireh Faramarzi[2], Yuntong She[1], and Wenming Zhang[1]

[1]Department of Civil & Environmental Engineering, University of Alberta, Edmonton, Alberta, Canada, T6G 1H9

[2]Department of Earth & Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 1H9

Abstract
Increased organic carbon levels have been impacting seasonally ice-covered rivers, raising concerns about water quality. Total organic carbon (TOC) in rivers typically peak during spring snowmelt and river ice breakup, highlighting the role of wintertime processes in influencing this parameter. Despite this, studies that examine the effects of river ice and cold season processes on in-stream TOC remain limited. In this study, the North Saskatchewan River Basin is used as the study region, and colour measured at two water treatment plants in the City of Edmonton, Alberta is used as a proxy for TOC. Spearman correlations have been found between spring TOC and winter parameters such as cumulative degree-days of freezing, snowfall, and ice thickness. Furthermore, correlations have been found using snowfall, snow depth, and spring cumulative degree-days of thawing data at the headwaters of the North Saskatchewan River to understand TOC fate and transport in the watershed. The results indicate that an overall increase in magnitude or severity of cold season variables is associated with higher springtime TOC, demonstrating the importance of winter conditions on in-stream carbon dynamics. These findings will provide insight for future work involving hydrological modelling, predicting TOC behaviour under climate change. The hydrological model results could also be used as boundary conditions for a hydrodynamic river model to look at ice effects.

*Presenting author. ferdaus@ualberta.ca

POSTER SESSION

Optimization-Based Estimation of Water Quality Index using Principal Component Analysis with Standalone and Hybrid Modeling Techniques

Ajaz Ahmad Mir[1*], Mahesh Patel[2] and Wenming Zhang[3]
[1,3]Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Canada
[2]Department of Civil Engineering, Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab, India

Abstract

Water quality is essential for sustaining human health, ecosystems, industrial activities and environmental balance. However, in recent decades it has been significantly degraded due to increasing contamination and pollution. Therefore, it is very important to continuously monitor, evaluate, and optimize water quality parameters to ensure the sustainability of water resources and to support effective environmental management and policy decisions. In this regard, an optimized prediction of the Water Quality Index (WQI) is performed using standalone and hybrid analytical techniques to improve precision and decision-making in water quality assessment. The overall methodology is illustrated in the flowchart as shown in Figure 1.

The dataset used in this study comprises comprehensive water quality observations collected from various lakes and rivers across multiple locations in India covering the period from 2005 to 2014. It includes key physico-chemical parameters such as **Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, Conductivity, Temperature, Nitrate, Fecal Coliform,** and **Total Coliform**. The **Water Quality Index (WQI)** was computed based on these parameters. The dataset was pre-processed to handle missing values and normalized where required. The Principal Component Analysis (PCA) was applied for dimensionality reduction and to enhance model performance by extracting the most influential features for WQI prediction.

Various standalone machine learning (SML) models such as Random Forest (RF), XGBoost (XGB), and K-Nearest Neighbors (KNN) were utilized. In case of hybrid machine learning (HML) models, RF was combined with Gradient Boosting (GB) and Extra Trees Regression (ETR). Additionally, RF was hybridized with the Ridge Regression (RR) model, and KNN was combined with Support Vector Machines (SVM). The performance of these models was evaluated using key statistical metrics Coefficient of Determination (R^2), Root Mean Square Error (RMSE), Mean Squared Error (MSE), Mean Absolute Error (MAE) and Nash-Sutcliffe Efficiency (NSE). The results demonstrate that hybrid models, particularly the RF-ETR and RF-GB combinations, outperform standalone models in WQI prediction accuracy, achieving higher R^2 values and lower error rates.

The RF-RR hybrid model achieved the highest accuracy (R^2 = 0.9967, RMSE = 0.1309), reducing error by 67.1% compared to the standalone RF model (RMSE = 0.3982). As depicted in Table 1, the hybrid models consistently outperformed standalone models,

with 15–20% higher R^2 and NSE values above 0.99 for top performers, indicating superior prediction reliability for water quality assessment. Also, the feature importance analysis revealed dissolved oxygen and nitrate levels as key WQI determinants.

This research contributes significantly to sustainable water management by enabling real-time monitoring and providing a robust framework for predictive water quality assessment. The developed system offers water authorities an effective decision-support tool for early contamination detection and resource allocation, with future work focusing on IoT integration for basin-scale implementation.

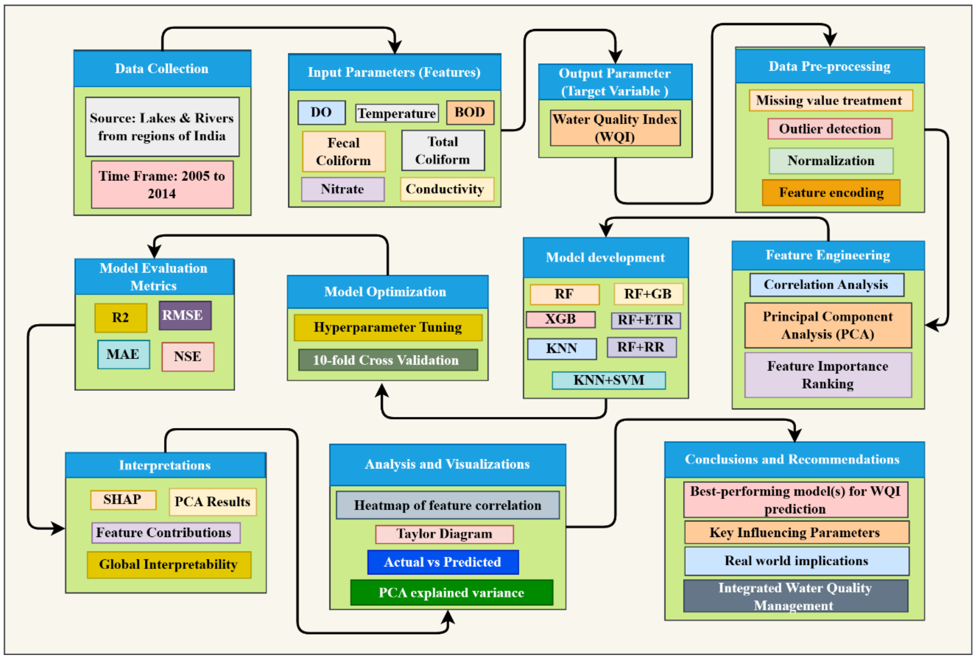

Figure 1: Methodology adopted in the present study to estimate WQI using PCA with Standalone and Hybrid Modeling Techniques

Table 1: Comparative performance metrics (R^2, RMSE, MSE, MAE, and NSE) of standalone and hybrid machine learning models for Water Quality Index (WQI) prediction

Model	R^2	RMSE	MSE	MAE	NSE
RF (Standalone)	0.9697	0.3982	0.1586	0.3857	0.9697
XGBoost (XGB)	0.9822	0.3047	0.0929	0.3000	0.9822
KNN	0.8515	0.8807	0.7757	0.8714	0.8515
RF-GB (Hybrid)	0.9915	0.2104	0.0443	0.1857	0.9915
RF-ETR (Hybrid)	0.9825	0.3024	0.0914	0.2857	0.9825
RF-RR (Hybrid)	0.9967	0.1309	0.0171	0.0857	0.9967
KNN-SVM (Hybrid)	0.9243	0.6291	0.3957	0.6143	0.9243

*Presenting author. *ajaz1@ualberta.ca*

POSTER SESSION

Physicochemical Properties of Fat, Oil, and Grease (FOG) Deposits in Sewers: From Experimental Analysis to Mitigation Strategies

Xinzai Peng*, David Z. Zhu and Wenming Zhang

Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada.

Abstract

The accumulation of fat, oil, and grease (FOG) deposits is a common cause of blockages in urban sewer systems, resulting in severe environmental hazards and public health risks. To support effective control strategies, this study investigates the physicochemical properties of FOG deposits, focusing on their formation efficiency, chemical composition, and rheological behavior.

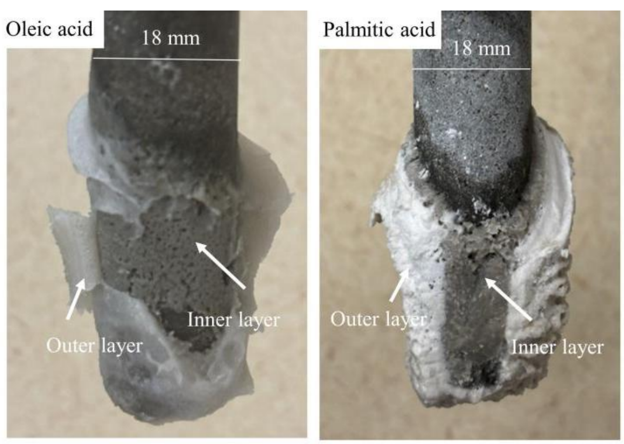

Fig.1 FOG deposits formed on concrete surfaces.

The experiments were conducted in 250 mL glass beakers. Flow fields with different velocity gradients were generated using a stir bar placed at the bottom of the beaker. Oleic acid and palmitic acid were selected as representative free fatty acids (FFA). Calcium chloride provided Ca^{2+} to initiate the saponification reaction with FFA. Canola oil was used to disperse FFA within the mixture. The reaction solution consisted of deionized water, FFA, calcium chloride, and canola oil. A concrete rod (18 mm in diameter) was inserted into the solution to provide a surface for FOG deposit attachment.

Results show that FOG deposits formed on concrete surfaces exhibited clear stratification, with a gray inner layer and a white outer layer. The weight of FOG deposits increased with increasing velocity gradient. Palmitic acid posed a greater risk to sewer systems due to its higher solid mass. The asymmetric stretching of the carboxylate group was found to be suitable for quantifying percent saponification. Concrete can promote FOG deposit formation by leaching metal ions and hydroxide. The relationship between shear rate and viscosity was well described by the power-law model, reflecting the non-Newtonian, shear-thinning behavior of the deposits. A comprehensive formation mechanism of FOG blockages in sewers was proposed, involving saponification, cooling and incorporation, and interactions with concrete surfaces.

It is recommended to prioritize the in-place removal of adhered FOG deposits rather than flushing them downstream. Although high flow velocities can break up existing FOG, they may simultaneously facilitate new deposit formation. The distinct properties of different free fatty acids highlight the need for composition-specific maintenance strategies.

*Presenting author. xinzai@ualberta.ca

POSTER SESSION

Optimization of micro-Fourier Transform Infrared Spectroscopy and Data Analysis Technique for Enhanced Detection of Microplastics in Environmental Samples

Alabi, R.O.[1], Foetisch, A.[2], Weber, C.J.[2], Bigalke, M.[2]

[1] Department of Environmental Engineering, University of Alberta, Canada
[2] Institute of Applied Geoscience, Technical University of Darmstadt, Germany

Fourier Transform Infrared (FTIR) spectroscopy has emerged as a state-of-art technique for effectively analysing microplastics in the environment. Despite its advancements, challenges remain in optimizing the method to improve data quality and reduce analysis time, particularly when analysing large datasets. This study focuses on enhancing Focal Plane Array (FPA)-based micro-FTIR imaging by improving both spectral quality and measurement efficiency for accurate identification and quantification of microplastics in environmental samples. A mixture of known pristine polymers, spiked and soil samples were analyzed to evaluate the effects of varying scan numbers and binning settings on the performance of FPA-based micro-FTIR imaging. The spectra data were analyzed with respect to Relevance and Similarity thresholds using a machine learning approach. Findings show that binning reduces Relevance, as it can merge distinct spectral features critical for accurate particle identification. Conversely, increasing scan numbers enhances Similarity, indicating that additional scans improve spectral matching with reference data. Among the measurement configurations tested, 2 scans with 2x2 binning provided a reasonable balance between accuracy and measurement time. Although 4 scans with 2x2 binning yielded the highest accuracy for total particle detection, this configuration required an impractically long measurement time for a whole filter analysis. Thus, the 2 scans and binning 2x2 configuration is recommended as a more practical approach for routine analyses. Additionally, threshold configuration should be considered during the data analysis as optimal thresholds provide a reliable balance, minimizing both overestimation and underestimation in microplastic recognition. Our study demonstrates that optimizing both scan/binning configurations and threshold settings are critical to achieving accurate and efficient microplastic characterization. The proposed approach can be applied as a standard operating procedure for microplastic analysis using micro-FTIR imaging.

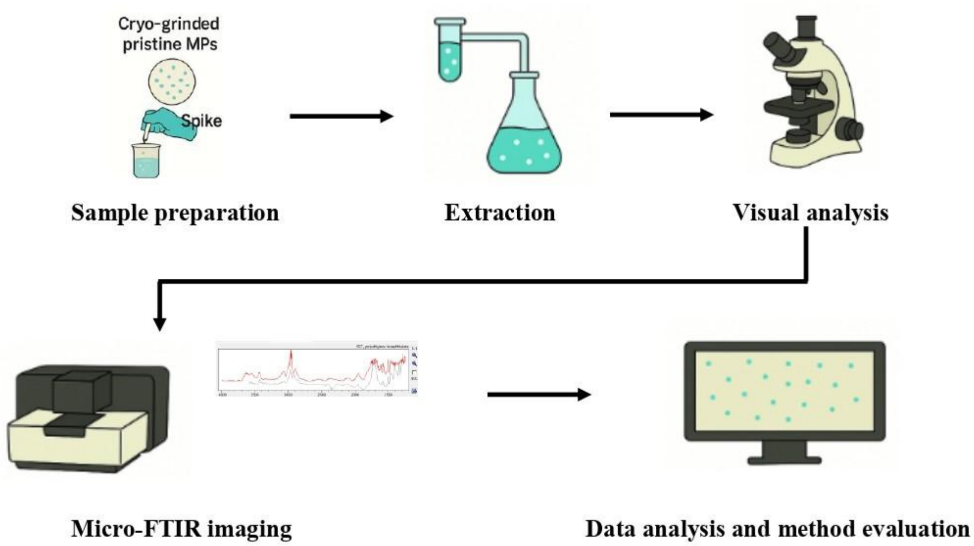

Figure: The workflow used in the study.

*Presenting author. alabiolaider@gmail.com

POSTER SESSION

Hydrothermal Liquefaction of Sludge for Biocrude Production with Integrated Anaerobic Digestion of Byproducts

Parisa Niknejad[1*], Simran Kaur Dhillon[1*], Rajender Gupta[2], Bipro Ranjan Dhar[1 *]

[1]Civil and Environmental Engineering, University of Alberta, 116 Street NW, Edmonton, AB T6G 1H9, Canada

[2]Chemical and Materials Engineering, University of Alberta, 116 Street NW, Edmonton, AB T6G 1H9, Canada

Abstract

As contamination levels in sludge continue to rise, traditional treatment methods are increasingly unsustainable, emphasizing the need for innovative and sustainable management strategies. To address these challenges, hydrothermal liquefaction (HTL) has emerged as an alternative for the conversion of sludge to valuable biocrude, hydrochar (HC), gaseous and aqueous phase bioproducts (HTL-AP). HTL experiments observed that the reactors operated at higher temperatures exhibited higher biocrude yield, while the HC and AP produced reduced. Further, we investigated the effect of incorporating HTL-AP and HC produced into anaerobic digestion (AD). For the HTL-AP reactors, the highest methane yield was observed at 280°C due to the presence of relatively less recalcitrant compounds in AP produced at lower temperatures. However, adding HC enhances methane production at 330°C and 370°C. Despite the promising results, challenges remain in optimizing process conditions to balance bioenergy recovery and waste valorization. Future research should explore long-term system stability, economic feasibility, and potential inhibitory effects of HTL byproducts on microbial communities.

Keywords:
Bioenergy recovery; Hydrothermal liquefaction; Anaerobic Digestion; Hydrochar; Aqueous phase

Background

Globally, the predominant disposal method for waste, including sludge, remains landfilling, with around 70% of generated waste directed to landfill sites [1]. However, this practice poses severe environmental and health risks, such as the leaching of contaminants into groundwater, leading to pollution and long-term health issues [2]. Hydrothermal liquefaction (HTL) is a promising thermochemical process widely studied for its high efficiency, cost-effectiveness, and environmental benefits. Operating at temperatures ranging from 250 to 370°C and pressures above the saturation point, HTL facilitates decomposition and fractionation of complex organic molecules into valuable products, including biocrude oil, hydrochar (HC), gases, and an aqueous phase (HTL-AP) [3]. HC and HTL-AP represent important components of the HTL process, offering opportunities for resource recovery and waste valorization. Most studies focus on individual byproducts or fail to explore how variations in HTL process conditions, such as temperature, influence the properties of HC and HTL-AP and their interactions within AD systems. This gap underscores the need for comprehensive investigations into the co-utilization of these byproducts in AD.

Findings

Biocrude yield increased significantly with rising temperatures, peaking at 370°C with a maximum yield of 42.1 wt.%. This increase is due to the greater energy available at higher temperatures, which facilitates bond cleavage, hydrolysis, and the breakdown of volatile biomass into biocrude [4]. For the HTL-AP reactors, the total cumulative methane production was 262±1.69 mL/g VS at 280°C, 164±1.28 mL/g VS at 330°C, and 153±1.08 mL/g VS at 370°C. When HC was added under the same conditions, the cumulative methane production increased to 327±1.01 mL/g VS at 280°C, 213±2.04 mL/g VS at 330°C, and 181±0.97 mL/g VS at 370°C. Although the highest cumulative methane production was observed at 280°C with HC addition, the relative increase in methane production compared to the respective control was more pronounced at 330°C. Specifically, the methane production increase relative to the control was 25% at 280°C, 29% at 330°C, and 19% at 370°C. This suggests that while methane production was highest at 280°C, the enhancement effect of HC addition was most significant at 330°C.

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*Presenting author. pnikneja@ualberta.ca, skdhill3@ualberta.ca

POSTER SESSION

Characterization and antibiofilm properties of Plasma-Activated Nanobubble Water

Prithviraj V[1*], Adityasukumar Pasagadi[1], Shivani Sonkar[1], Negar Ravash[1], Bhagyashree Tiwari[1], Michael Gänzle[1], Xianqin Yang[2], M S Roopesh*[1]

[1]Department of Agricultural, Food & Nutritional Science, University of Alberta, Edmonton, Alberta T6G 2P5, Canada

[2]Lacombe Research and Development Centre, Lacombe, Alberta T4L 1W1, Canada

Abstract

Cold plasma and nanobubbles are recognized for their effectiveness in microbial inactivation and wastewater treatment. The production of large quantities of plasma-activated species poses a challenge due to the requirement for high voltage systems and the short lifespan of plasma species, which hinders the commercial application of this technology. This study combines gaseous plasma species and nanobubbles to generate plasma-activated nanobubble water (PANBW) in an 8L batch treatment for 30 minutes. The PANBW was then integrated with a plasma bubble system to enhance the reactive nitrogen and oxygen species through continuous treatment. This solution subsequently flowed over biofilms cultivated with spoilage microorganisms on 25x25mm stainless steel coupons. Bacterial enumeration using standard plate counts revealed a >3 log CFU/cm² reduction in microbial counts when nanobubbles were combined with plasma species, indicating high treatment efficacy.

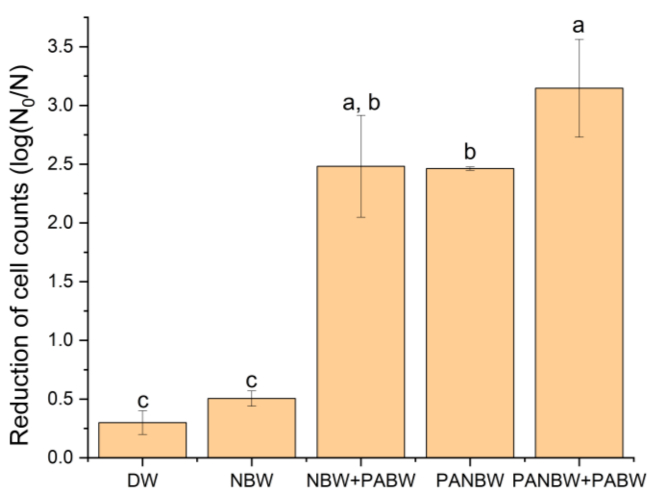

Fig. 1. Comparison between different plasma and nanobubble treatment combinations. DW-Distilled water, NBW-Nanobubble water.

This outcome is likely due to the nanobubbles serving as effective carriers for plasma-activated species. Additional estimations of reactive oxygen and nitrogen species (RONS), oxidation-reduction potential, and electrical conductivity for the combined treatments indicated increased numerical values. Nanobubble characterization through zeta potential measurements showed a high negative charge of -42.23±1.49 mV for plasma nanobubbles (PNB), indicating their enhanced stability, along with a smaller size of 188.33±17.44 nm as noted in nanobubble tracking analysis (NTA) compared to standard nanobubbles. The innovative synergistic effect of plasma nanobubbles could be highly effective for the scale-up application of plasma for sanitation purposes across various industries, ensuring microbiological safety and paving the way for more efficient and sustainable treatment technologies.

*Presenting author. prithvi1@ualberta.ca

POSTER SESSION

Plasma-Activated Water (PAW) Spray: An Effective Technique for Microbial Biofilm Elimination

Negar Ravash[1]*, Shivani Sonkar[1], Prithviraj V[1], Adityasukumar Pasagadi[1], M. S. Roopesh[1]*

[1] Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada.

Abstract

This study evaluates the efficacy of PAW spray technology as an innovative approach for the eradication of microbial biofilms on stainless steel surfaces. PAW was generated through the exposure of water to atmospheric plasma within a plasma bubbler unit. The sequential application of distilled water (DW) and PAW sprays was designed to maximize antimicrobial efficacy through a synergistic approach, combining mechanical dislodgement with chemical oxidation. Microbial assessments revealed that sequential DW and PAW spray treatments achieved complete microbial inactivation on stainless steel surfaces, corresponding to a reduction of >5.62 log CFU/cm². Physicochemical analyses demonstrated that PAW sprays exhibited a reduced pH range of 2.97–3.02, an elevated oxidation-reduction potential (ORP) of 533.50–578.50 mV, enhanced conductivity of 458-469 µS, and increased concentrations of reactive oxygen and nitrogen species (RONS), including 10.74–21.89 mg/L peroxide, 0.35– 0.82 mg/L ozone, 1.85–6.68 mg/L nitrite, and 71.93–107.35 mg/L nitrate, compared to DW sprays, which showed a pH range of 5.98–6.45, an ORP of 406.50–426.50 mV, conductivity of 1.82-2.72 µS, and RONS concentrations of 0.08–0.10 mg/L peroxide, 0.000–0.004 mg/L ozone, 0.02–0.03 mg/L nitrite, and 2.58–3.26 mg/L nitrate. PAW's enhanced antimicrobial properties result from high RONS levels, elevated ORP, increased conductivity, and low pH.

This eco-friendly technology enhances safety and sustainability, with future research needed to scale up the spray system for industrial use.

*Presenting author. ravash@ualberta.ca

POSTER SESSION

Plasma activated water mist: a promising surface disinfection technology

Shivani Sonkar[1*], Prithviraj V. [1], Negar Ravash[1], Xianqin Yang[2], M S Roopesh*[1]

[1] Department of Agricultural, Food & Nutritional Science, University of Alberta, Edmonton, Canada T6G

[2] Agriculture and Agri-Food Canada Lacombe Research and Development Centre, Lacombe, Canada.

Abstract

Increasing microbial resistance has led to the use of concentrated chemical disinfectant in industries. However, the higher the concentration of chemicals, the higher the health risk it poses. This creates the need for novel and safer alternative to the chemical disinfectants. Plasma activated water mist is a promising alternative to chemical surfactants. Plasma activated water mist (PAM) was produced by activating water using bubble spark discharge plasma reactor and atomizing into fine mist. In this study, low concentrations of peracetic acid (10ppm), hydrogen peroxide (34 ppm) solutions, and their mixture were also used to generate PAM. The disinfection efficiency of PAM was examined against dual strain *Escherichia coli* biofilm. Reactive oxygen and nitrogen species, pH, oxidation-reduction potential, and temperature of PAM were analyzed. Crystal violet (CV) staining and confocal laser imaging (CLSM) used to analyze reduction of biomass. Results showed that plasma activation improved the antimicrobial properties of the disinfectant solutions. Moreover, PAM with mixture of the chemicals showed highest antimicrobial efficacy (~3.5 log CFU/cm^2). The inactivation was attributed to the reactive species generated during plasma treatment. In addition, lower pH, higher electrical conductivity and oxidation reduction potential possibly contributed to the biofilm inactivation. CV staining and CLSM images underlined the changes in the process of biofilm disruption. PAM is proved to be a promising alternative for surfactants, by reducing chemical demand and health concerns. However, detailed studies are necessary to determine the contribution of each of these RONS and their interactions with chemical disinfectant solution composition.

*Presenting author. sonkar@ualberta.ca

POSTER SESSION

Fat to Fuel: Optimizing Beef Tallow Anaerobic Digestion Using Nanobubble Water

Alsayed Mostafa, Bipro Ranjan Dhar

Department of Civil and Environmental Engineering, University of Alberta, Alberta, Canada

Abstract

This experiment targeted to evaluate the impact of nanobubble water (NBW) supplementation on the anaerobic digestion (AD) of beef tallow, which is widely known for its low conversion efficiency and limited biodegradability when digested without a co-substrate. Tallow concentrations of 0.5% and 2.0% were tested in batch reactors. The results demonstrated that nitrogen-NBW (N_2-NBW) remarkably enhanced methane production from tallow by 165.3% and 173.2% at 0.5% and 2.0% concentrations, respectively, compared to the control batches supplemented with deionized water (DW). Such improvements were found to be consistent across both tested concentrations, with chemical oxygen demand (COD) conversion efficiencies of 33.0% and 11.8%, respectively. In addition, N_2-NBW reduced the lag phase from 7–8 days in the control batches to only 5 days in the NBW-supplemented batches. Residual volatile fatty acids (VFAs) in NBW-supplemented reactors were 3–5 times less than those in the control, confirming less accumulation of VFAs and improved metabolic conversion of tallow in N_2-NBW supplemented batches. The reasons behind the NBW-induced improvements are expected to be the enhanced mass transfer, improved enzymatic activity and increased microbial accessibility to substrate, all facilitated by distinctive properties of NBW, such as high surface area and ability to generate reactive species. This experiment highlights the potential of supplementing N_2-NBW in the AD of recalcitrant wastes such as beef tallow. Future research should be directed to evaluating the impact of N_2-NBW on other low-biodegradability substrates under continuous system operation, which is vital for assessing both long-term operation and scalability.

*Presenting author. alsayed2@ualberta.ca