Canadian Association on Water Quality (CAWQ)
60th Central Canadian Symposium on

Water Quality Research

February 23-24, 2025

Toronto Metropolitan University
Department of Civil Engineering
Faculty of Engineering and Architectural Science

Toronto Metropolitan University
Faculty of Engineering and Architectural Science

February 23, 2025:
Sears Atrium, George Vari Engineering & Computing Center
245 Church St, Toronto, ON M5B 1Z4
Toronto Metropolitan University

February 24, 2025:
Toronto Metropolitan University Student Centre
63 Gould Street Toronto, ON M5B 1E9

CAWQ ACQE · Toronto Metropolitan University · YORK U · Western University · Canada · University of Toronto · IWA the international water association · Young Water Professionals Canada

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Welcome to the 60th Central Canadian Symposium on Water Quality Research

From the Chair

On behalf of the organizing committee, it is my great pleasure to welcome you to the 60th Central Canadian Symposium on Water Quality Research, hosted at Toronto Metropolitan University. This symposium marks an exciting milestone as we celebrate six decades of impactful collaboration, innovation, and progress in addressing Canada's water quality challenges.

Our symposium is designed to be a dynamic and inclusive space where students, young professionals, academics, established researchers, industry leaders, municipal representatives, and policymakers come together. Whether you are a student presenting your first research or a seasoned expert sharing cutting-edge innovations, this is a space where diverse voices unite to advance sustainable solutions.

This year's program reflects the evolving challenges and opportunities in water research, focusing on wastewater process intensification, net zero wastewater systems, emerging contaminants, wastewater reuse, and sustainable water management. These topics aim to bridge the gap between innovative research and practical applications for more resilient water systems. Emerging researchers are celebrated through awards like the Philip H. Jones Awards and the Glen Daigger-inspired Best Poster Awards, recognizing outstanding contributions in both research and presentation. The one-slide, 3-minute presentations, alongside poster and podium sessions, will showcase creative and impactful work from students and young professionals who represent the future of our field.

This symposium is proudly supported by Toronto Metropolitan University, including its Department of Civil Engineering, the Faculty of Engineering and Architectural Science, and the Office of the Provost and Vice-President, Academic. Their commitment to fostering innovation, knowledge exchange, and collaboration has been integral to making this event possible.

Our university's downtown location offers the ideal setting for this event, blending academic excellence with access to the vibrant culture of Toronto. I encourage you to explore our campus and enjoy all that the city has to offer.

I extend my sincere thanks to the organizing committee, volunteers, and sponsors who have worked tirelessly to bring this symposium to life. Their dedication has created a welcoming environment where ideas can flow freely, new collaborations can form, and knowledge can be shared to address complex water challenges As we reflect on six decades of progress, let's embrace this moment to build on our achievements and drive meaningful change. The challenges we face—whether in wastewater treatment, public health, or resource recovery—are complex but surmountable with collective effort and interdisciplinary collaboration. Whether you're here to share research, discover new ideas, or connect with colleagues, I hope this symposium leaves you inspired and energized to contribute to the advancement of water quality solutions. Welcome to the 60th Central Canadian Symposium on Water Quality Research, and welcome to Toronto Metropolitan University. Let's make this an event to remember!

Dr. Rania Hamza
Conference Chair

60th Central Canadian Symposium on Water Quality Research

Symposium Objectives

The symposium seeks to unite experts and practitioners in water quality research and management to discuss the latest advancements in science, engineering, and policy. The event fosters collaboration across universities, industry, government, and consulting sectors to promote innovative and impactful solutions for Canada's water quality challenges.

Conference Chair

Dr. Rania Hamza
Associate Professor, Toronto Metropolitan University

Conference Co-chairs and Organizing Committee

Dr. Martha Dagnew
Associate Professor,
Western University

Dr. Stephanie Gora
Assistant Professor,
York University

Dr. Ron Hofmann
Professor,
University of Toronto

Organizing Commitee

Rania Hamza, Martha Dagnew, Stephania Gora, Satinder Brar, Mandeep Rayat, Hussain Aqeel, and Farshad Dabbaghisouraki.

Keynote Speakers

Dr. Arthur Umble
Senior Vice President - Emeritus
Stantec Consulting Services, Inc.

Dr. Robert Andrews
Professor, Department of Civil & Mineral Engineering
University of Toronto

60th Central Canadian Symposium on Water Quality Research

Feb 23–24, 2025

Symposium Themes

- Emerging Contaminants and Microplastics
- Climate Adaptation and Resilience in Water Systems
- Indigenous & Remote Communities: Water Quality Solutions
- Water Quality Monitoring and Advanced Analytics
- Drinking Water Treatment and Public Health
- Wastewater Treatment Innovations and Nutrient Recovery
- Stormwater Management and Green Infrastructure
- Groundwater Quality and Sustainable Remediation
- Water and Social Policy: Equity and Accessibility
- Hydrology, Hydraulics, and Extreme Events
- Sludge and Biosolids Treatment and Reuse
- Circular Economy Approaches in Water Management
- Digitalization and Smart Water Solutions
- Other Topics Relevant to Water Quality Research

Student Awards Information

To compete for the Award, authors should indicate if they are currently students or presenting graduate research on the Abstract Information Form. In order to encourage student participation and showcase the talents of students conducting water quality research, there will be several awards for the students in both poster and presentation sessions:

- Philip H. Jones Awards: Cash prizes of $300 to 1st place and $200 to 2nd place winner. Both winners will have one year membership in CAWQ.
- Best Posters Awards (inspired by Patty and Glen Daigger): Cash prizes of $300 to the best two posters.
- Bioenergy and/or Sludge Management Bioenergy, Sludge management, and/or Drinking Water Presentation Awards: Cash prizes of $300 to 1st place and $200 to 2nd place winner.

All award recipients will receive certificates acknowledging their performances.

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Pre-Conference Activities led by IWA-YWPs-Canada

The future of water/wastewater research and the intersection with operations and career implications

February 23, 1:00 - 3:00 pm

Research is a growing need for utilities to help them make decisions. As dollars and staff become more stretched, how can utilities organize themselves to ensure that they continue to leverage benefits from research? Is there an optimal method to engage staff throughout and outside a utility? What does that mean for careers in the water sector and how should the next generation prepare so they can add value to their respective organizations?

Session Chair: Samantha LeValley
Regional Co-director – Central International Water Association, Young Water Professionals

Panelist: Adriano Mena
Research & Innovation Program Regional Municipality of York, Public Works

Panelist: Dr. Steven N. Liss
Vice-President, Research and Innovation Toronto Metropolitan University

Panelist: Dr. Laura Yu
Regional Director, Government Relations & Partnerships Mitacs

Panelist: Prasoon Adhikari Manager, Sanitary and Stormwater Utilities Infrastructure Services Department City of Kitchener

Panelist: Dr. Genevieve Peters
Director of Research ECO Canada

Conference Networking

February 23, 3:30 - 4:30 pm

Conference networking can be overwhelming! You've prepared your elevator pitch, researched key attendees, and now it's time to put yourself out there. But what if you struggle to start conversations? How do you network with other academics who don't share your expertise? What if you miss an opportunity to connect with someone important? In this session, you'll hear from experienced researchers about how to network and have an opportunity to establish relationships with fellow water quality experts that will grow throughout the conference.

Dr. Stephanie Gora
Assistant Professor, York University

Brian Mahayie Waters
Geography Ph.D. Candidate, York University

60th Central Canadian Symposium on Water Quality Research

Toronto Metropolitan University Student Centre
63 Gould Street, Toronto, ON Canada M5B 1E9

Time	February 24		
8:00	**Sign up and Coffee** The Courtyard Lounge		
8:30	**Opening Remarks - Dr. Rania Hamza, Dr. Roberta Iannacito-Provenzano, Dr. Steven Liss, Dr. Stephen Waldman, Dr. Banu Örmeci, Dr. Elsayed Elbeshbishy** Tecumseh Auditorium		
9:15	**Keynote - Dr. Art Umble** Tecumseh Auditorium		
	Technical Session - Chair: Adriano Mena Oakham Lounge **Innovations in sustainable water management**	**Technical Session** - Chair: Stephanie Gora Thomas Lounge **Water quality Monitoring, Advanced Analytics, Drinking Water Treatment and Public Health**	**Technical Session** - Chair: Parin Izadi Tecumseh Auditorium **Advancing Wastewater Process Intensification: Innovations for a Sustainable Future**
10:00	**Effects of Smart Blue Roof Adoption on Stormwater Management Pond Performance, Afsana Alam Akhie (TMU)***	**Evaluating UV-LEDs for Decentralized Rainwater Treatment in Peri-Urban Communities in Mexico, Karlye Wong (UofT)***	Intensification of the mainstream anammox process using an inverse fluidized bed bioreactor: process performance and kinetics, George Nakhla (WesternU)
10:15	**Rainwater Harvesting Systems in Quebec: Water quality and system characterization, Niloufar Naserisafavi (Polytechnique Montreal)***	**Exploring the Use of UV Disinfection for Drinking Water Safety in Humanitarian Settings, Patrick Di Falco (YorkU)***	
10:30	**Innovative Solutions for Biofilm Removal: Using UV-AOP Technology to Mitigate Biofilm in Water and Wastewater Applications, Yiqian Wu (YorkU)***	**Leaching of Organotin Compounds from Polyvinyl Chloride (PVC) Pipe, Juan Li (UofT)***	Aeration Strategy for BNR Simultaneous Nitrification Denitrification: STAR Control offers Flexibility, Mehran Andalib (EnviroSim)
10:45	Advancing reuse via cryopurification, Daria Popugaeva (University of Western Ontario & Core Geoscience Services Inc.)	**Quantifying the impact of cryogenic landslides on lakes in the eastern Mackenzie Delta NT, Canada, Victoria Carroll (YorkU)***	Intensification of Ozone-Based Disinfection and AOPs with the MITO3X Technology: A Low-Capex Solution for Canadian Small and Remote Communities, Ted Mao (MW Technologies)
11:00	Advancing communication strategies on reuse, Stephanie Schouldice (City of Guelph/Royal Roads University)	**Impact of silver-stabilized hydrogen peroxide on Salmonella enterica serovar Typhimurium interactions with Acanthamoeba castellanii, Stefania Conforti (TMU)***	**Biological Aggregates in Low-Strength Wastewater Treatment: Lessons from 600 Days of Operation , Fatima-zahra Ezzahroui (TMU)***
11:15	Textile Wastewater Effluents: Impact on Ecosystem and Remediation Approaches, Adedapo Adeola (YorkU)	**Revisiting the Choices of Probe Compound Used in Measuring the Hydroxyl Radical Scavenging Capacity of Water in UV/H2O2 System, Zhijie Nie (UofT)***	Enhancing Anaerobic Digestion Efficiency with IntensiCarb™: A Breakthrough in Solids Treatment, Domenico Santoro (USP Technologies)
11:30	Policy Perspetives On Water Reuse Implementation, Faisal Haq Shaheen (TMU)	**Silver-Stabilized Hydrogen Peroxide: A Sustainable and Effective Solution for Hot Water Pathogen Control, Nate Clark (TMU)***	Machine Learning Applications for Sustainable Wastewater Treatment, Ahmed AlSayed (Veolia)
11:45	Panel Discussion	Panel Discussion	Panel Discussion
12:00	**Lunch** ** Tecumseh Auditorium		

***Student Presenting Authors**

** **CAWQ General Annual Meeting - Oakham Lounge**

CAWQ ACQE

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Toronto Metropolitan University

Time	February 24		
13:00	**Keynote - Dr. Robert Andrews** Tecumseh Auditorium		
	Technical Session - Chair: Indra Maharjan Oakham Lounge **Advancing Net Zero Wastewater Systems through Integration of Innovation and Resource Recovery**	**Technical Session** - Chair: Hussain Aqeel Thomas Lounge **Emerging Contaminants and Microplastics**	**Technical Session** - Chair: Satinder Kaur Baur Tecumseh Auditorium **Wastewater as a Source of Water, Energy, and Nutrients**
13:45	Anaerobic digestion: driving process intensification and biogas upgrading for sustainability, Bipro Dhar (UAlberta)	**Accumulation of antibiotics in the environment: Have appropriate measures been taken to protect Canadian human and ecological health? Oluwatosin Aladekoyi (TMU)***	The Essential Use Concept: A Regulatory Approach to Manage PFAS in Wastewater, Patricia Hania (TMU)
14:00	Using Wastewater Energy Recovery to Decarbonize Toronto Western Hospital, Ed Rubinstein (Noventa Energy)	**Closed-Loop Reverse Osmosis with VUV Photolysis for the Removal of Pharmaceuticals and PFAS from Water Systems, Ehsan K. Nazloo (Western U)***	Water Reuse and Recycling in Canada: Yuck Factor, Prosumers and Future Perspectives, Ratul Kumar Das (York U)
14:15	Durham Region's GHG Roadmap for Water and Wastewater Systems, Joseph Green (Durham Region)	**Evaluating Fluoride Mass Balance and Foam Formation as Indicators of PFAS Destruction in Electrooxidation Treatment of Contaminated Leachate, Omar Mohamed (WesternU)***	Microfiber-Induced Effects on Wastewater Treatment and Aerobic Granule Formation in Sequencing Batch Reactors, Victoria Onyedibe (TMU)
14:30	Toronto Water's GHG Reduction Journey, Emily Zegers (City of Toronto)	**Isolation of Microplastics in Drinking Water Using Density Separation, Wanzhen Chen (UofT)***	**The Role of Soil Hydrogeology in Oxygen Availability and Nitrogen Removal Efficiency in Onsite Wastewater Soil Treatment Units, Sorour Sheibani (Polytechnique Montreal)***
14:45	**Methane Monitoring at WWTPs: Choosing the Right Sensors for Emissions Monitoring, Omar Abdelrahman (TMU)***	**The Role of Microplastic Biofilms in Disseminating Antibiotic Resistance: Insights from Metagenomics and Targeted Chemical Analysis, Maryam Zarean (YorkU)***	**Enhancing Methane Production from Thickened Waste-Activated Sludge: Evaluating YDRO Bioaugmentation and Hydrothermal Pretreatment, Meagan Morrow (TMU)***
15:00	**N2O Emissions in a Full-scale Wastewater Treatment Plant: Effects of Flow Models and Key Operational Parameters, Marwan El Saleh(TMU)***	**Analyzing the potential of wastewater microorganisms to degrade or deteriorate cotton, cotton denim and polyester microfibers, Fatima Ahmed (TMU)***	Optimizing thermophilic biomethanation plant set up for municipal sludge treatment in Quebec City: Lesson learnt, Bikash Ranjan Tiwari (YorkU)
15:15	Improving Water Treatment Resilience and Sustainability with Biological Treatment, Hayat Raza (Continental Carbon Group)	Wastewater Surveillance for Tracking Temporal Dynamics of Beta-lactam Resistance Genes, Influenza A, and SARS-CoV-2 at two Wastewater Treatment Plants and a University Campus, Hassan Waseem (Carleton University)	Comparing Biomethane Production from Different Industrial Wastes: Effect of Substrate Type and Food- to- Microorganism (F/M) Ratio, Ahmed El Sayed (TMU)
15:30	Panel Discussion	Panel Discussion	Panel Discussion
15:45	**Coffee and Posters**		
16:15	**3MTs** - Chair: Farshad Dabbaghisouraki Tecumseh Auditorium		
17:00	Break for Student Awards Deliberations		
17:30	**Awards and closing** Tecumseh Auditorium		

***Student Presenting Authors**

Poster Presentations championed by Dr. Stephanie Gora

1. Algal Bacterial Granular Sludge: An innovative addition on the Aerobic Granular Sludge treatment system, **Nada Hosni**, TMU
2. Impact of Nutrient Limitation Conditions on Suspended Biofilms and Biomass and Associated Nitrous Oxide Emissions, **Bianca Lino Wozniak**, TMU
3. Comparing the adsorption to desorption capacity of aerobic granular sludge (AGS): Four per and polyfluoroalkyl substances (PFAS), **Ani Memuduaghan**, TMU
4. Adsorptive Removal of Long-Chain Perfluoroalkyl Carboxylic Acids Using Biochar: A Study on Efficiency and Predictive Modeling, **Sepideh Nasrollahpour**, York U
5. Digesting Data: How Machine Learning is Transforming Anaerobic Digestion, **Nesma Ahmed**, TMU
6. Enhanced subsurface remediation of BTEX through geothermal heating and bioremediation, **Ginelle Aziz**, York U
7. Biodegradation of Polycyclic Aromatic Hydrocarbons by Bacillus megaterium in Aquatic Environments, **Khyati Joshi**, York U
8. Detection of microplastics in wastewater sludge using Laser direct infrared imaging (LDIR) technique. **Juviya Mathew**, York U
9. Swan Lake Citizen Science Lab: Enhancing Water Quality by Connecting Science, Technology, Environment and the Community, **Peyman Naeemi**, York U
10. Comparing Biomethane Production from Different Industrial Wastes: Effect of Substrate Type and Food- to- Microorganism (F/M) Ratio, **Ahmed El Sayed,** TMU

NOTE: Grab a coffee and join us for a poster display at 15:45! Presenters will be available to share insights and answer your questions.

Three Minute Thesis (3MT) Presentations championed by Dr. Farshad Dabbaghisouraki

1. Algal Bacterial Granular Sludge: An innovative addition on the Aerobic Granular Sludge treatment system, **Nada Hosni**, TMU
2. Impact of Nutrient Limitation Conditions on Suspended Biofilms and Biomass and Associated Nitrous Oxide Emissions, **Bianca Lino Wozniak**, TMU
3. Investigation of geothermal heating impacts on BTEX biodegradation in soil under cyclic fluctuating temperature,**Gurpreet Kaur**, York U
4. Nutrient Polishing of Municipal Wastewater: A Start-up Study Using a Novel Internally Illuminated Algal Photobioreactor, **Siena Ianni-Palarchio**, Western U
5. The Influence of Diet on the Uptake, Bioaccumulation, and Depuration of Microplastics in Daphnia magna, **Sejal H. Dave**, York U
6. Comparing the adsorption to desorption capacity of aerobic granular sludge (AGS): Four per and polyfluoroalkyl substances (PFAS), **Ani Memuduaghan**, TMU
7. Seasonal Water Access and Informal Markets: Insights from Freetown's Urban Communities, **Brian Waters**, York U
8. Exploring Operational Boundaries in Low Oxygen Activated Sludge Systems for Municipal Wastewater Treatment, **Fatima-zahra Ezzahraoui**, TMU
9. Quantifying the impact of cryogenic landslides on lakes in the eastern Mackenzie Delta NT, Canada, **Victoria Carroll**, York U
10. Enhancing Methane Production from Thickened Waste-Activated Sludge: Evaluating YDRO Bioaugmentation and Hydrothermal Pretreatment, **Meagan Morrow**, TMU
11. Digesting Data: How Machine Learning is Transforming Anaerobic Digestion, **Nesma Ahmed**, TMU
12. Assessment and Design of Treatment Alternative for a Wastewater Treatment Plant in Toronto, **Sarah Gardiner**, TMU
13. From Food to Fuel: Tailoring Microbial Diversity for VFA Production, **Reema Kumar,** York University.

ABSTRACTS

Innovations in sustainable water management

Chair: Adriano Mena

Oakham Lounge

Effects of Smart Blue Roofs Adaptation Levels on Stormwater Management Pond Sizing

Afsana Alam Akhie[1] and Darko Joksimovic[1]

[1] *Department of Civil Engineering, Toronto Metropolitan University, 350 Victoria St.,Toronto, ON M5B 2K3, Canada*

In 2024, the City of Mississauga experienced two severe storms that caused emergency flood conditions, including inundated streets. Rainfall in certain areas reached up to 115 mm during the first event on July 16th and 112.20 mm during the second event on August 17th. To manage stormwater runoff from such a largely commercial and industrial area, Saigon Park stormwater management pond (SWMP) was built in 2020 on around 5.31 ha area at the head of the Cooksville watershed stream. With a capacity to hold approximately 250,000 m3 of water, the SWMP was designed in 2016 using a dual drainage system connected to the head of Cooksville Creek. However, only minor drainage system runoff with a return period of up to 10 years is transported to the pond. Surface overflow that exceeds pipe capacity during longer return period storm events (up to 100 years) is conveyed via the major drainage system. The objective of the study was to investigate the potential impacts of adopting Smart Blue Roofs (SBRs) in the Saigon Park drainage area, the concept that is currently implemented and monitored at the Credit Valley Conservation headquarters. After revising the sub-catchment imperviousness to reflect catchment changes since construction, the case study deployed SBR networks on commercial building roofs in the drainage area in conjunction with existing SWMP at varying adoption rates (0%, 25%, 50%, 75%, and 100%). The Saigon Park SWMP is modeled as a storage node on PCSWMM using pond head level and total inflow as key validation parameters. The model was evaluated utilizing 24-hour Chicago design storms for 2, 5, 10, 25, 50, and 100-year return periods, using SBRs with 50 mm storage that were assumed to be empty at the onset of the events, and drain valves closed for their durations to retain all roof runoff effectively. The model outcomes showed that all events could be efficiently confined within the existing SWMP, reducing the required pond depth and footprint by up to 1.5 m and 0.5 ha, respectively, with 100% SBR adoption in the event of a 100-year storm, as opposed to the existing system. The study also tested the model for the July 16th and August 17th storm events, considering the existing SWMP system and network of SBRs combined with the SWMP. The existing system resulted in flooding of downstream roads during the events, at reported times and locations from images on social media. Water levels at relevant sites were validated using Google Earth and LiDAR contour data, and successfully replicated using the existing conditions model. The study demonstrates that applying SBRs may greatly reduce the required storage capacity of SWMPs, hence lowering the area requirements for a traditional design that will result in lower land acquisition and excavation costs. SBRs can be strategically integrated on site to control water at its source and deliver water conservation advantages. In the long term, this can assist in extending the pond's service life by lowering sediment loads and lowering maintenance costs.

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Rainwater Harvesting Systems in Quebec: Water quality and system characterization

N. NASERISAFAVI[1]*

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Rainwater harvesting systems (RWHS) are structural climate change adaptation measures to control runoff after heavy rainfall events and provide a primary water source for non-potable usage. In Canada, RWHSs are becoming increasingly popular in large buildings and some municipalities also require the installation of RWHS for new residential buildings. There is however limited guidance on the proper design, operation, and maintenance of the systems, leading to uncertainties about the harvested water quality and the associated health risks. The study objective is to evaluate the impact of systems' treatment and design features to establish practices for broader adoption of RWHSs. Repeated sampling was conducted in three residential and two large building RWHSs (a total of 80 samples). Water quality parameters (pH, turbidity, organic carbon, Legionella pneumophila, coliforms, E. coli, heterotrophic plate count (HPC), and metals) were assessed for all samples. Furthermore, continuous water flow and tank level monitoring was performed in the three residential RWHSs. Concerning the treatment technology, residential systems have a 5-micron filter and an activated carbon filtration unit, while large buildings utilize sand filter treatment and chlorination. Large buildings included <1 MPN total coliforms and E. coli per 100ml, while residential systems harbored up to 3,180 MPN/100ml coliforms and 630 MPN/100ml E. coli, reflecting the potential effect of chlorination. Higher levels of chromium (0.4 ug/l) and lead (2.7 ug/l) were detected in rainwater compared to municipal water for both residential and large buildings. However, the detected metal elements were within the limits set by Health Canada's Guidelines for Canadian Drinking Water Quality. Dissolved organic carbon ranged from 0.64 mg/L to 7.14 mg/L. However, a slight reduction was observed after treatment for both types of buildings. Residential systems are being further investigated to assess the impact of ozonation.

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Innovative Solutions for Biofilm Removal: Using UV-AOP Technology to Mitigate Biofilm in Water and Wastewater Applications

Y. WU [1*], S. GORA [1], A. ELDYASTI [1]
[1]*YorkU*

Biofilms are ubiquitous in aquatic environments. However, biofilms attached to pipelines have increasingly been recognized as a potential health hazard and a challenge to traditional UV disinfection. Extracellular polymeric substances (EPS), a critical component of biofilms, form a protective barrier that enhances biofilm resistance to UV damage. The EPS matrix shields embedded bacteria via various mechanisms including: (1) increasing the UV path length, (2) scavenging reactive oxygen species (ROS), (3) absorbing UV through pigments, and (4) scattering light with inorganic particles. This comprehensive literature review examined the integration of UV and advanced oxidation processes (AOPs) for biofilm control on wetted surfaces, focusing on five representative UV-AOP technologies: (1) UV/H2O2, (2) UV/O3, (3) UV/PMS and UV/PDS, (4) UV/HOCl, UV/ClO2, and UV/NH2Cl, and (5) UV/TiO2. The mechanisms underlying biofilm control and the applications of these technologies for biofilm control in various industries in recent years were analyzed. This review underscored the need for tailored strategies to address biofilm-related challenges and highlighted the potential of UV-AOP for biofilm control in water infrastructure applications. The main outcome of this review was an energy consumption model, EE/O-Surface, specifically designed for UV and UV-AOP surface disinfection and biofilm inactivation.

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Textile Wastewater Effluents: Impact on Ecosystem and Remediation Approaches

A. ADEOLA [1*], S. GORA [1]
[1]*Safe and Sustainable Water Research Group, Department of Civil Engineering, York University, Toronto, ON, M3J 1P3, Canada.*

The growth of the textile/fashion industry contributes to water pollution in many countries in the Global South, particularly through the discharge of hazardous wastewater. Textile production processes include several steps such as washing, scouring, bleaching, and dyeing, and the effluents that are generated often contain dyes, heavy metals, surfactants, and other toxic trace compounds. These hazardous compounds threaten aquatic ecosystems and public health, leading to loss of biodiversity, genotoxicity, oxygen depletion in water bodies, death of aquatic fauna and upon human exposure may cause cancer. Conventional wastewater treatment plants employ several processes to facilitate water reclamation and reuse, yet challenges persist due to the recalcitrance of most synthetic dyes and other emerging contaminants. Advanced treatment technologies, such as UV advanced oxidation processes (AOPs), adsorption, nanofiltration, bioremediation, amongst others, offer promising solutions for sustainable textile wastewater management. This presentation examines existing treatment methods, highlights emerging trends, and discusses innovative pathways for improving textile wastewater treatment. Addressing current drawbacks in existing technologies is crucial to protecting ecosystems, preserving water reusability, and promoting eco-sustainability in the textile industry.

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Water quality Monitoring, Avdanced Analytics, Drinking Water Treatment and Public Health

Chair: Stephanie Gora

Thomas Lounge

Evaluating UV-LEDs for Decentralized Rainwater Treatment in Peri-Urban Communities in Mexico

K. WONG[1*], R. HOFMANN [1], A. BILTON [1], Y. CHEN [1], M. LIEDO [2]

[1]*University of Toronto*
[2]*Isla Urbana, Mexico*

Access to safe drinking water remains a critical challenge in decentralized settings, particularly in low- to middle-income and rural communities that rely on rainwater and intermittent water supplies. In these settings, the availability and acceptance of chlorine can be limited. Ultraviolet light-emitting diodes (UV-LEDs) offer a potential resilient disinfection solution due to their theoretical long service life (perhaps 10+ years), solar compatibility, and possible affordability. UV-LEDs are a recent technology and there is an absence of reported data on real-life performance under these field conditions. In collaboration with a Mexico City-based social enterprise, Isla Urbana, this research investigates UV-LED disinfection for harvested rainwater of POE-treatment in peri-urban Mexican households and schools. Over the course of 24 months, the study evaluates 10 UV-LED pilot systems with 20 control households using chlorination. Preliminary analysis indicates a 100% reduction in E. coli in households using UV-LED (n=10) at the point of use (POU), whereas households using chlorination revealed discrepancies in perceived and actual water safety. While 81% of chlorinating households expressed confidence in water safety post-chlorination, only 7% (n=26) were found to have a free chlorine residual above 0.1 ppm at the POU. Ongoing monitoring, water quality testing, user feedback, and maintenance evaluations, have highlighted key barriers to adoption and effective system performance. This research aims to offer guidance and recommendations on the assessment and implementation of innovative water technologies, like UV-LED. Initial long-term results have provided valuable insights on system configuration, maintenance protocols, and practical approaches to evaluate performance in field settings. These findings will aim to contribute research-informed policy recommendations to promote resilient, sustainable, and scalable water safety in diverse decentralized communities in Latin America and globally.

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Exploring the Use of UV Disinfection for Drinking Water Safety in Humanitarian Settings

Authors: Patrick Di Falco[1] , Ahmed Eldyasti[1] , Syed Imran Ali[1,2] , Stephanie Gora[1]

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[2]*Dahdaleh Institute for Global Health Research, York University, Toronto, Ontario, Canada*

Drinking water safety is often threatened by microbial contamination in humanitarian settings, resulting in an increased risk of water-related disease outbreaks. While water is often treated at a centralized location, recontamination can occur during collection, transport, and storage at the household level, presenting a significant public health risk. Household water storage containers, such as jerrycans and buckets, can harbour microorganisms either in a planktonic phase (suspended in water) or through surface attachment (biofilms) contributing to recontamination of previously treated water. To clean water storage containers, containers may be scraped with abrasive materials such as stones, rinsed with soapy water or bleach/chlorine, and/or scrubbed with brushes. While these methods are better than none at all, they may not be enough to properly disinfect containers and prevent recontamination. Germicidal ultraviolet (UV) light is an efficient and environmentally friendly disinfection method that can provide passive protection against microbiological recontamination of household stored water in humanitarian settings. Absorption of UV photons by microorganisms in water and biofilm damages DNA and suppresses further growth. This method has demonstrated effectiveness for drinking water protection in controlled laboratory and urban infrastructure contexts, but is yet underexplored in humanitarian setting and offers considerable potential as a water safety solution.

A fundamental factor in UV disinfection is delivering an adequate amount of UV radiation to as much of a storage container as possible. If specific areas inside a container do not receive UV light (known as "dead zones"), complete disinfection cannot occur. We analyzed how UV light propagates through storage containers, where dead zones exist, and how much irradiation is received at specific areas of interest. We conducted this analysis using *TracePro*, a 3D modelling software that simulates the emittance of light from UV sources and the incidence of UV light at different surfaces inside storage containers. The two main modes of UV disinfection examined included a conventional setup, where a UV device was positioned at the mouth/opening of the container, and a modified setup, where a UV device was inserted into the mouth/opening of the container. Preliminary results demonstrate that the maximum irradiance of incident flux in the conventional setup measured 0.108 mW/cm^2 while the modified setup measured 2.80 mW/cm^2 . Additionally, the modified setup allowed this irradiance to be distributed over a larger area, overcoming the geometric obstructions preventing the conventional setup from achieving similar results. These results suggest that the modified setup possesses greater disinfection potential than the conventional setup for containers. Next steps for evaluating the potential for UV disinfection in household water storage containers include exploring different container geometries, materials, surface properties, and UV light metrics, as well as verifying the results of modelling through lab experiments inoculating containers with microorganisms to analyze the efficiency of UV disinfection in water storage containers.

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Leaching of Organotin Compounds from Polyvinyl Chloride (PVC) Pipe

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Many drinking water utilities are now replacing aging cast- and ductile irone pipe with polyvinyl chloride (PVC) which is less expensive and easier to install. During manufacturing, a range of chemicals are added to PVC pipe material in order to provide oxidation resistance, flexibility, and durability. However, some added chemicals may be toxic and potentially leach into water. Certification standards such as NSF/ANSI 61 exist to address the leaching of chemical additives. However, previous work has shown that leaching of chemicals, including organotin (OT) heat stabilizers, may be accelerated under operational conditions which are not considered in certification tests, such as the presence of chlorine and at higher pH levels. Consequently, concern exists that the potential leaching of OT compounds may be underestimated. In this study, leaching of several chemical additives including mono- and dibutyltin was assessed for a range of PVC pipe types which conform to AWWA pipe specifications C900 and C909. In addition, free chlorine concentrations of up to 4 mg/L were applied to simulate the maximum allowable in distribution systems. Leaching trials were conducted using previously designed pipe section reactors (PSRs) for periods up to 2 weeks; samples were collected at several intervals during the first 24 h, as well as daily. Subsequent analyses were conducted using liquid and gas chromatography-mass spectrometry to identify a range of chemicals. Results suggest that leaching of organotins increases in both the presence of chlorine as well as following a typical pipe disinfection procedure that is employed in North America following installation. In contrast, a standard static extraction procedure described by NSF/ANSI 61 did not produce organotin leaching. As such, some existing certification standards may not accurately represent the leaching of chemical additives from PVC pipe due to the lack of consideration for disinfection practices.

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Quantifying the impact of cryogenic landslides on lakes in the eastern Mackenzie Delta NT, Canada

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Enhanced warming in Canada's northwest is driving geomorphological change caused by permafrost thaw. Cryogenic landslides, a consequence of thaw, are mass movement features that can have significant physical, chemical, and biological implications to low-lying waterbodies. The Caribou Hills, located along the eastern edge of the Mackenzie Delta (NT), are subject to near-surface permafrost thaw during extreme summer temperatures and precipitation events. Due to the steep elevation gradient between the delta and hills, the region is an optimal geography for cryogenic landslide development. In July 2023, we visited three lakes at the base of the Caribou Hills, all of which had experienced cryogenic landsliding to varying degrees, along with one control lake. At all study lakes we collected sediment cores and landslide grab samples which were analyzed for mercury, carbon, and nitrogen content. By directly comparing the pulses observed in the sediment core with the values of the grab samples, we estimate if terrestrial landsliding drove elemental shifts. Mercury values in some cores showed a coincident increase of concentration during landsliding. These concentrations fell just below the interim sediment quality guidelines developed by the Canadian Ministers for the Environment. Carbon-to-nitrogen ratios, a proxy for organic carbon source, also marked upward shifts in response to landslide events. Elemental loading from permafrost degradation poses serious threats to water quality, particularly of mercury and its potential human health impact. Understanding how waterbodies respond to shifts in elemental concentrations is vital as they can further affect local communities, wildlife, and future environmental processes. This research adds to pan-Arctic efforts to understand permafrost thaw impacts on aquatic environments and provides valuable context to land users and ecosystem managers to interpret changes in northern waterbodies impacted by permafrost thaw.

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Impact of silver-stabilized hydrogen peroxide on Salmonella enterica serovar Typhimurium interactions with Acanthamoeba castellanii

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Chlorine has served as the gold standard for drinking water disinfection for over a century. Although chlorine has played a pivotal role in protecting society from waterborne diseases, it produces toxic disinfection by-products and chlorine-resistant bacteria can survive water treatment, negatively impacting the safety and quality of drinking water. Bacteria may also survive drinking water disinfection through survival and protection within Acanthamoeba species. Acanthamoeba species are more resistant to disinfection than bacteria and several species of pathogenic bacteria can survive and replicate within amoebae, such as Legionella pneumophila and Salmonella enterica serovar Typhimurium. For L. pneumophila, intracellular growth within Acanthamoeba is well-documented and it is known that the amoeba serves as a reservoir. However, while there is evidence of S. Typhimurium intracellular survival, some reports have demonstrated that it also grows intracellularly within amoebae, while others have reported that the amoeba supports the growth of S. Typhimurium in co-culture, but do not suggest that the growth is intracellular. Further, S. Typhimurium has also been reported to be cytotoxic to Acanthamoeba species. The mixed reports on S. Typhimurium interactions with Acanthamoebae suggest that the interactions between these two organisms are complex and not completely understood. The survival of bacterial pathogens within Acanthamoeba during chlorination suggests that the amoeba provide a protective intracellular habitat for bacteria and serve as an environmental reservoir/host. This has led to the hypothesis that Acanthamoeba may facilitate the transmission and persistence of bacteria in water- and food-related environments. Thus, it is important that we understand their interactions and investigate methods that may reduce their ability to interact with each other. Exposure of Salmonella to chlorine increases its uptake and survival time inside Acanthamoeba, suggesting that chlorine may enhance the ability of bacteria to survive within Acanthamoeba species throughout drinking water systems. Alternative disinfection strategies may inhibit bacterial survival and replication inside host species, while enhancing the effectiveness of drinking water disinfection and provision of safe drinking water. Silver-stabilized hydrogen peroxide (SSHP) is an effective microbial biocide that may be applied in drinking water treatment. This work investigated the impact of SSHP on the host-pathogen interactions between S. Typhimurium and Acanthamoeba castellanii. S. Typhimurium was exposed to a sublethal concentration of SSHP and placed in co-culture with A. castellanii. Imaging flow cytometry was used to determine the impact of disinfection on bacterial uptake into amoebae. We found that SSHP reduced the number of internalized S. Typhimurium within A. castellanii but increased the percentage of infected amoeba. In comparison, sodium hypochlorite (chlorine; NaOCl) did not impact internalization but increased the surface association of S. Typhimurium with A. castellanii. Using high-content screening, we found that S. Typhimurium growth in co-culture with A. castellanii appeared to be 'amoeba-associated' rather than strictly intracellular. Both SSHP and NaOCl reduced the replication of S. Typhimurium in co-culture with A. castellanii. Our work demonstrates that SSHP may serve as an alternative disinfectant that may reduce the survival and proliferation of bacteria within Acanthamoeba in drinking water systems.

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Revisiting the Choices of Probe Compound Used in Measuring the Hydroxyl Radical Scavenging Capacity of Water in UV/H2O2 System

Z. NIE[1*], R. HOFMANN [1]
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The UV/H2O2 process is the most widely used ultraviolet advanced oxidation process (UV-AOP) that relies on a nonselective, highly reactive and short-lived species, the hydroxyl radical (•OH), to degrade a variety of organic micropollutants oxidatively. The •OH concentration, which controls the efficiency of target micropollutants decay, depends on its production rate and the quenching rate at which •OH reacts with all the scavenging compounds in the water matrix. The latter is conventionally known as the •OH scavenging capacity of the water, which is a useful parameter in the design and operation of a UV/H2O2 system. The •OH scavenging capacity is typically determined by measuring the decay rate of a probe compound, which reacts selectively with •OH with a known reaction rate constant. However, there has been doubt about whether the commonly used probe compounds in these experiments are reliable. This study reviewed three probe compounds used in scavenging capacity measurement in UV/H2O2 systems and identified their potential errors in different water matrices. Bench-scale experiments were conducted using a quasi-collimated beam UV apparatus equipped with a low-pressure mercury lamp to measure the decay rate of the probe compounds under different testing conditions. Preliminary results have shown that the most popular probe compound, 4-chlorobenzoic acid (pCBA), can cause significant errors in the scavenging capacity results, leading to possible underdesign of the UV-AOP reactor. The two alternative probe compounds, nitrobenzene and methylene blue, have shown more reliability and robustness in complex water matrices. Based on the results, recommendations were made regarding the choice of probe compounds used in measuring the •OH scavenging capacity of water in the UV/H2O2 System.

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Silver-Stabilized Hydrogen Peroxide: A Sustainable and Effective Solution for Hot Water Pathogen Control

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The growing demand for sustainable water management requires solutions that enhance water quality and system adaptability while reducing water-related energy and healthcare costs. Chlorination is widely used to control microbes in distribution and plumbing systems; however, chlorine's rapid decay at high temperatures requires additional treatment in hot water networks (HWNs), such as maintaining temperatures above 60°C. Despite this, both methods often fail to control hot water pathogens like Legionella pneumophila. Moreover, hot water generation is highly energy-intensive, and chlorine's accelerated decay under these conditions increases toxic disinfectant byproduct (DBP) formation. This study examines silver-stabilized hydrogen peroxide (SSHP) as an alternative disinfectant to chlorine for HWNs. We investigated the effect of hot water temperatures on SSHP\'s biocidal efficiency against high L. pneumophila concentrations (1x10âµ CFU/mL). We examined how heat, inorganics, and organics individually affect the stability of chlorine and SSHP in a synthetic medium mimicking Toronto tap water. Additionally, we evaluated the impact of prolonged incubation at high temperatures on SSHP's effectiveness as a secondary disinfectant. SSHP's performance improved drastically with increasing water temperatures. At 35°C, 20 mg/L of SSHP achieved a >2-log reduction of L. pneumophila in under an hour, while the same reduction occurred in under 10 minutes at 45°C, and less than 5 minutes at 55°C. SSHP also demonstrated much greater stability in hot water than chlorine (Figure 1), maintaining high concentrations and full biocidal efficiency even after 3 days of incubation at 55°C. These findings suggest that SSHP is a promising alternative to chlorine for HWNs, offering improved L. pneumophila control, reduced DBP formation, and the opportunity to lower operating water temperatures where employed. Endnotes 1. Presenting author: Nate Clark, nate.clark@torontomu.ca a) b) Figure 1. The average percentage of the starting concentrations of SSHP and NaOCl remaining after 72 hours of incubation at 55°C in synthetic tap water containing organics. The organics used were a) tannic and b) humic acid, added to achieve a total organic carbon concentration of 1.4 mg/L. Note that in a) the lines for 2 and 4 mg/L of NaOCl overlap, as both decayed at the same rate regardless of their starting concentration. Data are presented as mean ± SEM.

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Advancing Wastewater Process Intensification: Innovations for a Sustainable Future

Chair: Parin Izidi

Tecumseh Auditorium

Intensification of the mainstream anammox process using an inverse fluidized bed bioreactor: process performance and kinetics

George Nakhla (WesternU)

The inverse fluidized bed bioreactor (IFBBR) is an emerging biofilm technology for biological wastewater treatment, offering significant potential for intensification. Despite its promise, development of the IFBBR stagnated in recent decades, hindered by challenges such as biomass overgrowth and reactor instability, particularly with fast-growing heterotrophic bacteria. This study presents the first successful application of the IFBBR for cultivating and sustaining slow-growing autotrophic anammox and ammonia oxidizing bacteria, enabling intensified mainstream nitrogen removal.

Over 200 days of continuous operation, a 2L IFBBR seeded with pure anammox bacteria achieved an exceptional nitrogen removal rate of 1.68 $kg/m^3 \cdot d$—almost triple the initial biomass activity of 0.63 $kg/m^3 \cdot d$ and surpassing performance metrics of practical sidestream nitrogen removal technologies, at hydraulic retention times as low as 10 hours. In a parallel IFBBR seeded with ammonia-oxidizing bacteria (AOB), 180 days of operation achieved 97% ammonia removal efficiency. The negligible in situ dissolved oxygen levels, combined with on-demand alkalinity and aeration, selectively enriched AOB and enabled a stable partial nitrification-anammox process. Off-line batch activity tests confirmed the absence of nitrifiers in the anammox IFBBR and the predominance of AOBs and to a much lower extent anammox in the partial nitrification IFBBR. This study redefines the operational and performance benchmarks of IFBBRs, showcasing their transformative potential as a next-generation solution for autotrophic mainstream nitrogen removal.

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Intensification of Ozone-Based Disinfection and AOPs with the MITO3X Technology: A Low-Capex Solution for Canadian Small and Remote Communities

Kourosh N. Esfahani, Ted Mao, Katherine Y. Bell. Domenico Santoro

Ozone-based Advanced Oxidation Processes (AOPs) are widely used for the degradation of persistent organic pollutants and pathogen inactivation in water treatment. However, ozone's low solubility and stability in water hinder mass transfer and reaction efficiency, particularly when coupled with chemistries like hydrogen peroxide or coagulants. This study integrates flow chemistry principles with high-pressure and high-mixing ozonation to address these limitations, utilizing the patented MITO3X® reactor. The reactor achieves ozone supersaturation and enhanced mass transfer efficiency (89% ± 2%) by leveraging high-pressure conditions and controlled bubble generation. Three experimental phases were conducted. First, hydraulic testing demonstrated stable performance at pressures up to 2.3 bar with flow rates of 18–200 L/min. Second, combined oxidation of model pollutants such as methylene blue (5.8 mg/L) and 4-chlorobenzoic acid (527.5 µg/L) achieved >90% degradation under optimized conditions, even in the presence of scavengers like nitrite (5 mg/L). Finally, the reactor's performance in challenging water matrices (10 mg/L TOC, 5 mg/L nitrite) showcased its ability to maintain high pollutant removal efficiency. This novel approach demonstrates significant process intensification by reducing residence time, minimizing reagent consumption, and achieving high pollutant removal efficiency. The MITO3X reactor offers a scalable, energy-efficient solution adaptable for diverse municipal and industrial wastewater treatment applications, redefining AOP technology.

Enhancing Anaerobic Digestion Efficiency with IntensiCarb™: A Breakthrough in Solids Treatment

Ali Khadir, Chris Muller, Ahmed Al-Omari, Kati Bell, George Nakhla, Farokh Kakar,
Elsayed Elbeshbishy, Domenico Santoro

Anaerobic digestion (AD) is a pivotal technology for renewable energy production and waste management. However, increasing treatment capacity within existing infrastructure poses significant challenges. IntensiCarb™, an innovative "bolt-on" intensification technology, addresses this by combining vacuum evaporation with anaerobic digestion or fermentation, enabling more than a fourfold increase in treatment capacity without the need for extensive infrastructure expansion.

Developed through a collaborative effort involving USP Technologies, Trojan Technologies, Brown and Caldwell, the University of Western Ontario, Toronto Metropolitan University, the Great Lakes Water Authority (GLWA), and Dynamita, with funding support from the Natural Sciences and Engineering Research Council of Canada (NSERC) and Next Generation Manufacturing Canada (NGEN), IntensiCarb ™ represents a significant advancement in the efficiency and sustainability of solids treatment.

The technology's efficacy has been recognized internationally, receiving the Bronze IWA Project Innovation Award in the category of Breakthroughs in Research and Development at the IWA World Water Congress & Exhibition in Toronto, Canada, on August 13, 2024.

A pilot implementation of IntensiCarb™ is scheduled with GLWA in Detroit, Michigan, early next year, aiming to validate its performance in a real-world setting.

This presentation will delve into the development and operational principles of IntensiCarb™, its integration into existing AD systems, and the anticipated benefits in terms of increased capacity and cost-effectiveness. Attendees will gain insights into how this technology can be applied to enhance the performance of anaerobic digestion processes, contributing to more efficient and sustainable waste treatment solutions.

Machine learning applications for sustainable wastewater treatment

Ahmed AlSayed, PhD
Veolia Water Technologies and Solutions

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Advancing Net Zero Wastewater Systems through Integration of Innovation and Resource Recovery

Chair: Indra Maharjan

Oakham Lounge

Anaerobic digestion: driving process intensification and biogas upgrading for sustainability

Bipro Ranjan Dhar

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

In recent years, research and development focus on anaerobic digestion (AD) has expanded significantly toward broader goals of process intensification, decarbonization, and resource recovery, establishing AD as a focal point in organic waste and high-strength wastewater management within the framework of the circular bioeconomy. As a result, emerging strategies such as nanobubble technology and microbial electrolysis/electrosynthesis have gained momentum, presenting promising avenues to achieve these goals. Unlike microaeration, which has already been applied on a full scale for in-situ biogas desulfurization and boosting biogas, nanobubble technology has recently drawn considerable attention. Nanobubbles possess several unique properties, including a higher surface charge, surface area-to-volume ratio, longer stability, enhanced mass transfer efficiency and gas solubility than microbubbles. Studies have shown that supplementing nanobubbles in anaerobic digesters enriches hydrolytic bacteria and methanogens, enhancing AD process kinetics and biogas production. Conventional ex-situ biogas upgrading and desulfurization methods usually require high capital and operational costs, extensive infrastructure, and significant energy input. In contrast, microbial electrosynthesis systems offer a promising alternative for efficient biogas upgrading by implementing electroactive microbes to convert CO_2 in biogas into methane. This talk will provide an overview of our research efforts and key findings on these areas, and a future outlook on opportunities on advancing AD through these emerging technologies.

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Methane Monitoring at WWTPs: Choosing the Right Sensors for Emissions Monitoring

Omar Abdelrahman[a], Ahmed Elsayed[a], Ahmed AlSayed[b], Farokh Laqa Kakar[c], Katherine Y. Bell[c], Trung Le[c], Shannon Cavanaugh[c], John Willis[c], Elsayed Elbeshbishy[a]

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Greenhouse gases (GHGs) have significantly impact global climate change, with methane (CH_4) contributing significantly due to its high global warming potential. The Intergovernmental Panel on Climate Change (IPCC) reports a rise in global temperatures by 0.3–0.74°C, driven by both anthropogenic and natural sources (Liu et al., 2019; Hopwood et al., 2008; Solomon et al., 2010). Anthropogenic activities, including oil and gas, landfills, and wastewater treatment plants (WWTPs), account for approximately 70% of CH_4 emissions, with WWTPs emitting up to 25 Tg-CH_4 annually through processes such as anaerobic digestion, primary clarification, and waste gas burning (Wallington et al., 2019). To effectively detect and quantify CH_4 emissions, innovative sensor technologies are essential for addressing diverse sources, including leaks, process emissions, and dissolved CH_4. This study examines the application and performance of CH_4 detection and quantification sensors at WWTPs, including Metal Oxide Semiconductor (MOS) sensors, an open-path laser spectrometer (OPLS), and Optical Gas Imaging (OGI) cameras. The goal is to enhance CH_4 emissions monitoring through optimal sensor combinations.

The ground-based SOOFIE sensors, equipped with MOS technology, continuously measure CH_4 emissions with a sensitivity as low as 0.4 kg/h. Additionally, integrated sonic wind anemometers in select sensors allow for probable emissions source attribution using the SOOFIE sensors. The drone-mounted OPLS sensors quantify emissions using horizontal flight paths at varying altitudes (30–150 ft) downwind of emission points, detecting concentrations from 10 ppb to 5000 ppm, providing flexibility and exceptional spatial coverage. The OGI cameras detect CH_4 emissions based on infrared (IR) absorption. The Konica Minolta OGI identifies close-range and indoor emissions, while the drone-mounted Halo OGI monitors large and inaccessible areas. The multi-sensor approach effectively identified CH_4 sources at a Canadian WWTP. During a comparison test between the various sensors, the ground-based SOOFIE sensors recorded concentrations of 2.4 ppm near waste gas burners. The drone-mounted OPLS sensors detected higher concentrations up to 5.5 ppm due to their ability to monitor emissions at varying altitudes. The OGI cameras (Konica Minolta and Halo OGI), used for detection, pinpointed emissions and validated data collected by drones. The Konica Minolta OGI excelled at detecting small, localized emissions, while the Halo OGI provided broader outdoor coverage from larger emissions sources. Combining the OPLS drone with the Konica Minolta OGI camera proved optimal for CH_4 monitoring at WWTPs. The OPLS drone's mobility and sensitivity enabled comprehensive emissions data collection, while the Konica Minolta OGI effectively detects smaller point sources.

The SOOFIE sensors performed well for continuous monitoring but are limited by their fixed positioning in densely packed facilities. These findings equip plant operators with tools to identify emissions, enabling targeted interventions to reduce CH_4 emissions and mitigate environmental impacts.

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N2O Emissions in a Full-scale Wastewater Treatment Plant: Effects of Flow Modes and Key Operational Parameters

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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 (N2O) 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 N2O emissions from WWTPs. This study aims to quantify N2O emissions, identify the pathways responsible for N2O production, and link environmental factors and operational parameters to N2O 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 N2O 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 NH3 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 N2O emissions, while step-feed mode showed the lowest emissions. An average N2O emission rate, defined as the estimated mass of N2O, expressed as nitrogen (N- N2O), released into the atmosphere per unit time, was observed to be 3.696 kg N-Nâ••O/hr for the plug flow mode, 0.444 kg N- N2O /hr for the semi-plug flow mode, and 0.068 kg N- N2O/hr for the step-feed mode.

However, NOâ••â»and NOâ••â» accumulation in plug flow and semi-plug flow modes suggest incomplete nitrification and/or denitrification, further contributing to Nâ••O 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, N2O emissions, NO3 production rates, and DO levels are being compared across the three flow modes to determine if there are any significant differences.

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Improving Water Treatment Resilience and Sustainability with Biological Treatment

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Utilities continue to face new source water quality challenges from climate change and emerging contaminants that require more robust and flexible treatment. Biological water treatment processes have the potential to boost treatment resiliency, as well as improve the overall sustainability of water treatment processes by leveraging microorganisms found in natural water systems to biologically transform or degrade compounds. Utilities have begun looking to biological treatment to achieve more economical and sustainable treatment in surface water, groundwater, and reuse applications. In response, the AWWA Biological Drinking Water Treatment Committee has developed a new Manual of Practice (MOP80). The new guidance developed addresses each application of biological treatment providing an overview of the benefits and contaminants removed, guidance for planning and evaluating biological processes, design considerations, operations and monitoring best practices, and case studies where design criteria and performance is presented. The committee has also developed guidance on the differences between aerobic and anoxic biological processes, the history of how biological treatment has emerged and evolved, and the different stages of biological treatment operation. This session introduces participants to MOP80 and will focus on similarities and differences between the different forms of biological treatment and how biological treatment can be beneficial across a variety of water supply applications (surface water, groundwater and reuse).

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Emerging Contaminants and Microplastics

Chair: Hussain Aqeel

Thomas Lounge

Accumulation of antibiotics in the environment: Have appropriate measures been taken to protect Canadian human and ecological health?

O. ALADEKOYI[1*], S. SIDDIQUI [1], P. HANIA [1], R. HAMZA [1], K. GILBRIDE [1]

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In Canada, every day, contaminants of emerging concern (CEC) are discharged from waste treatment facilities into freshwaters. CECs such as pharmaceutical active compounds (PhACs), personal care products (PCPs), per-and polyfluoroalkyl substances (PFAS), and microplastics are legally discharged from sewage treatment plants (STPs), water reclamation plants (WRPs), hospital wastewater treatment plants (HWWTPs), or other forms of wastewater treatment facilities (WWTFs). In 2006, the Government of Canada established the Chemicals Management Plan (CMP) to classify chemicals based on a risk-priority assessment, which ranked many CECs such as PhACs as being of low urgency, therefore permitting these substances to continue being released into the environment at unmonitored rates. The problem with ranking PhACs as a low priority is that CMP's risk management assessment overlooks the long-term environmental and synergistic effects of PhAC accumulation, such as the long-term risk of antibiotic CEC accumulation in the spread of antibiotic resistance genes. The goal of this review is to specifically investigate antibiotic CEC accumulation and associated environmental risks to human and environmental health, as well as to determine whether appropriate legislative strategies are in place within Canada's governance framework. In this research, secondary data on antibiotic CEC levels in Canadian and international wastewaters, their potential to promote antibiotic-resistant residues, associated environmental short- and long-term risks, and synergistic effects were all considered. Unlike similar past reviews, this review employed an interdisciplinary approach to propose new strategies from the perspectives of science, engineering, and law.

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Closed-Loop Reverse Osmosis with VUV Photolysis for the Removal of Pharmaceuticals and PFAS from Water Systems

Ehsan K. Nazloo, Erin Mackey, Andrew Safulko and Domenico Santoro

Pharmaceutical contaminants in water pose significant environmental and health challenges due to their persistence and bioactivity. Conventional treatment methods, including high-pressure membranes like reverse osmosis (RO), effectively reject pharmaceuticals but generate concentrated waste streams requiring further treatment. Vacuum ultraviolet (VUV) photolysis offers a chemical-free approach to degrading contaminants but is typically constrained by low pollutant concentrations and extended treatment times. This study introduces an integrated pilot-scale system combining RO membranes with VUV photolysis for simultaneous physical separation and chemical degradation of a pharmaceutical mixture. The integrated system demonstrated enhanced degradation efficiencies within shorter timeframes compared to standalone VUV treatment. Pharmaceuticals such as acetaminophen (ACE), caffeine (CAF), and ciprofloxacin (CIP) exhibited significantly faster degradation in the integrated configuration due to pollutant concentration by RO, improving the likelihood of interactions with oxidants. This study highlights the potential of hybrid RO-VUV systems as a scalable, efficient solution for removing pharmaceuticals and other emerging contaminants from water, offering cleaner brine streams, reduced operational costs, and adaptability for municipal and industrial water treatment applications.

Evaluating Fluoride Mass Balance and Foam Formation as Indicators of PFAS Destruction in Electrooxidation Treatment of Contaminated Leachate

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Effective treatment of per- and polyfluoroalkyl substances (PFAS) in contaminated landfill leachate requires methods that confirm complete destruction of these persistent pollutants. In electrooxidation (EO) processes, fluoride ion release serves as a critical indicator of PFAS mineralization, providing direct evidence of PFAS destruction by monitoring the breakdown of the carbon-fluorine bonds unique to these compounds. This study investigates fluoride mass balance and foam formation as indicators of PFAS degradation and treatment efficiency. During EO treatment, fluoride production progresses through distinct phases: an initial lag phase where fluoride release is minimal as the PFAS compounds begin breaking down, followed by a rapid release phase where fluoride concentration increases significantly as more PFAS molecules are degraded, and finally, a stabilization phase where fluoride production slows as PFAS concentrations diminish. These phases in fluoride release patterns help assess treatment effectiveness in real time, ensuring that PFAS destruction progresses toward complete defluorination. Monitoring fluoride mass balance throughout these phases is thus essential for confirming that PFAS molecules are fully mineralized, with no partially degraded intermediates remaining. Foam formation emerges as a secondary indicator of PFAS degradation in the EO process. This phenomenon is driven by the surfactant-like properties of PFAS, which stabilize gas bubbles generated during electrooxidation, forming persistent foams. Foam formation is more pronounced at higher PFAS concentrations (>100 mg/L) and gradually diminishes as PFAS levels decrease, reflecting a reduction in surface-active compounds within the solution. Understanding foam formation dynamics is important in designing treatment systems, as excessive foam can impact operational stability, potentially requiring containment strategies to ensure smooth operation. The study's findings emphasize that fluoride mass balance serves as a robust, real-time indicator of PFAS destruction in EO systems, while foam formation provides supplementary insights into treatment progression. Together, these indicators provide a comprehensive framework for monitoring PFAS degradation, supporting EO as an effective, sustainable solution for managing PFAS-contaminated leachate and ensuring safe environmental discharge standards are met.

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Isolation of Microplastics in Drinking Water Using Density Separation

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Microplastics (MPs) have been widely reported in source and treated drinking waters, with sizes predominantly ranging from 1–20 μm. When conducting analyses, a major challenge is that MPs comprise only a small fraction of total organic and inorganic particles that are present in a sample. As such, it is critical to isolate MPs prior to spectroscopic analysis, as may be achieved via a range of oxidative, enzymatic, and acidification techniques. However, concern exists regarding the potential for these methods to alter the chemical composition of MPs. Specific chemical additives are typically added during the production of plastics, many of which have been shown to be primary drivers of toxicity. It is therefore imperative that the chemical composition of environmental MPs be maintained during isolation procedures such that they may be accurately characterized. Unfortunately, existing physical isolation methods have only been applied to particles >100 μm in size. The objective of this work was to develop a physical isolation technique that does not adversely impact the chemical characteristics of MPs, while at the same time removing extraneous non-plastic particulates. This is especially important when considering small particles (1-20 μm), representative of those commonly present in drinking waters. In this study, a range of density-based separation methods were evaluated in terms of recovery of known (spiked) MPs, as well as any changes in the composition of chemical additives. Two polymer types commonly reported in drinking water were considered (polyethylene and polyethylene terephthalate) to evaluate the performance of density separation methods. These included the use of sodium iodide, zinc chloride, and polyvinyl pyrrolidone (PVP). Findings from this work will allow microplastics to be separated from other particulates such that the composition of chemical additives will not be altered, allowing their identification in source and treated drinking waters.

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The Role of Microplastic Biofilms in Disseminating Antibiotic Resistance: Insights from Metagenomics and Targeted Chemical Analysis

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Research Background: Microplastic pollution poses a serious environmental threat, particularly in aquatic ecosystems. These particles (< 5mm) develop biofilms called \"plastisphere\" that harbor distinct bacterial communities. The key concern is that these biofilms may act as reservoirs for antibiotic-resistant bacteria (ARBs) and genes (ARGs), potentially increasing public health risks. In Canada, particularly Lake Ontario, wastewater treatment plants (WWTPs) are major microplastics and antibiotic-resistant bacteria sources. However, there\'s still limited understanding of how antibiotic-resistance genes impact Canadian aquatic ecosystems. Research Objectives: The study focuses on three objectives: (1) Antibiotic Contamination and Transformation (sulfonamides, tetracyclines, and β-lactams), analyzing seasonal variations in antibiotics and their transformation products in biofilms and WWTP effluents; (2) Quantification of ARGs, identifying and measuring the diversity and abundance of antibiotic resistance genes to assess their role in resistance dissemination; and (3) Microbial Community Composition, examining bacterial structures in biofilms and effluents to understand microbial diversity and ecological dynamics. Methodology: The research was conducted at three WWTPs in Ontario, Canada, selected for their diverse influent characteristics and treatment processes. HDPE, PP, PVC microplastics, and natural stones as controls were sterilized and submerged in secondary and final effluents for 60 days during both summer and winter to study biofilm colonization. Analytical methodologies included surface characterization using SEM, and the analysis of antibiotics and their transformation products using LC-MS/MS. Genomic techniques, including DNA extraction and metagenomic sequencing, were employed to identify ARGs and assess microbial diversity through alpha and beta diversity metrics, offering a comprehensive understanding of microbial ecology and resistance profiles. Preliminary Results: Key physicochemical parameters (DO, temperature, pH, TN, TP, TOC, COD) were measured to establish baseline conditions influencing biofilm formation and microbial activity. The method validation optimized LC-MS/MS parameters for 16 compounds, including sulfonamides, tetracyclines, and β-lactams. Calibration curves showed strong linearity ($R^2 > 0.95$), and recovery tests with spiked analytes confirmed the method's accuracy and SPE effectiveness in quantifying compounds. Biofilm colonization on HDPE, PP, PVC, and natural stones over 60 days revealed seasonal differences: denser, complex biofilms in summer due to higher microbial activity, and simpler structures in winter. Additionally, DNA extraction from all wastewater and biofilm samples is currently underway to prepare for metagenomic analysis, which will profile ARGs and bacterial communities. Conclusion and Future Work: This research establishes a foundation for understanding the interactions between antibiotics, ARGs, microbial communities, and transformation products in biofilms and WWTP effluents. Future efforts will focus on advanced genomic strategies to investigate resistance mechanisms, biomarker discovery for contaminant detection, and ecotoxicological assessments to evaluate health and ecological risks, aiming to enhance environmental management and water quality standards.

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Adsorptive Removal of Long-Chain Perfluoroalkyl Carboxylic Acids Using Biochar: A Study on Efficiency and Predictive Modeling

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The persistent nature and rising concentrations of long-chain perfluoroalkyl carboxylic acids (PFCAs) pose significant environmental challenges. This study focuses on the adsorptive removal of perfluorononanoic acid (PFNA) and perfluorodecanoic acid (PFDA) using biochar derived from wood and compost. Key variables such as biochar size, weight, and initial PFCA concentrations were analyzed to understand their effect on adsorption performance. The investigation further leveraged deep neural networks (DNNs) to predict adsorption efficiencies, addressing uncertainties in experimental data. Results highlight the superior efficacy of compost-derived biochar, attributed to its enhanced aromaticity and functional group availability. The study also confirms a correlation between PFCA chain length and adsorption efficiency, with PFDA exhibiting higher removal rates. Keywords Biochar, perfluoroalkyl carboxylic acid (PFCA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), Adsorption, Deep Neural Networks. Introduction Perfluoroalkyl and polyfluoroalkyl substances (PFAS), particularly long-chain PFCAs, have garnered attention due to their environmental persistence, bioaccumulation, and associated health risks. Traditional treatment methods, including oxidation and biological degradation, have limited effectiveness against these compounds due to the robustness of the carbon-fluorine bonds. Adsorption has emerged as a viable method for PFCA removal, with biochar being a promising low-cost alternative to activated carbon. This study investigates the adsorptive properties of biochars derived from wood and compost, with a focus on their application in removing PFNA and PFDA from aqueous solutions. Additionally, the use of DNNs provides a novel approach to predictive modeling in this context. Materials and Methods Biochar Preparation and Characterization Two types of biochar—wood-derived and compost-derived—were procured and characterized. Particle sizes ranged from 0.063 to 1 mm, and Fourier Transform Infrared Spectroscopy (FTIR) was used to analyze surface functional groups. Compost-derived biochar demonstrated higher aromaticity, while wood-derived biochar exhibited increased hydroxyl and carbonyl content. Adsorption Experiments Batch adsorption studies were conducted using 25 mg of biochar in 25 mL of water containing PFNA and PFDA at concentrations of 10, 100, and 500 μg/L. Adsorption efficiency was measured over time (up to 72 hours) using LC-MS/MS. Predictive Modeling Deep neural networks (DNNs) were implemented to model adsorption efficiency. Input variables included PFCA concentrations, biochar size, and weight. The models incorporated noise injection to account for experimental uncertainties, ensuring robustness and generalizability. Results and Discussion The compost-derived biochar outperformed wood-derived biochar in removing PFNA and PFDA, achieving adsorption efficiencies of up to 90.13% and 85.8%, respectively, at higher concentrations (500 μg/L). The superior performance of compost biochar is attributed to its higher aromaticity and abundance of functional groups like carboxyl and phenol, facilitating stronger π-π interactions and hydrogen bonding.

In contrast, the wood biochar exhibited lower efficiency due to less favorable surface chemistry. A clear chain-length dependency was observed, with PFDA showing higher adsorption than PFNA across all conditions. The longer chain of PFDA enhances hydrophobic interactions, contributing to stronger adsorption. Kinetic studies revealed rapid uptake within the first 10 hours, with equilibrium reached at 24 hours. PFDA showed faster initial adsorption rates, aligning with its stronger interaction potential. Deep neural network (DNN) models accurately predicted adsorption efficiencies, achieving R^2 values over 0.99. Sensitivity analysis highlighted biochar size and weight as critical factors, with optimal particle size balancing surface area and agglomeration effects. The results underscore the potential of compost-derived biochar as a sustainable adsorbent for PFCA removal. Future work should explore real-world applications, scalability, and integration with advanced degradation technologies. Conclusion This study demonstrates the potential of compost-derived biochar as an efficient adsorbent for long-chain PFCA removal. The integration of experimental data with machine learning models provides a powerful framework for optimizing water treatment processes. Future research should explore the scalability of biochar-based systems and investigate their performance in real-world conditions.

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Wastewater Surveillance for Tracking Temporal Dynamics of ?-lactam Resistance Genes, Influenza A, and SARS-CoV-2 at two Wastewater Treatment Plants and a University Campus

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The rise of antimicrobial resistance (AMR) and the ever-increasing prevalence of respiratory viruses pose serious public health threats, necessitating innovative wastewater-based epidemiology (WBE) strategies. We investigated the prevalence of selected ?-lactamase resistance genes and elucidated the complex interplay between AMR and respiratory viruses in wastewater. A total of three ?-lactamase resistance genes (blaGES, blaIMP-27, & blaOXA-48) one integrase gene (intI1), and two respiratory viruses (influenza A and SARS-CoV-2) were quantified. Real-time qPCR assays were used to detect the genes in untreated wastewater samples from two wastewater treatment plants (WWTPs) and a university campus in Ontario for five months. The absolute abundance of the antibiotic-resistant genes (ARGs) and intI 1 were of the order of 104 to 107, while influenza A reached up to 102 and SARS-CoV-2 up to 103 copies/ mL. Statistical analyses revealed significant differences in gene abundances across the sites, with blaIMP-27 showing the lowest detection frequency (12.1?27.6%), while blaGES and intI1 were detected in 100% of samples. Analysis of the 16S rRNA gene revealed distinct microbial community profiles across sites, with WWTP site 1 showing the lowest and the university campus showing the highest diversity. A surge in relative abundance of ARGs followed by the influenza A wave, particularly observed from November to December 2022, highlighting a potential link between viral activity and antibiotic resistance dynamics. Our research signifies the complex interplay between respiratory viruses and AMR, advocating integrated wastewater surveillance in public health strategies to manage infectious diseases and resistance proliferation effectively.

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Wastewater as a Source of Water, Energy, and Nutrients

Chair: Satinder Kaur Brar

Tecumseh Auditorium

Podium: The Essential Use Concept: A Regulatory Approach to Manage PFAS in Wastewater

Dr. Roxana Suehring & Dr. Patricia Hania,
Toronto Metropolitan University

In this paper, we explore the question: How and in what ways, can the 'essential use' concept be aligned with Canada's regulatory system (i.e., the recent amendments to Canadian Environmental Protection Act, 1999) in order to manage PFAS and create a sustainable chemical management approach that protects human health, the environment, wildlife, and biota?

PFAS containing products and raw materials are widely used in Canada. The ubiquitous nature of PFAS within the environment has led Environment and Climate Change Canada (ECCC) and Health Canada (HC) to conclude that Canadians are being exposed to PFAS through drinking water, dermal contact, as well as food. A particular pathway of concern is water treatment plants and the challenge of removing of PFAS resulting in the legal discharge of PFAS contaminated effluent streams. This means that these highly persistent chemical compounds are released into Canada's freshwater and drinking water sources, where they can remain as 'forever chemicals', and accumulate essentially indefinitely. In May 2023, ECCC and HC proposed a class approach to the risk and management of PFAS compounds with individual CAS numbers. Currently, under the *Canadian Environmental Protection Act, 1999*, (CEPA) only four long-chain PFAS are listed as toxic substances.

This paper advances the 'essential use' concept (Cousins) as an approach to implement the federal government's class method to be applied to CEPA's risk assessment of PFAS. Cousins' three-stage approach to managing PFAS hazards via the essential use concept is a novel idea within Canada's regulatory regime but, in principle, it has been recently adopted in Europe. One aim of the EU strategy is to protect "consumers, vulnerable population groups (e.g., elderly, women, children and infants) and workers" from the most harmful chemicals through the characterization of chemicals into essential use categories, and by nudging alternative greener chemical substitutions through industry innovation.

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Microfiber-Induced Effects on Wastewater Treatment and Aerobic Granule Formation in Sequencing Batch Reactors

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The potential impacts of anthropogenic fibres on wastewater treatment plants remains poorly understood. The effects of commonly encountered denim and polyester fibres on the performance of aerobic granular sludge (AGS) reactors were investigated. Various concentrations of fibres (ranging from 10 to 8000 microfibres per litre) were explored, with a focus on wastewater treatment (nutrient removal, system performance, and efficacy).

The mechanism and formation of aerobic granules were also explored in sequence batch reactors, the treatability of microfibres using aerobic granular sludge was determined, and it was discovered that aerobic granular sludge could remove microfibres up to 95-99%. Denim and polyester fibres had a noticeable impact on the reactor's performance and nutrient removal at very high concentrations.

Notably, the reactor with fibres exhibited a remarkable enhancement in the granulation process, as observed by a slower granulation rate in the control reactor relative to the reactor with fibres. These findings suggest a beneficial effect of fibres on granulation. The microbial community analysis conducted on the reactors revealed a range of 400-650 observed species, indicating a high alpha diversity. Interestingly, the reactors with high fibre concentrations exhibited a more diverse microbial community compared to the control reactor. These findings provide valuable insights into the effectiveness of aerobic granular sludge in removing microfibres from wastewater treatment plants, as well as the inhibitory impacts of microfibres on nutrient concentrations, chemical oxygen demand, and total suspended solids in the final effluents of wastewater treatment plants. This information carries significant implications for both regulatory bodies and treatment plant operators in terms of optimizing wastewater treatment processes.

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The Role of Soil Hydrogeology in Oxygen Availability and Nitrogen Removal Efficiency in Onsite Wastewater Soil Treatment Units

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Onsite wastewater treatment systems (OWTSs) are widely used for wastewater treatment in decentralized settings. Nitrogen, a common contaminant in wastewater, can result in groundwater contamination, eutrophication, and harmful algal blooms, posing serious threats to water quality, aquatic ecosystems, and public health. These systems rely on soil treatment units (STUs) to remove nitrogen through natural processes. However, achieving simultaneous nitrification and denitrification in STUs poses a significant challenge due to the opposing environmental conditions required for these processes. Nitrification, the oxidation of ammonium nitrogen (NHâ••âº-N) to nitrate nitrogen (NOâ••â»-N), thrives in aerobic environments, while denitrification, the reduction of NOâ••â»-N to gaseous nitrogen, depends on anoxic conditions with adequate organic carbon availability. Oxygen availability in soil is replenished through diffusion, a process that is heavily influenced by hydrogeological properties such as permeability, porosity, and moisture retention. This study investigated how soil hydrogeological properties affect dissolved oxygen (DO) dynamics and nitrogen removal efficiency in STUs. Two soil columns with contrasting hydrogeological characteristics were constructed to simulate STUs and tested over 13 weeks using synthetic septic tank effluent. Column 1 was filled with rapidly draining, coarse soil characterized by a sharp transition from saturated to unsaturated conditions, while Column 2 contained finer soil with higher moisture retention and a gradual transition between saturation states. Both soils had a hydraulic conductivity high enough to support wastewater infiltration in a drain field according to design guidelines in Quebec, Canada. Nitrogen transformation processes and effluent DO levels were monitored to evaluate the treatment performance of each soil type. The high-permeability soil in Column 1 facilitated efficient oxygen transport, enabling complete nitrification with effluent nitrate nitrogen (NOâ••â»-N) concentrations averaging 35.4 mg N/L. However, the lack of sustained anoxic conditions limited denitrification, resulting in moderate total nitrogen (TN) removal efficiencies of 36.1%. In comparison, the low-permeability soil in Column 2 inhibited oxygen diffusion, fostering anoxic conditions favorable for denitrification. By the end of the experiment, Column 2 achieved near-complete TN removal (>94%), attributed to the establishment of sustained anoxic zones. Results suggest that the organic carbon in the wastewater was quickly depleted in the oxygen-rich environment of Column 1, whereas it contributed to denitrification in Column 2. DO levels further highlighted the contrasting nitrogen removal dynamics in the two columns. In Column 1, DO concentrations dropped to ~1 mg/L during the initial weeks but gradually increased in a linear trend. Conversely, Column 2 maintained DO levels of ~0.78 mg/L after the third week, signaling the onset of stable denitrification activity. The novelty of this study lies in its detailed exploration of the interplay between soil hydrogeological properties as revealed by a clear contrast in the performance of the two columns. DO distribution, and nitrogen removal pathways in STUs.

By demonstrating how soil characteristics influence the balance between aerobic and anoxic conditions, this work provides critical insights into optimizing STU design for enhanced nitrogen removal. These findings contribute to the development of more effective and sustainable OWTSs, offering practical solutions for decentralized wastewater management.

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Enhancing Methane Production from Thickened Waste-Activated Sludge: Evaluating YDRO Bioaugmentation and Hydrothermal Pretreatment

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Anaerobic digestion is a biological process in which microorganisms degrade organic material in the absence of oxygen, generating methane-rich biogas that can be utilized as electricity, heat, or fuel. This process is a sustainable method for converting organic waste, such as thickened waste-activated sludge (TWAS), into value-added products. This study evaluates and compares the biochemical methane potential (BMP) of TWAS subjected to various pretreatment methods: hydrothermal pretreatment (HTP) at 70°C (HTP 70) and 170°C (HTP 170), bioaugmentation using YDRO, and combinations of YDRO with HTP 70 and HTP 170. Additionally, two control scenarios were included: raw TWAS and YDRO-bioaugmented TWAS without hydrothermal pretreatment. The results demonstrate that TWAS pretreated with YDRO alone achieved an average cumulative methane yield of 661 mL/g VS, representing a 26% increase compared to the control bioreactor with untreated raw TWAS, which produced the lowest yield of 526 mL/g VS. Combining YDRO bioaugmentation with hydrothermal pretreatment at 70°C or 170°C did not result in significant additional improvement. While increasing the hydrothermal pretreatment temperature to 170°C yielded a 13% increase in cumulative biogas production, the performance of YDRO bioaugmentation alone was comparable to this temperature effect. The study also explores the impact of bioaugmentation on the extracellular polymeric substances (EPS) of TWAS and particle size distribution. These findings suggest that YDRO bioaugmentation is a promising standalone technology for enhancing biogas production in anaerobic digestion processes.

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Optimizing Thermophilic Biomethanation Plant set up for Municipal Sludge Treatment in Quebec City: Lesson learnt

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Anaerobic digestion is a biological process in which microorganisms degrade organic material in the absence of oxygen, generating methane-rich biogas that can be utilized as electricity, heat, or fuel. This process is a sustainable method for converting organic waste, such as thickened waste-activated sludge (TWAS), into value-added products. This study evaluates and compares the biochemical methane potential (BMP) of TWAS subjected to various pretreatment methods: hydrothermal pretreatment (HTP) at 70°C (HTP 70) and 170°C (HTP 170), bioaugmentation using YDRO, and combinations of YDRO with HTP 70 and HTP 170. Additionally, two control scenarios were included: raw TWAS and YDRO-bioaugmented TWAS without hydrothermal pretreatment. The results demonstrate that TWAS pretreated with YDRO alone achieved an average cumulative methane yield of 661 mL/g VS, representing a 26% increase compared to the control bioreactor with untreated raw TWAS, which produced the lowest yield of 526 mL/g VS. Combining YDRO bioaugmentation with hydrothermal pretreatment at 70°C or 170°C did not result in significant additional improvement. While increasing the hydrothermal pretreatment temperature to 170°C yielded a 13% increase in cumulative biogas production, the performance of YDRO bioaugmentation alone was comparable to this temperature effect. The study also explores the impact of bioaugmentation on the extracellular polymeric substances (EPS) of TWAS and particle size distribution. These findings suggest that YDRO bioaugmentation is a promising standalone technology for enhancing biogas production in anaerobic digestion processes.

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POSTERS

Chair: Dr. Stephanie Gora

Algal Bacterial Granular Sludge: An innovative addition on the Aerobic Granular Sludge treatment system

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Wastewater treatment is essential in maintaining environmental protection. However, traditional systems are often costly and have large environmental and physical footprints. Algal Bacterial Granular Sludge (ABGS) is an emerging treatment process that can be seen as a space-efficient method involving a small footprint and is more sustainable due to the lower cost associated with sludge management when compared to the traditional treatment of conventional activated sludge. Before the development of ABGS, Aerobic Granular Sludge (AGS) was developed as an innovative treatment process that uses the formation of dense, self-aggregated microbial granules that experience aerobic, anoxic, and anaerobic zones within the same cycle, which allows the removal of organic matter (85%), nitrogen (59%), ammonia (99%), and phosphorus (80%) (Wang, et al., 2024) to happen simultaneously in the treatment process. During this formation process, extracellular polymeric substances (EPS) help to bind the microbial granules together to help form stable and large granules. As innovative as AGS is, the treatment process involves using a large amount of air during the aerobic zone to maintain the shear force needed to be applied to the granules to help them maintain their structure, with a 5.4L sequencing batch reactor (SBR) needing a superficial air velocity (SAV) of typically 1.2-3.2 cm/s of air to maintain the granules (Devlin, di Biase, Kowalski, & Oleszkiewicz, 2016). From this drawback enters ABGS, which introduces algae into the system where it attaches to the granule helping them form larger and more stable flocs. The use of LED lights promotes the growth of algae and simulates the process of photosynthesis using a light-to-dark ratio of 12 hours on and 12 hours off. ABGS helps to create a synergistic relationship with the granules and algae. The algae produce oxygen through photosynthesis which helps to support the metabolism and growth of the microbial bacteria in the sludge, while this happens the bacteria provide carbon dioxide, and the essential nutrients needed that help fuel the algae's growth. This synergistic relationship not only helps to enhance the removal of organic matter (95%), nitrogen (77%), ammonia (99%), and phosphorus (95%) (Wang, et al., 2024) due to the O_2 generated by the algae itself but maintains these higher levels of removal with the aeration rate dropping as low as 0.007 cm/s (Wang, et al., 2024). All of this contributes to ABGS producing up to 86% lower carbon emissions compared to AGS (Bao, et al., 2024).

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Impact of Nutrient Limitation Conditions on Suspended Biofilms and Biomass and Associated Nitrous Oxide Emissions

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This study investigates the effects of nutrient limitation on suspended biofilms and biomass, focusing on the associated nitrous oxide (Nâ••O) emissions in wastewater treatment processes by tracking genes associated with the nitrogen cycle. This research aims to advance the field of water and wastewater quality science by exploring the dynamics of hybrid biomass (biofilms and suspended biomass under high-strength organic wastewater conditions and during transition to higher chemical oxygen demand (COD) to nitrogen (N) ratios in the influent. The associated changes in nitrogen cycle gene expression to determine nitrous oxide emission will be tracked. The hybrid wastewater treatment process is crucial for treating high-strength wastewater due to its settling abilities and resilience to stress. This study examines the role of microbial community structure and extracellular polymeric substances (EPS) in biofilm formation and stability, as previous research has highlighted EPS as crucial for biofloc production. Preliminary analysis indicates that nutrient composition significantly impacts sludge aggregation ability and Nâ••O emissions. The laboratory-scale integrated fixed-film sequencing batch reactors (IF-SBRs) are used in this study to treat 4 different COD:N:P ratios of synthetic high-strength wastewater: (1) 500:50:5, (2) 200:20:2, (3) 200:40:2, (4) 200:80:2. Many wastewater treatment plants directs the digestate from the anaerobic digesters to the secondary treatment tanks that results in relatively higher nitrogen concentrations in the influent for the aeration tanks. The spike in ammonia concentration presents a unique challenge for wastewater treatment, including increased filamentous growth and decreased aggregation ability and poor nutrient removal. Key operational challenges addressed in this study include the instability of the suspended biomass and nutrient deficiencies on greenhouse gas emissions. Data collected from the IF-SBRs include reactor performance parameters, nutrient analysis, EPS protein and sugar quantification, and microbial community assessments. These findings highlight the importance of optimizing nutrient concentration and operating conditions to mitigate the greenhouse gas emissions from wastewater.

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Comparing the adsorption to desorption capacity of aerobic granular sludge (AGS): Four per and polyfluoroalkyl substances (PFAS)

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Contaminants of emerging concerns (CECs): microplastics, pharmaceuticals and personal care products (PPCPs), hazardous household wastes (HHW), pesticides and herbicides, and Per and Polyfluoroalkyl Substances (PFAS); though detected in low concentrations have adverse effects in the environment. PFAS which are highly persistent have received much attention lately, with various technologies developed for the mitigation. Many of these technologies have reported the adsorption of this contaminant, however this poses another challenge, what next? Aerobic Granular Sludge (AGS) was employed to reduce the concentration of four representative PFAS and determine the adsorption and desorption capacity of the technology. The result showed that among Perfluorobutane sulfonic acid (PFBS), Perfluorodecane sulfonic acid (PFDS), Perfluoropentanoic acid (PFPeA), and Perfluorooctanoaic acid (PFOA); PFDS had the highest adsorption and the highest desorption capacity. This could suggest that AGS is more effective for PFDS separation and removal among the analysed PFAS.

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Digesting Data: How Machine Learning is Transforming Anaerobic Digestion

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Anaerobic digestion (AD) is a well-established process to break down complex organic matter into methane-rich biogas through multiple steps including hydrolysis, acidogenesis, acetogenesis, and methanogenesis. However, there are several challenges associated with the AD process including the variability of feedstock and operational conditions. Such challenges magnify the importance of employing data-driven models using machine learning (ML) algorithms to better describe the interdependence between the process parameters. ML algorithms can solve complicated systems with many process parameters with high uncertainty and non-linearity which is common in the AD process. In addition, the application of ML algorithms in AD can be employed as an effective tool to predict biogas production and improve process stability. Although there are multiple previous studies investigated the application of ML models in AD applications, no systematic review has described the standard datasets, features, and evaluation metrics required for robust ML algorithms. In the current study, a comprehensive review of the current state of ML integration in AD processes, focusing on the recommended dataset sizes, ML techniques, nature of model input and output variables, and the most realistic evaluation metrics to assess the performance of the employed ML models. In addition, this study covers the most commonly investigated AD applications using ML models including the prediction of biogas production, optimization of operational conditions (e.g., temperature of digesters), and the co-digestion of different feedstocks (e.g., waste activated sludge and food waste). The main outcomes of this study can provide valuable insights for researchers and decision-makers about the transformative role of ML in driving innovative and sustainable AD processes. In addition, this study can identify the critical research gaps and future directions that can bridge the application of ML models in AD systems.

Enhanced subsurface remediation of BTEX through geothermal heating and bioremediation

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The degradation of BTEX (benzene, toluene, ethylbenzene, xylene) in soil and groundwater presents persistent environmental challenges due to its long-term stability and mobility in the subsurface. Bioremediation, an economical and eco-friendly approach, often faces limitations from the naturally low temperatures of the subsurface, which hinder microbial activity and slow down the degradation process. Geothermal heating, a sustainable technology that harnesses the subsurface for temperature regulation in buildings, offers a novel solution by providing the necessary heat to enhance microbial activity. This research investigates the impact of cyclic temperature fluctuations, introduced by geothermal heat pumps, on the bioremediation of BTEX-contaminated soil and groundwater. Laboratory experiments were conducted using an isolated bacterial strain, Microbacterium esteraromaticum, in nutrient-rich groundwater and soil spiked with BTEX. By simulating geothermal heating cycles with temperatures ranging from 15°C to 40°C, the study evaluated the efficiency of microbial growth and BTEX degradation. The results demonstrated that cyclic temperatures improved microbial metabolism and BTEX breakdown compared to lower temperatures, highlighting the potential of integrating geothermal heating with bioremediation. This combined approach leverages renewable energy to enhance the remediation process, offering a sustainable strategy for addressing subsurface pollution and promoting environmental restoration.

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Biodegradation of Polycyclic Aromatic Hydrocarbons by Bacillus megaterium in Aquatic Environments

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Diesel contamination in aquatic environments is a pressing global issue, leading to severe ecological degradation and health hazards. Conventional remediation approaches, including physical, chemical, and thermal methods, often fall short due to their limited efficiency, high costs, and potential secondary pollution. In contrast, bioremediation provides an environmentally friendly and sustainable solution by utilizing the natural degradative abilities of microorganisms. This study focuses on the screening, isolation, and characterization of polycyclic aromatic hydrocarbon-degrading bacteria from diesel-contaminated environments. Among the isolates, Bacillus megaterium exhibited remarkable efficiency, achieving 83.3% degradation of C10-C11 hydrocarbons within 15 days. Advanced Gas Chromatography-Mass Spectrometry (GC-MS) analysis revealed significant reductions in 1-methylnaphthalene (40.8%) and 2-methylnaphthalene (37.3%). Furthermore, the strain demonstrated the ability to degrade complex polycyclic aromatic hydrocarbons, such as 2,3,5-trimethylnaphthalene. The findings highlight the potential of Bacillus megaterium as a robust candidate for bioremediation of diesel-contaminated water. Its preferential degradation of lighter hydrocarbons and ability to target complex PAHs suggest a promising avenue for mitigating hydrocarbon pollution. Future studies exploring its metabolic pathways and optimization strategies could broaden its application in environmental cleanup efforts.

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Detection of microplastics in wastewater sludge using Laser direct infrared imaging (LDIR) technique.

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Research background: The versatility and affordability of plastics have led to their global acceptance, but they have now become a global threat, causing the pressing issue of microplastic (MPs) pollution. MPs, defined as plastic particles smaller than 5 mm, are particularly challenging to quantify due to their variable sizes, shapes, and compositions[1]. Wastewater treatment plants serve as both sources and sinks of MPs in the environment. Furthermore, the high organic content of wastewater (WW) adds complexity to the separation and quantification of MPs which themselves are undigestible organic sludge. At present, no standardized protocol exists for analyzing MPs in WW and sludge. Significance: A newly developed standard protocol for the WW pretreatment called as Ferrosonication (Fe-UlS) can significantly reduce the temperature, time and effort required for the sample preparation, making the MP analysis more efficient in the WW matrix [2]. Owing to the complexity of wastewater sludge (WWS), density separation is to be done as an additional pretreatment procedure after Fe-UlS. However, during density separation, there is a chance of losing MPs trapped in undigested organic matter through pore-filling interactions. This entrapment can increase the density of MPs and make them difficult to separate. Thus, Fe-UlS pretreatment approach can disintegrate organic matter and prevent them from settling down with recalcitrant. Rather than using the conventional separation funnel, centrifugation using the density gradient solution makes extraction of MPs from WWS faster and more efficient. Using $ZnCl_2$ as the density gradient solution is a cost-efficient solution and can be reused[3]. This optimized pretreatment protocol for WWS brought down the sample preparation time considerably from 2 to 3 days to less than 2 hours[4]. The Laser direct infrared imaging (LDIR) is a promising analytical technique for quantitative analysis of MPs but is not explored for MPs analysis in WWS so far. Methodology: A 10 mL of the primary WWS was placed in a 250 mL glass beaker. A 1:1 Fenton reagent (0.05 M $FeSO_4$ + 30% H_2O_2) was added to the WWS and made up to 200 mL. The pH was adjusted to 2–3 using 100 µL H_2SO_4. Fe-UlS pretreatment was done at 31% amplitude for 30 minutes. After Fe-UlS, the pretreated WWS was filtered onto cellulose filter paper (Ahlstrom-Munksjö qualitative filter papers; pore size 10 µm) and the residues were washed out using $ZnCl_2$ (density 1.9 g/mL) into a 50 mL centrifuge tube. Density separation was done by centrifugation at 3000 rpm for 15 minutes. The supernatant after density separation was again filtered onto cellulose filter paper and residues washed out using 70% ethanol. It was then filtered onto Polycarbonate (PCTG) Gold-Coated Membrane Filters (Sterlitech 0.8 micron, 40/20 nm Coating, 25 mm diameter) using Millipore Glass Microanalysis Filtration setup. Quantitative analysis of MPs in terms of their chemical composition was studied in detail using Agilent 8700 LDIR Chemical Imaging System.

A fully automated analysis was done using the Clarity software (Agilent version 1.5.58) using Microplastics Starter 2.0 library. Particle analysis was done on the selected area (~16mm diameter) of the filter, with a size range of 20–500 µm. Data analysis was done on particles that were detected at higher confidence (>90%). The pretreatment protocol was validated by adding known concentration of MPs and recovery efficiency was calculated. Results and Discussion: Figure 1 shows the data regarding the number, type and size distribution on the total number of MPs detected at higher confidence levels (>90%) by LDIR. Polyurethane (PU) was the most abundantly detected MPs in the primary sludge followed by polyethylene (PE), polypropylene (PP), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polyoxymethylene (POM). The most detected MPs with high confidence was <50 µm followed by MPs in the 50-100 µm range. High-density MPs such as polylactic acid (PLA) and polytetrafluoroethylene (PTFE). were also detected but with 80% confidence. A 100% recovery efficiency was obtained after Fe-UlS and density separation pretreatment with the known number of spiked MPs. Thus, the developed pretreatment protocol for WWS is efficient for MPs analysis. The density gradient solution ($ZnCl_2$: 1.9 g/mL) used could separate even the high-density MPs present in WWS. Figure 1: Distribution of MPs detected by LDIR based on the number, type and size at higher confidence levels (>90%) References: [1] L.G.A. Barboza, B.C.G. Gimenez, Microplastics in the marine environment: Current trends and future perspectives, Marine Pollution Bulletin 97 (2015) 5–12. https://doi.org/10.1016/j.marpolbul.2015.06.008. [2] J. Mathew, G. Bhardwaj, R. Pulicharla, P. Rezai, S. Kaur Brar, Innovating Ferro-Sonication Approach for Extracting Microplastics from Wastewaters, (2024). https://doi.org/10.2139/ssrn.4872595. [3] M.O. Rodrigues, A.M.M. Gonçalves, F.J.M. Gonçalves, N. Abrantes, Improving cost-efficiency for MPs density separation by zinc chloride reuse, MethodsX 7 (2020) 100785. https://doi.org/10.1016/j.mex.2020.100785. [4] J. Mathew, R. Pulicharla, P. Rezai, S.K. Brar, Microplastics in wastewaters: Pretreatment to detection trail, Journal of Water Process Engineering 64 (2024) 105702. https://doi.org/10.1016/j.jwpe.2024.105702.

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Swan Lake Citizen Science Lab: Enhancing Water Quality by Connecting Science, Technology, Environment and the Community

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This poster aims to introduce Swan Lake Citizen Science Lab (SLCS Lab) jointly initiated by OneWater Institute, ADERSIM, and CIFAL York in collaboration with the Friends of Swan Lake. SLCS Lab is an innovative, participatory and co-creation initiative integrating science, technology, and community efforts to address water quality challenges in Swan Lake (Markham). The project focuses on enhancing water quality monitoring through cutting-edge technologies including drone, GIS mapping, artificial intelligence (AI), simulation, virtual reality, and documentary filming in close collaborations with community members, partners, and stakeholders. Drone-based imaging and sensing (thermal and sonar) are employed to map the Swan Lake Park surface features and detect water temperature, depth, color, and existence of algae. These technologies allow for detailed 2D and 3D representations of Swan Lake, providing insights into habitat structures and environmental conditions. Data collected using these technologies will be augmented with water quality data (pH, turbidity, temperature, and dissolved oxygen) collected through conventional methods. Various AI and data science methods will be used to understand biodiversity patterns in the area and translate them into generative AI-based applications to inform the public, residents, and decision-makers. Advanced simulation methods (Agent-Based Modeling) will simulate behaviors and interactions between the key agents in Swan Lake Park and the impacts of different environmental changes and human actions on the environment. Virtual Reality (VR) technology is used to visualize the invisible aspects of the lake, such as the lake bottom, for the public, as well as visualize the impacts of various interventions or environmental threats on the lake. These science and technology-based engagements enhance ecological awareness and strengthen the connection between citizens and scientific research.

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Comparing Biomethane Production from Different Industrial Wastes: Effect of Substrate Type and Food- to- Microorganism (F/M) Ratio

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Introduction Waste generation from food processing and packaging industries has increased significantly over the past decades to keep pace with population growth. Between 2011 and 2015, over 10 billion tons of human-generated solid waste were disposed of each year, with 32% originating from industrial sources (Song et al., 2015; Wilson et al., 2015). This increase in fact necessitates a paradigm shift towards a circular economy approach to achieve zero-emission by 2050. Anaerobic digestion (AD) has emerged as a promising waste treatment modality, distinguished by its low carbon footprint and capacity to recuperate value-added byproducts, notably biomethane. Objectives This study has the following objectives: • Investigate the effect of substrate composition on AD process and biomethane generation. • Compare the biomethane production of the following feedstocks: bakery processing and kitchen waste (BP+KW) mixture, fat, oil, and grease (FOG), powder whey, ultrafiltered (UF) milk permeates, and pulp and paper (P&P) sludge. • Find the optimum AD food-to-microorganism (F/M) ratio for each feedstock. Methodology The five types of organic waste feedstock were all collected from local facilities in Toronto, ON, including the Ashbridges Bay Wastewater Treatment Plant, Walker Environmental Industries, and Agropour Dairy Cooperative. The AD process was performed in batch reactors of 200mL under mesophilic conditions for 40 days with F/M ratios of 1, 2, 4, and 6 gCOD/gVSS. Results Experimental results demonstrated that methane yield values decreased with increasing F/M ratio for all feedstocks, but to varying degrees, with FOG showing the most significant decrease and pulp and paper showing the least decline. The optimal F/M ratio for methane yield in all feedstocks was 1 gCOD/gVSS, except for UF whey permeate and powder whey, where the optimal F/M ratio was 2, as shown in figure 1. Maximum methane yields ranged from 333 mL CH_4/g COD added for FOG to 135 mL CH_4/g COD added for P&P at F/M=1. Pearson's coefficient values (-0.85 to -0.97) highlighted a strong inverse correlation between methane yield and increasing F/M ratios. Process kinetics, evaluated through a first-order model, revealed the highest reaction rate coefficients (k) values for FOG. The highest k values of 0.23 and 0.21 day-1 for FOG occurred at F/M ratios of 2 and 4, respectively. The k values also corresponded to the observed experimental yield values, which decreased as the F/M ratio increased.

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3MT

Chair: Dr. Farshad Dabbaghisouraki

Algal Bacterial Granular Sludge: An innovative addition on the Aerobic Granular Sludge treatment system

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Wastewater treatment is essential in maintaining environmental protection. However, traditional systems are often costly and have large environmental and physical footprints. Algal Bacterial Granular Sludge (ABGS) is an emerging treatment process that can be seen as a space-efficient method involving a small footprint and is more sustainable due to the lower cost associated with sludge management when compared to the traditional treatment of conventional activated sludge. Before the development of ABGS, Aerobic Granular Sludge (AGS) was developed as an innovative treatment process that uses the formation of dense, self-aggregated microbial granules that experience aerobic, anoxic, and anaerobic zones within the same cycle, which allows the removal of organic matter (85%), nitrogen (59%), ammonia (99%), and phosphorus (80%) (Wang, et al., 2024) to happen simultaneously in the treatment process. During this formation process, extracellular polymeric substances (EPS) help to bind the microbial granules together to help form stable and large granules. As innovative as AGS is, the treatment process involves using a large amount of air during the aerobic zone to maintain the shear force needed to be applied to the granules to help them maintain their structure, with a 5.4L sequencing batch reactor (SBR) needing a superficial air velocity (SAV) of typically 1.2-3.2 cm/s of air to maintain the granules (Devlin, di Biase, Kowalski, & Oleszkiewicz, 2016). From this drawback enters ABGS, which introduces algae into the system where it attaches to the granule helping them form larger and more stable flocs. The use of LED lights promotes the growth of algae and simulates the process of photosynthesis using a light-to-dark ratio of 12 hours on and 12 hours off. ABGS helps to create a synergistic relationship with the granules and algae. The algae produce oxygen through photosynthesis which helps to support the metabolism and growth of the microbial bacteria in the sludge, while this happens the bacteria provide carbon dioxide, and the essential nutrients needed that help fuel the algae's growth. This synergistic relationship not only helps to enhance the removal of organic matter (95%), nitrogen (77%), ammonia (99%), and phosphorus (95%) (Wang, et al., 2024) due to the O_2 generated by the algae itself but maintains these higher levels of removal with the aeration rate dropping as low as 0.007 cm/s (Wang, et al., 2024). All of this contributes to ABGS producing up to 86% lower carbon emissions compared to AGS (Bao, et al., 2024).

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Impact of Nutrient Limitation Conditions on Suspended Biofilms and Biomass and Associated Nitrous Oxide Emissions

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This study investigates the effects of nutrient limitation on suspended biofilms and biomass, focusing on the associated nitrous oxide (Nâ••O) emissions in wastewater treatment processes by tracking genes associated with the nitrogen cycle. This research aims to advance the field of water and wastewater quality science by exploring the dynamics of hybrid biomass (biofilms and suspended biomass under high-strength organic wastewater conditions and during transition to higher chemical oxygen demand (COD) to nitrogen (N) ratios in the influent. The associated changes in nitrogen cycle gene expression to determine nitrous oxide emission will be tracked. The hybrid wastewater treatment process is crucial for treating high-strength wastewater due to its settling abilities and resilience to stress. This study examines the role of microbial community structure and extracellular polymeric substances (EPS) in biofilm formation and stability, as previous research has highlighted EPS as crucial for biofloc production. Preliminary analysis indicates that nutrient composition significantly impacts sludge aggregation ability and Nâ••O emissions. The laboratory-scale integrated fixed-film sequencing batch reactors (IF-SBRs) are used in this study to treat 4 different COD:N:P ratios of synthetic high-strength wastewater: (1) 500:50:5, (2) 200:20:2, (3) 200:40:2, (4) 200:80:2. Many wastewater treatment plants directs the digestate from the anaerobic digesters to the secondary treatment tanks that results in relatively higher nitrogen concentrations in the influent for the aeration tanks. The spike in ammonia concentration presents a unique challenge for wastewater treatment, including increased filamentous growth and decreased aggregation ability and poor nutrient removal. Key operational challenges addressed in this study include the instability of the suspended biomass and nutrient deficiencies on greenhouse gas emissions. Data collected from the IF-SBRs include reactor performance parameters, nutrient analysis, EPS protein and sugar quantification, and microbial community assessments. These findings highlight the importance of optimizing nutrient concentration and operating conditions to mitigate the greenhouse gas emissions from wastewater.

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Investigation of geothermal heating impacts on BTEX biodegradation in soil under cyclic fluctuating temperature

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Urban contamination of soil and groundwater by BTEX (benzene, toluene, ethylbenzene, xylene) compounds is a prevalent concern that requires proper remediation to address the problem. Among different remediation technologies, biological methods have gained ample attention due to their economical and eco-friendly advantages. However, in-situ bioremediation of BTEX can be slow due to the low temperature of the subsurface (10-15 °C) which limits microbial degradation activity. Providing optimum growth temperatures may proliferate microbial growth, and enhance bioremediation, however adding heat to the subsurface to augment remediation results in increased costs. Geothermal heating is a sustainable technique that utilizes the shallow subsurface to extract and inject heat in winter and summer respectively, using heat pumps for heating and cooling of buildings. This technology is growing in popularity and in 2020, approximately 100,000 geothermal projects were in place in Canada alone. The excess heat injected into the subsurface during geothermal heating can be used as the temperature source needed to enhance bioremediation. In this project, the effect of cyclic fluctuation of temperature (from 10 to 40 °C) in the subsurface has been studied on a small scale in BTEX contaminated soil using Microbacterium esteraromaticum and native Consortia. The study revealed that the increased and cyclic temperature helped in enhancing microbial metabolism with simultaneous BTEX biodegradation in comparison to constant average temperature of subsurface (10-15 °C). This research helps develop a cleaner approach to subsurface remediation.

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Nutrient Polishing of Municipal Wastewater: A Start-up Study Using a Novel Internally Illuminated Algal Photobioreactor

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This work introduces a novel approach to cultivate microalgae for the tertiary treatment of municipal wastewater using a novel internally illuminated photobioreactor (PBR) (Patent Pending). This bioprocess enables biofilm growth to remove nutrients Nitrogen (N) and Phosphorus (P), which is critical for source water protection. The success of microalgae for nutrient uptake is well documented. Microalgae efficiently uptake N and P through their metabolic pathways, and they have been found to reduce low concentrations of nutrients further than conventional approaches. Traditionally, microalgae have been cultivated in suspension, but these systems face challenges from large footprints, infrastructure costs, and reduced efficacy due to light scattering from suspended biomass. Attached growth systems due not suffer from these distinct challenges. The scope of existing attached microalgal growth studies, however, fail to account for the criteria required for scale-up beyond bench-scale application. This research intends to validate the design of a modular product that can be implemented for the intensification of WWTPs. Overall, this work is a significant advancement for wastewater treatment since the proposed technology has not been tested previously. A start-up study was conducted as proof of concept for the novel PBR, using real municipal secondary effluent to evaluate the system's performance. Key parameters included internal light configuration, nutrient removal efficacy, and biomass growth. The microalgal biofilm successfully treated low-nutrient effluent, simulating post-anoxic conditions. Initial results suggest that nutrient removal is comparable to suspended systems. Furthermore, biofilm formation was observed within four days. The success of this bioprocess for the cultivation of microalgae may be indicative of its applicability for other phototrophic microorganisms.

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The Influence of Diet on the Uptake, Bioaccumulation, and Depuration of Microplastics in Daphnia magna

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Microplastics (MPs) are widespread pollutants in freshwater, and they pose risks to aquatic organisms and food web dynamics. Planktonic crustaceans such as Daphnia magna are important model organisms because they serve a primary food source for higher trophic levels, and pollutants ingested by daphnia can be transferred through the food web. This makes daphnia an ideal species for studying the accumulation dynamics of pollutants like MPs. This study examines the ingestion of polyethylene (PE) MPs in daphnia to address: (1) How MP size and concentration effects MP biokinetics (i.e., uptake, bioaccumulation, and depuration)? and (2) How does different quality of diets (artificial, live algae, and a mixture of artificial and algae) influence MP bioaccumulation? Studying the biokinetics helps to understand how MPs are retained and eliminated, which is critical for assessing MP risks in freshwater. Additionally, investigating different diets informs future studies on the impact of diet on experimental design. I hypothesized that daphnia would exhibit size-dependent MP ingestion and that the presence of food would reduce MP bioaccumulation. To test these hypotheses, adult daphnia were exposed to fluorescent PE microbeads (45-53, 63-75, and 90-106 μm) at environmentally relevant concentrations (16 to 16 000 particles/ L) for 48 hours. MPs were quantified using fluorescence microscopy. Results showed a size dependent pattern in MP ingestion, with smaller MPs being more readily consumed compared to larger sizes. The presence of food reduced MP uptake, suggesting that there is preferential selection to food. Ongoing depuration studies indicate rapid MP elimination within the first two hours. Additionally, preliminary diet results showed no difference in bioaccumulation across the diets. These findings provide insight MP biokinetic dynamics under varying feeding conditions.

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Comparing the adsorption to desorption capacity of aerobic granular sludge (AGS): Four per and polyfluoroalkyl substances (PFAS)

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Contaminants of emerging concerns (CECs): microplastics, pharmaceuticals and personal care products (PPCPs), hazardous household wastes (HHW), pesticides and herbicides, and Per and Polyfluoroalkyl Substances (PFAS); though detected in low concentrations have adverse effects in the environment. PFAS which are highly persistent have received much attention lately, with various technologies developed for the mitigation. Many of these technologies have reported the adsorption of this contaminant, however this poses another challenge, what next? Aerobic Granular Sludge (AGS) was employed to reduce the concentration of four representative PFAS and determine the adsorption and desorption capacity of the technology. The result showed that among Perfluorobutane sulfonic acid (PFBS), Perfluorodecane sulfonic acid (PFDS), Perfluoropentanoic acid (PFPeA), and Perfluorooctanoic acid (PFOA); PFDS had the highest adsorption and the highest desorption capacity. This could suggest that AGS is more effective for PFDS separation and removal among the analysed PFAS.

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Seasonal Water Access and Informal Markets: Insights from Freetown's Urban Communities

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This presentation focuses on the findings from a nine-month study on water source choices and the role of informal water markets in Freetown, Sierra Leone. The existing data reveals significant seasonal variations in household water sources, with reliance on informal water vendors increasing during the dry season due to the unreliability of municipal supply. These findings also highlight the gendered and economic dimensions of water access, where women and lower-income households face heightened challenges. By mapping water sources and documenting informal market dynamics, this research sheds light on the adaptive strategies used by residents in the informal settlements. The insights gathered from this data serve as a critical foundation for understanding the seasonal vulnerabilities and resilience of urban communities in Freetown.

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Exploring Operational Boundaries in Low Oxygen Activated Sludge Systems for Municipal Wastewater Treatment

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Low oxygen (DO ≤ 0.7 mg/L) Activated Sludge (AS) systems demonstrated significant potential for optimizing energy consumption in wastewater treatment. However, their performance under extreme operational conditions, including low dissolved oxygen levels, high sludge retention times (SRTs), low temperatures, high mixed liquor suspended solids (MLSS), and poor sludge settleability, is poorly explored. These challenges often limited system efficiency and stability, particularly in energy-constrained and cold environments. This research systematically tested the boundary conditions of low oxygen activated sludge systems using Response Surface Methodology (RSM) to Configure and coordinate experimental trials. Key operational parameters, including dissolved oxygen, hydraulic retention time (HRT), SRT, MLSS, and transmembrane pressure, were changed to quantify their impact on system performance. The study focused on biofilm dynamics in Membrane-Aerated Biofilm Reactors (MABRs), where low transmembrane pressure was found to alleviate the operational burden of high MLSS and bulk SRT in low DO AS while providing a substratum that protected biomass from temperature and substrate fluctuations. The results offered actionable insights into creating guidelines for Wastewater Treatment Plants to transition to low oxygen wastewater treatment.

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Quantifying the impact of cryogenic landslides on lakes in the eastern Mackenzie Delta NT, Canada

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Enhanced warming in Canada's northwest is driving geomorphological change caused by permafrost thaw. Cryogenic landslides, a consequence of thaw, are mass movement features that can have significant physical, chemical, and biological implications to low-lying waterbodies. The Caribou Hills, located along the eastern edge of the Mackenzie Delta (NT), are subject to near-surface permafrost thaw during extreme summer temperatures and precipitation events. Due to the steep elevation gradient between the delta and hills, the region is an optimal geography for cryogenic landslide development. In July 2023, we visited three lakes at the base of the Caribou Hills, all of which had experienced cryogenic landsliding to varying degrees, along with one control lake. At all study lakes we collected sediment cores and landslide grab samples which were analyzed for mercury, carbon, and nitrogen content. By directly comparing the pulses observed in the sediment core with the values of the grab samples, we estimate if terrestrial landsliding drove elemental shifts. Mercury values in some cores showed a coincident increase of concentration during landsliding. These concentrations fell just below the interim sediment quality guidelines developed by the Canadian Ministers for the Environment. Carbon-to-nitrogen ratios, a proxy for organic carbon source, also marked upward shifts in response to landslide events. Elemental loading from permafrost degradation poses serious threats to water quality, particularly of mercury and its potential human health impact. Understanding how waterbodies respond to shifts in elemental concentrations is vital as they can further affect local communities, wildlife, and future environmental processes. This research adds to pan-Arctic efforts to understand permafrost thaw impacts on aquatic environments and provides valuable context to land users and ecosystem managers to interpret changes in northern waterbodies impacted by permafrost thaw.

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Enhancing Methane Production from Thickened Waste-Activated Sludge: Evaluating YDRO Bioaugmentation and Hydrothermal Pretreatment

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Anaerobic digestion is a biological process in which microorganisms degrade organic material in the absence of oxygen, generating methane-rich biogas that can be utilized as electricity, heat, or fuel. This process is a sustainable method for converting organic waste, such as thickened waste-activated sludge (TWAS), into value-added products. This study evaluates and compares the biochemical methane potential (BMP) of TWAS subjected to various pretreatment methods: hydrothermal pretreatment (HTP) at 70°C (HTP 70) and 170°C (HTP 170), bioaugmentation using YDRO, and combinations of YDRO with HTP 70 and HTP 170. Additionally, two control scenarios were included: raw TWAS and YDRO-bioaugmented TWAS without hydrothermal pretreatment. The results demonstrate that TWAS pretreated with YDRO alone achieved an average cumulative methane yield of 661 mL/g VS, representing a 26% increase compared to the control bioreactor with untreated raw TWAS, which produced the lowest yield of 526 mL/g VS. Combining YDRO bioaugmentation with hydrothermal pretreatment at 70°C or 170°C did not result in significant additional improvement. While increasing the hydrothermal pretreatment temperature to 170°C yielded a 13% increase in cumulative biogas production, the performance of YDRO bioaugmentation alone was comparable to this temperature effect. The study also explores the impact of bioaugmentation on the extracellular polymeric substances (EPS) of TWAS and particle size distribution. These findings suggest that YDRO bioaugmentation is a promising standalone technology for enhancing biogas production in anaerobic digestion processes.

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Digesting Data: How Machine Learning is Transforming Anaerobic Digestion

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Anaerobic digestion (AD) is a well-established process to break down complex organic matter into methane-rich biogas through multiple steps including hydrolysis, acidogenesis, acetogenesis, and methanogenesis. However, there are several challenges associated with the AD process including the variability of feedstock and operational conditions. Such challenges magnify the importance of employing data-driven models using machine learning (ML) algorithms to better describe the interdependence between the process parameters. ML algorithms can solve complicated systems with many process parameters with high uncertainty and non-linearity which is common in the AD process. In addition, the application of ML algorithms in AD can be employed as an effective tool to predict biogas production and improve process stability. Although there are multiple previous studies investigated the application of ML models in AD applications, no systematic review has described the standard datasets, features, and evaluation metrics required for robust ML algorithms. In the current study, a comprehensive review of the current state of ML integration in AD processes, focusing on the recommended dataset sizes, ML techniques, nature of model input and output variables, and the most realistic evaluation metrics to assess the performance of the employed ML models. In addition, this study covers the most commonly investigated AD applications using ML models including the prediction of biogas production, optimization of operational conditions (e.g., temperature of digesters), and the co-digestion of different feedstocks (e.g., waste activated sludge and food waste). The main outcomes of this study can provide valuable insights for researchers and decision-makers about the transformative role of ML in driving innovative and sustainable AD processes. In addition, this study can identify the critical research gaps and future directions that can bridge the application of ML models in AD systems.

From Food to Fuel: Tailoring Microbial Diversity for VFA Production

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Acidogenic fermentation of food waste using mixed microbial cultures presents a sustainable route for the production of high-value bioproducts, such as volatile fatty acids (VFAs). VFAs are versatile chemical intermediates with applications in biofuels, bioplastics, and other industrial processes. However, achieving high VFA yields remains a challenge due to the complexity of microbial networks and the limited understanding of their interplays within fermentation systems. Existing processes often yield a diverse mixture of metabolites, complicating downstream extraction and valorization for specific VFAs. Temperature is a critical factor influencing the biochemical pathways and microbial activity in acidogenic fermentation. While mesophilic or thermophilic conditions are widely studied, they are energy-intensive and less practical in colder regions, where average ambient temperatures predominantly fall below the mesophilic range. To address these challenges, this study explores a multi-faceted approach to enhance hydrolysis and acidogenesis at psychrophilic temperatures, paving the way for selective and efficient VFA production.

The first phase of this work involved employing pretreatment strategies to improve substrate hydrolysis and enhance the bioavailability of organic compounds for microbial uptake. This pretreatment strategy not only accelerated hydrolysis but also promoted acidogenesis, selectively enriching microbial pathways for targeted VFA production under psychrophilic conditions. Additionally, the use of biosurfactants, further enhanced the solubilization of hydrophobic and recalcitrant compounds, increasing substrate accessibility for key microbial populations. Given the inherent complexity of microbial interactions in mixed culture fermentations, advanced -omics techniques will be applied to unravel the taxonomic and functional dynamics of microbial communities. Metagenomics provides critical insights into the structural and functional characterization of both cultivable and non-cultivable microbial fractions, highlighting key taxa and enzymatic pathways involved in VFA synthesis. This comprehensive understanding will enable the identification of microbial community shifts and metabolic bottlenecks during the fermentation process.

The final phase of this study focuses on employing bioaugmentation to tailor the microbial community for enhanced and targeted VFA production. By introducing specialized microbial strains, the fermentation system can be directed toward the synthesis of specific VFAs, such as butyric acid, with higher efficiency. This approach harnesses the combined efforts of native and added microbes to improve metabolic processes and boost VFA yields.
Overall, this study presents a comprehensive strategy to tackle key challenges in converting food waste into VFAs under psychrophilic conditions. By integrating pretreatment methods, biosurfactant use, and microbial community optimization, it offers an energy-efficient and selective way to produce VFAs.

Analyzing The Potential of Wastewater Microorganisms to Degrade or Deteriorate Cotton, Cotton Denim and Polyester Microfibers

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Microplastics are plastic fragments (<5mm), pervasive in the environment. They present health risks among other threats. Polyester (a microplastic) and denim are textile microfibers released from washing of clothes, transported into wastewater treatment plants (WWTPs), and subsequently accumulated in water bodies. More information is to be learned about interactions of microorganisms and microfibers in WWTPs. Our research objectives were to investigate the impact of readily degradable carbon sources on microbial degradation/deterioration of microfibers and their effects on total suspended solids, volatile suspended solids, chemical oxygen demand (COD), dissolved oxygen and pH. The biological step of WWTPs was simulated using synthetic wastewater (with or without carbon) and activated sludge as inoculum in reactors containing either cotton, dyed denim or polyester microfibers. Greater degradation was observed in the presence of glucose/acetate. Cotton fibers degraded faster (within three weeks) in comparison to cotton denim. Polyester microfibers remained intact over the test period of seven weeks. In the absence of glucose/acetate, pH became more acidic; basic conditions developed in the presence of glucose/acetate. The presence of denim microfibers yielded the highest pH and lowest COD removals. Our research provides insights on microfiber behavior in simulated biological treatment and emphasizes the need for upstream solutions to limit microfiber pollution at the source.

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Detection of microplastics in wastewater sludge using Laser direct infrared imaging (LDIR) technique.

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Research background: The versatility and affordability of plastics have led to their global acceptance, but they have now become a global threat, causing the pressing issue of microplastic (MPs) pollution. MPs, defined as plastic particles smaller than 5 mm, are particularly challenging to quantify due to their variable sizes, shapes, and compositions[1]. Wastewater treatment plants serve as both sources and sinks of MPs in the environment. Furthermore, the high organic content of wastewater (WW) adds complexity to the separation and quantification of MPs which themselves are undigestible organic sludge. At present, no standardized protocol exists for analyzing MPs in WW and sludge. Significance: A newly developed standard protocol for the WW pretreatment called as Ferrosonication (Fe-UlS) can significantly reduce the temperature, time and effort required for the sample preparation, making the MP analysis more efficient in the WW matrix [2]. Owing to the complexity of wastewater sludge (WWS), density separation is to be done as an additional pretreatment procedure after Fe-UlS. However, during density separation, there is a chance of losing MPs trapped in undigested organic matter through pore-filling interactions. This entrapment can increase the density of MPs and make them difficult to separate. Thus, Fe-UlS pretreatment approach can disintegrate organic matter and prevent them from settling down with recalcitrant. Rather than using the conventional separation funnel, centrifugation using the density gradient solution makes extraction of MPs from WWS faster and more efficient. Using $ZnCl_2$ as the density gradient solution is a cost-efficient solution and can be reused[3]. This optimized pretreatment protocol for WWS brought down the sample preparation time considerably from 2 to 3 days to less than 2 hours[4]. The Laser direct infrared imaging (LDIR) is a promising analytical technique for quantitative analysis of MPs but is not explored for MPs analysis in WWS so far. Methodology: A 10 mL of the primary WWS was placed in a 250 mL glass beaker. A 1:1 Fenton reagent (0.05 M $FeSO_4$ + 30% H_2O_2) was added to the WWS and made up to 200 mL. The pH was adjusted to 2–3 using 100 µL H_2SO_4. Fe-UlS pretreatment was done at 31% amplitude for 30 minutes. After Fe-UlS, the pretreated WWS was filtered onto cellulose filter paper (Ahlstrom-Munksjö qualitative filter papers; pore size 10 µm) and the residues were washed out using $ZnCl_2$ (density 1.9 g/mL) into a 50 mL centrifuge tube. Density separation was done by centrifugation at 3000 rpm for 15 minutes. The supernatant after density separation was again filtered onto cellulose filter paper and residues washed out using 70% ethanol. It was then filtered onto Polycarbonate (PCTG) Gold-Coated Membrane Filters (Sterlitech 0.8 micron, 40/20 nm Coating, 25 mm diameter) using Millipore Glass Microanalysis Filtration setup. Quantitative analysis of MPs in terms of their chemical composition was studied in detail using Agilent 8700 LDIR Chemical Imaging System. A fully automated analysis was done using the Clarity software (Agilent version 1.5.58) using Microplastics Starter 2.0 library. Particle analysis was done on the selected area (~16mm diameter) of the filter, with a size range of 20–500 µm. Data analysis was done on particles that were detected at higher confidence (>90%).

The pretreatment protocol was validated by adding known concentration of MPs and recovery efficiency was calculated. Results and Discussion: Figure 1 shows the data regarding the number, type and size distribution on the total number of MPs detected at higher confidence levels (>90%) by LDIR. Polyurethane (PU) was the most abundantly detected MPs in the primary sludge followed by polyethylene (PE), polypropylene (PP), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polyoxymethylene (POM). The most detected MPs with high confidence was <50 μm followed by MPs in the 50-100 μm range. High-density MPs such as polylactic acid (PLA) and polytetrafluoroethylene (PTFE). were also detected but with 80% confidence. A 100% recovery efficiency was obtained after Fe-UlS and density separation pretreatment with the known number of spiked MPs. Thus, the developed pretreatment protocol for WWS is efficient for MPs analysis. The density gradient solution (ZnCl2: 1.9 g/mL) used could separate even the high-density MPs present in WWS. Figure 1: Distribution of MPs detected by LDIR based on the number, type and size at higher confidence levels (>90%) References: [1] L.G.A. Barboza, B.C.G. Gimenez, Microplastics in the marine environment: Current trends and future perspectives, Marine Pollution Bulletin 97 (2015) 5–12. https://doi.org/10.1016/j.marpolbul.2015.06.008. [2] J. Mathew, G. Bhardwaj, R. Pulicharla, P. Rezai, S. Kaur Brar, Innovating Ferro-Sonication Approach for Extracting Microplastics from Wastewaters, (2024). https://doi.org/10.2139/ssrn.4872595. [3] M.O. Rodrigues, A.M.M. Gonçalves, F.J.M. Gonçalves, N. Abrantes, Improving cost-efficiency for MPs density separation by zinc chloride reuse, MethodsX 7 (2020) 100785. https://doi.org/10.1016/j.mex.2020.100785. [4] J. Mathew, R. Pulicharla, P. Rezai, S.K. Brar, Microplastics in wastewaters: Pretreatment to detection trail, Journal of Water Process Engineering 64 (2024) 105702. https://doi.org/10.1016/j.jwpe.2024.105702.

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Thank You !