International conference on

Circular Economy for Climate and Environment

CECE 2023

Abstract Booklet

26 – 27 September 2023
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Welcome note

Dear CECE2023 delegates,

With great excitement and anticipation, we extend our warmest welcome all the delegates to the first Circular Economy for Climate and Environment Conference (CECE 2023), held at the vibrant city campus of the University of Technology Sydney (UTS). This two-day event (26-27 September 2023) promises to be an enlightening exploration of recent advancements in research and innovations under eight different themes.

CECE 2023 is a pioneering initiative jointly organized by the University of Technology (UTS) and the ARC Hub for Nutrient in a Circular Economy or the **NiCE Hub**. As the first of its kind, this international conference marks a significant milestone in the field of circular economy, providing a platform for interdisciplinary discourse on a multitude of subjects, including circular economy applications in water, energy, environment, waste, resource recovery, and climate change.

Our conference is a unique convergence of thought leaders and innovators, bringing together researchers from academia, industry professionals, government representatives, and passionate advocates from non-governmental organizations. We believe that meaningful change arises from the exchange and collaboration of ideas, and CECE 2023 is designed to precisely facilitate that.

We have lined up prominent speakers at the plenary, keynote, and panel discussions, representing academia, industry, and government who can inspire us with their insights and expertise, charting the course for a more sustainable future in circular economy. We are proud to announce that attractive prizes have been established to recognize excellence in both the academia and industry, including categories for young researchers and student awards.

The features of the conference include two plenary sessions, two panel discussions, session keynote speakers, oral presenters, poster presenters, gala dinner, and CECE awards. As you embark on this intellectual journey with us, we encourage you to seize the opportunity for networking, collaboration, and the exchange of ideas that can shape a more circular and sustainable world.

Once again, we extend our heartfelt welcome to CECE 2023 and wish you a profoundly productive conference experience filled with knowledge sharing, innovation, and impactful connections.

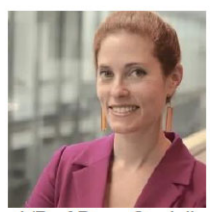
Thank you.

CECE2023 Chairs


Prof Hokyong Shon, UTS, Chair


A/Prof. Stefano Freguia, University of Melbourne


Prof Bernadette McCabe, University of Southern Queensland Co-chair


A/Prof Dana Cordell, UTS, Co-chair


A/Prof Leonard Tijing, UTS, Co-chair

Conference Committees

Organizing committee

- Prof Hokyong Shon, UTS, Chair
- A/P Stefano Freguia, University of Melbourne, Co-chair
- A/P Leonard Tijing, UTS, UT, Co-chair
- A/Prof Dana Cordell, UTS, Co-Chair
- Prof Bernadette McCabe, University of Southern Queensland, Co-Chair
- Dr Sherub Phuntsho, UTS
- Dr Ibrahim El Saliby, ARC NiCE Hub, UTS
- Dr Li Gao, South-East Water
- Dr Gary Leeson, Organic Crop Protectants (OCP)
- A/Prof Cara Beal, Griffith University
- Prof Mikel Duke, Victoria University
- Ms Jade Jiang, UTS (student, UTS)
- Ms Weonjung Sohn (student, UTS)
- Ms Hanwei Yu (student, UTS)

Scientific committee

- Prof Hadi Khabbaz, UTS/FEIT, Australia
- A/Prof Behzad Fatahi, UTS/FEIT, Australia
- Prof Qilin Wang, UTS/FEIT, Australia
- A/Prof Liu Ye, University of Queensland, Australia
- Prof Jason Prior, UTS/ISF, Australia
- Prof Anne Roiko, Griffith University, Australia
- Dr Jason Reynolds, Western Sydney University, Australia
- Prof Jeff Powell, Western Sydney University, Australia
- Kim Nance, Rich Earth Institute, USA
- Dr Amit Chanan, Water Authority Fiji

Conference executive team

- Prof Hokyong Shon, UTS
- A/P Stefano Freguia, UOM
- A/P Leonard Tijing, UTS
- Dr Sherub Phuntsho, UTS
- Dr Ibrahim El-Saliby, UTS

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- Yeshi Choden, UTS
- Hao Liu, UTS
- The Hyeon Tae Kim, UTS
- Chen Wang, UTS
- Saeid Rajabzadeh, UTS
- Mohsen Askari, UTS

Conference full programme

Scan for most updated programme

Day 1: Tuesday 26 September 2023

8:30 AM	**Registration**	
9:00 AM	**Opening ceremony (ROOM: Jones + Broadway)**	
9:30 AM	**Plenary Session 1: Circular Economy and climate change – the issues** Chair: Dana Cordell, University of Technology Sydney (UTS), Australia	
30 min each. Q&A in panel discussion	Circular Economy: A National agenda for Australia and Pacific **Lisa Mclean**, Circular Australia	
	Inputs of anthropogenic nutrients and other contaminants into coastal waters **Martina Doblin**, UTS, Australia	
	Ten years of urine diversion development in the United States: findings and lessons learned **Abraham Noe-Hays,** Rich Earth Institute, USA	
11:00 AM	**Panel discussion 1: Theme: Challenges in the circular economy and climate change** (Moderated by Dana Cordell) Panellists: Lisa Mclean, Abraham Noe-Hays, Martina Doblin, Melita Jazbec (UTS)	
12:00 PM	**Morning Tea break**	
	ROOM: Jones	**ROOM: Broadway**
12:30 AM	**Session 1: Circular economy** Chairs: Jason Prior (UTS) & Li Gao (South-East Water)	**Session 2**: **Circular economy** Chairs: Sherub Phuntsho (UTS) & Sanjay Kumarasingham (GANDEN)
Keynote: 20 mins (incl. 5 min Q&A) All other speakers: 15 mins (incl. 3 min Q&A)	Evaluating the sustainability risks and opportunities of circular economy initiatives: a urine-based fertiliser circular ecosystem case study **Aldo Ometto, Griffith University** (keynote), Australia	Biochar for circular economy: Nutrients recovery for fertilizer production **Dong-Jin Kim**, Hallym University, Korea (keynote)
	Advancing the Circular Economy of Plastics in Australia through 3D Printing: A Conceptual Framework **Aziz Ahmed**, University of Wollongong, Australia	Exploring biochar applications for nutrient recovery in sustainable aquaculture systems **Cathryn O'Sullivan**, CSIRO, Australia
	Hospital waste management: Autoclave-coupled gasification **Peter Harris**, University of Southern Queensland	Governing circular nutrient value chains: lessons learnt from precinct governance **Jordan Roods,** University of Technology Sydney, Australia
	Nickel boride for efficient energy-saving Hydrogen production via Urine electrolysis **Zhijie Chen**, University of Technology Sydney, Australia	Recovery of ammonium from anaerobic digester wastewater, from lab to pilot scale **Sydur Rahman,** Southern Cross University, Australia
	Organic based fertilisers: Agronomic potential and greenhouse gas emissions **Robert Impraim**, Incitec Pivot Fertilisers, Australia	
1:50 PM	**Lunch break**	
2:50 PM	**Session 3: Climate change/Water, Energy & environment** Chairs: Leonard Tijing (UTS) & Tanisha Shields (Ruminati)	**Session 4: Resource recovery from wastes** Chairs: Hokyong Shon (UTS) & Bernadette McCabe (University of Southern Queensland)
Keynote: 20 mins (incl. 5 min Q&A) All other speakers: 15 mins (incl. 3 min Q&A)	How wastewater facilities could tackle food waste, generate energy & slash emissions **Melita Jazbec,** ISF, UTS (keynote)	Reflections on resource recovery within the waste-water industry **Sanjay Kumarasingham**, GANDEN Engineers & Project Managers (keynote)
	Effectively Tracking Agricultural Emissions to Refine the Understanding of Agriculture's Impact on Climate Change **Tanisha Shields,** Ruminati, Australia	Kerbside collection and treatment of household food and garden waste in a Queensland regional local government – is it feasible and socially acceptable? **Christine Blanchard**, Lockyer Valley Regional Council & USQ (invited)

	Modelling Energy Demand, Supply, and Carbon Footprint Projections for Greenfield Planning Within the Framework of Net-Zero Systems: A Case Study of the Western Sydney Aerotropolis in New South Wales, Australia. **Gobinath Rajarathnam**, University of Sydney, Australia	Nutrient Recovery from Hydroponics Waste Nutrient Solution **Dharma Hagare,** Western Sydney University, Australia
	A techno-economic evaluation of urine separation for wastewater treatment plant configurations **Jia Meng**, **Haoran Duan,** University of Queensland, Australia	Fertilizer recovery from human urine by novel two-stage processes **Zhiqiang Zuo**, University of Queensland, Australia
	Creating a Comprehensive Hydroponic Fertilizer by Blending Micro and Macro Nutrients from Bio-Digested Aquatic Floating Weed and Nitrified Human Urine **Swaminathan Palanisami,** Western Sydney University, Australia	Microbial community in an activated carbon incorporated membrane bioreactor with the biofilm carriers for the nitrification of source-separated urine **Weonjung Sohn**, UTS, Australia
	Views of stakeholders on complains rating assessment of industrial effluent discharges: a Malaysian context. **Zulaikha Mokhtar,** University of Queensland, Australia	Membrane capacitive deionization for selective lithium recovery from brines **Hanwei Yu,** UTS, Australia
4:25 PM	**Tea break**	
5:00 – 6:30 PM	**Poster Session (ROOM: Broadway for 3 min presentation & Harris for poster display)** **Chair: Sherub Phuntsho**	**Workshop (ROOM: Jones)**
Poster presenters are allocated 3 mins each to present their poster from the podium. They can then be at their poster board for Q&A	1. Gam T. Nguyen, Griffith Uni, Supply, Demand and the Economic Effectiveness of Urine-diverting Technologies and Products: A Systematic Literature Review 2. Niti Bhattarai, UTS, Exploring Sustainable Alternatives: Urine as a substitute for urea in Bio-cementation techniques for improved soil properties. 3. Ibrahim El Saliby and Juan Lucas, Royal Botanic Garden Sydney, Nutrients recovery from human urine and their reuse as fertiliser to grow spearmint (Mentha Spicata) – Ibrahim will present. 4. Cathryn O'Sullivan, CSIRO Agriculture and Food, Harvesting nutrients and clean water from wastewater with biomimetic membranes. 5. Jiaxi Jiang, UTS. Potential nutrient recovery from source-separated urine through hybrid membrane bioreactor and membrane capacitive deionisation. 6. Chen Wang, UTS. Graphene oxide-based layer-by-layer nanofiltration using inkjet printing for desalination. 7. Andrea Merenda, UTS. Catalytic membrane reactors for energy-efficient wastewater treatment. 8. Hao Liu, UTS. Enhanced Strategies for Phosphate Recovery from Urine by Magnesium Galvanic Process. 9. A. S. M. Mohiuddin, UTS. Climate change driven extreme events impacting the water quality of Sydney's largest water source	Workshop: Roadmapping Workshop for Nutrients Circular Ecosystem (Open to all interested delegates)
7:00 – 9:00 PM	**Circular Award Ceremony and Gala Dinner** **(ROOM: Wattle + Thomas)**	

Day 2: Wednesday 27 September 2023

8:30 AM	Registration	
	ROOM: Jones	**ROOM: Broadway**
9:00 AM	**Session 5: Resource recovery from wastes** Chairs: Mikel Duke (VU) & Cara Beal (Griffith)	**Session 6: Environmental Pollution/Technologies** Chairs: Stefano Freguia (UoM) & Behzad Fatahi (UTS)
Keynote: 20 mins (incl. 5 min Q&A) All other speakers: 15 mins (incl. 3 min Q&A)	Cost-effective Water Production **Qiang Fu (keynote)**	Carbonisation – a sustainable technology for circular economies **Durell Hammond**, Pyrocal (keynote)
	Unveiling the resource within: Extracting rare earth elements from mine tailings **Biplob Kumar Pramanik,** RMIT, Australia	Performance Prediction of Plate-and-frame Forward Osmosis Membrane using Machine Learning Models **Sungyun Lee**, Kyungpook National University (invited speaker)
	Selective separation and recovery of rare-earth elements using electrochemical methods **Youngwoo Choo,** UTS, Australia	Improving urban wastewater management by using on-site iron carbonate chemical manufactured with biogas upgrading **Xiaotong Cen**, University of Queensland, Australia
	Selective recovery of Rare Earth Elements by direct contact membrane distillation and adsorption from acid mine drainage **Charith Fonseka,** UTS, Australia	Production of affordable sodium borohydride as a hydrogen carrier **Rui Han**, UTS, Australia
10:20 AM	**Morning Tea break**	
10:50 AM	**Session 7: Bioresource/resource recovery** Chairs: Qilin Wang (UTS) & Haoran Duan (UQ)	**Session 8: Environmental health & risks** Chairs: Jason Reynolds (WSU) & Youngwoo Choo (UTS)
Keynote: 20 mins (incl. 5 min Q&A) All other speakers: 15 mins (incl. 3 min Q&A)	Technologies for achieving energy positive wastewater treatment **Qilin Wang**, UTS (keynote)	A nature-positive economy: - opportunities and challenges **Liana Downey**, Australian Conservation Foundation
	Biomineralization in a high-rate anaerobic distillery wastewater treatment **Lei Zhang**, QUT, Australia/Univ of Alberta, Canada	Techno Economic Assessment of Urine Diversion and Conversion to Fertiliser Products at Sydney Central Park WWTP **Umakant Badeti,** UTS/Xylem, Australia
	Novel Anaerobic Fermentation Paradigm of Producing Medium-chain Fatty Acids from Food Wastes with Self-Produced Ethanol as Electron Donor **Lan Wu,** UTS, Australia	Optimised start-up and mass transfer for efficient nutrient recovery in a bio-electro concentration system **Veera Koskue**, University of Melbourne, Australia
	Biofouling Control of Reverse Osmosis Membrane Using Biocidal Ammonia from Concentrated Hydrolyse Urine **Chee Xiang Chen,** University of Melbourne, Australia	Different sizes of microplastics induced distinct microbial responses of anaerobic granular sludge **Chen Wang**, UTS, Australia
11:55 PM	**Lunch break**	
1:00 PM	**Plenary session 2: Circular economy and climate change in action Room (Jones + Broadway)** Chair: Bernadatte McCabe, USQ, Australia	
30 min each. Q&A in panel discussion	Biochar in the circular economy **Johanna Johnson**, Logan City Council, QLD, Australia	
	Circular economy in Sydney Water **Django Seccombe**, Sydney Water	
	Net Zero Strategies of The City of Sydney **Neil Palagedara**, City of Sydney	
2:30 PM	**Panel discussion 2: Technology and Circular Economy** Panellists: Johanna Johnson, Django Seccombe, Neil Palagedara, Durell Hammond (Pyrocal) and Mikel Duke (Victorial University) Panel moderators: Bernadette McCabe (USQ) and Stefano Freguia (University of Melbourne)	
3:30 PM	**Afternoon tea break**	
4:00 - 4:30 PM	**Closing ceremony & awards (Room: Jones + Broadway)**	

Plenary 1: Circular Economy and climate change - the issues

Chaired by Dana Cordell, University of Technology Sydney

Circular Economy: A National agenda for Australia and Pacific

Lisa Mclean

Circular Australia
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Brief Bio

Lisa McLean Managing Director of Circular Australia, a national independent NFP leading the transition to a 2030 Australian circular economy and a member of the federal Government's Circular Economy Ministerial Advisory Group (CEMAG). She has been successfully advising industry and governments in developing new policy frameworks and regulations that bring about market change to enable the circular zero-carbon economy over the past 20 years in infrastructure, energy, water, waste and mobility sectors in the UK and Australia.

Abstract

Australian governments now have a target for the establishment of a circular economy. By 2030 the nation will have frameworks and roadmaps in place to drive this critical systems transition. Circular economy is the only viable economic framework the world has to grow jobs and industries in the resource and carbon constrained world we now live in. We need the circular economy and its new sustainable approaches to achieve Net Zero, we need it to design out waste and pollution, keep materials in the economy at their highest value for as long as possible, and to regenerate natural systems.

Circular Australia is driving this new circular reform agenda across key sectors including the finance and investment, infrastructure and precincts, agriculture, consumables, and the built environment. Working with industry, government and researchers, Circular Australia is helping to demonstrate the opportunities to embed new practices that will not only cut emissions, generate jobs, extract resource value - but do so in a way that regenerates natural systems.

We highlight: the need for the scaling of place-based innovation like the UNIDO industrial symbiosis centres in NSW regional centres Parkes and Wagga; the human role of circularity - who are the transition brokers, the cat-herders?; how to embrace First Nations expertise; the need for a circular financial taxonomy so investment can scale circular outcomes; embedding circular economy as a key requirement in the renewable energy transition; and the best metrics to measure progress and help us understand what circular economy means in businesses, operations and our everyday work and life.

The building of the circular economy is a collective effort not one business, government, individual can do it on their own. By working together to accelerate the circular transition we can reduce the risks and ensure the outcome: a viable sustainable future for us all.

Inputs of anthropogenic nutrients and other contaminants into coastal waters

Martina A. **Doblin,**
University of technology Sydney, Australia
Team Leader, Productive Coasts Climate Change Cluster
Director and CEO, Sydney Institute of Marine Science
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Brief bio

Martina Doblin is Professor of Oceanography at the University of Technology Sydney and current Director and CEO of the Sydney Institute of Marine Science. Passionate about the ocean from a young age, she has been a marine researcher for over 20 years, leading highly successful research teams investigating the impacts of climate change, harmful algal blooms, and more recently the ecological impacts of emerging contaminants released into coastal waters. She is a board member of Australia's Integrated Marine Observing System, and member of the

National Marine Sciences Committee, providing scientifically-robust, practical advice on marine issues of national significance to Australia. Martina has a profile of scientific and public engagement, is an advocate for diversity in the science, technology, and engineering professions, and has a strong interest in accelerating solutions for improving water quality in the urban ocean.

Abstract

We are currently living in the Anthropocene, an epoch when the human footprint on Earth has become so large it is being captured in the geological record. Three Earth-system processes, climate change, rate of biodiversity loss and interference with the nitrogen cycle, have already transgressed their boundaries, increasing the potential for non-linear, abrupt environmental change.

A key component of the Earth-system is the connectivity between terrestrial, atmospheric and ocean compartments. This means that anthropogenic pressures on the atmosphere cascade to the ocean (e.g. rising atmospheric CO_2 causing ocean acidification), and pressures on the landscape cascade to adjacent waterways (e.g. intensive agriculture causing eutrophication), highlighting that we can't concentrate our efforts on any one process in isolation.

In Australia, there are over 190 wastewater treatment plants that discharge treated water into estuarine and coastal environments. Additionally, there are an order of magnitude more stormwater outlets that channel untreated runoff into urban waterways. This suggests a large potential for inputs of natural and anthropogenic materials into coastal environments - for example, 66% of contaminants to Sydney Harbour are introduced via stormwater. Wastewaters are typically monitored for suspended solids, dissolved nutrients and pathogens (enterococci, E. coli), but there is growing interest in contaminants of emerging concern such as antibiotics, industrial chemicals and microplastics, because of their potential for ecological harm. Furthermore, climate extremes such as drought, flood and fires, are modulating the fluxes of materials into the ocean.

This talk will provide an environmental perspective on the management of wastewater sources in Australia, and how innovations such as valorizing nutrients as part of a Circular Economy have other considerations as part of the connected Earth-system.

Ten years of urine diversion development in the United States: findings and lessons learned

Abraham Noe-Hays

Rich Earth Institute
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Brief bio

Abraham Noe-Hays is the Co-Founder and Research Director of the Rich Earth Institute, which operates the nation's first community-scale urine recycling program and conducts research relating to reclaiming resources from human waste. He is also the Chief Technology Officer of Rich Earth Tools, LLC, which develops technology for productive sanitation, particularly for concentrating and sanitizing source-separated urine and vacuum-flushed blackwater for fertilizer production.

Abstract

Diverting urine from the wastewater stream can, in theory, constitute a more sustainable approach to wastewater treatment and fertilizer production. In practice, there are several critical aspects to navigate, including the cost and environmental impacts of collecting and processing urine, the incentives driving people to adopt urine diversion, and the farming context in which the fertilizer will eventually be used. The Rich Earth Institute takes a practical approach to urine diversion, operating the first and largest community-scale urine-to-fertilizer program in the United States. Initiated in 2012 as an unfunded, grassroots project to collect urine for reuse on local farms, it has grown into a research and demonstration institute with a diverse program. Research topics include urine processing technologies, microcontaminant management, social acceptance, soil health impact, and factors affecting adoption by farmers.

Over the last ten years, we have come to several broad conclusions about the prospects for urine diversion: There is much more enthusiasm for urine diversion than we initially expected. Individuals hearing about urine diversion for the first time frequently report personal interest in the concept, with the caveat that they do not

believe that others will be as receptive. This difference between ascribed and actual attitudes appears to be widespread, and it seems that the United States public is much more receptive to the idea of urine diversion than people imagine.
A significant group of early adopters are ready to begin diverting urine, if participation is affordable. About 230 individuals currently participate in our urine recycling program, despite the lack of any financial incentive. Most urine donors use inexpensive, portable urine collection systems, and although many of these people would like to have a permanently-installed urine-diverting toilet, most are deterred by the cost, logistical complexity, and permitting requirements.

Urine diversion will be most readily adopted where the practical value justifies the expense and effort of adoption. These scenarios include:

1) Where urine meets an onsite fertilizer need, using minimal treatment and infrastructure?
2) Where nutrient pollution is a problem and centralized treatment with nutrient removal is impractical?
3) Where urine diversion can facilitate water reuse by reducing problematic dissolved solids?

Plenary 2: Circular economy and climate change in action

Chaired by Bernadatte McCabe, University of Southern Queensland, Australia

Biochar in the circular economy

Johnna Johnson

Logan City Council, QLD, Australia and, Logan Water
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Brief bio

Johanna is the Sustainability Solutions Lead for Logan City Council and Logan Water. Jo has a Bachelor of Science majoring in Chemistry and Microbiology and a Master of Integrated Water Management. Jo has had the pleasure of working for Logan City Council for over a decade in various roles in Logan Water. Jo started off in the laboratory where she gained hands on experience with the science of water. Jo utilises her background in science and integrated water management Jo has successful completed multiple projects to achieve successful outcomes and specialises in circular economy and resource recovery.

Abstract

Logan City Council's Carbon Reduction Strategy and Action Plan (Logan City Council, 2018) included a commitment to becoming a carbon neutral, green city. This plan set a target of 'carbon neutral' for all quantifiable carbon emissions that occur as a direct and indirect result of Council's operations by 2022. In 2021/2022 Council emitted over 160,000 tonnes of carbon, and carbon neutrality was achieved through a combination of energy sustainability projects, green energy generation and purchasing carbon credits on the carbon market.
This achievement was certified by Climate Active, a partnership between the Australian Government and Australian businesses to drive voluntary climate action. To maintain this status, and to progress towards a sustainable future, prudent, and efficient manner, Logan Water has developed an Australian first gasification facility, which converts wastewater biosolids into biochar.
Logan Water began operating Australia's first biosolids gasification facility in 2022. The facility transforms human waste, or biosolids, into renewable energy and a sustainable product called biochar. Logan Water is now working with researchers on 'proof of performance' studies to analyse our biochar, confirm that persistent organic pollutants (POPs) are destroyed in the gasification process, and show we comply with environmental regulations. We are developing a market for biochar across a range of industries. We will release our findings and demonstrate how Logan Water has created a circular economy around biochar. This can be replicated by other governments and utilities.

Sydney Water Unlocking the Circular Economy

Django Seccombe

[1]Sydney Water
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Brief bio

Django Seccombe, Circular Economy Manager, Western Sydney Development, Sydney Water. He is an environmental engineer committed to unlocking new enterprise and creating a more sustainable economy in Greater Sydney and beyond. Django's experience spans operations, planning, strategy and policy development in the water sector. His current role focuses on establishing circular economy collaborations with customers in the rapidly growing Western Sydney. His projects focus on organic waste management, bioenergy, agribusiness and integrated water cycle management.

Abstract

Sydney Water has committed to embracing and unlocking the circular economy, putting this objective clearly within its Corporate Strategy. For the organisation this translates to 5 key focus areas; (1) restoring natural systems, (2) conserving & recycling water for a reliable and resilient water supply, (3) reducing energy and carbon toward net zero target, (4) designing out waste and adopting circular material use, (5) partnering with our customers and stakeholders. Sydney Water's CE Strategy is designed on the Ellen Macarthur Foundation Framework. This talk will unpack Sydney Water's progress building this strategy, the programs of work within it, the governance approach and key challenges along the way.

Net Zero Strategies of The City of Sydney

Neil Palagedara

City of Sydney
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Brief Bio

Neil has more than 10 years' experience across contracts performance, and sustainability at both Qantas and the City of Sydney. Through innovative thinking, effective performance management and driving accountability, he has been able to shift his portfolios from a reactive, operational perspective to a proactive, cost focus. He has delivered over $10M in savings, including delivering annual savings of $500K and reducing the City of Sydney's emissions by 20,000 tonnes per year, through procurement of Australia's largest standalone council 100% renewable power agreement. Neil has successfully managed portfolios of more than $2b, including slashing costs. For example, reducing utility service base costs by $2M at Qantas. Neil has been invited to deliver presentations on sustainability and environmental management, including at the Merrill Lynch Waste Management Round table and as a speaker at the Australasian Waste and Recycling Expo. Neil is a practical individual with a logical and positive approach to challenges, and he is willing to question the status quo to drive improved performance.

Session 1 Theme: Circular economy

Keynote: **Evaluating the sustainability risks and opportunities of circular economy initiatives: a urine-based fertiliser circular ecosystem case study**

Aldo Ometto[1,2 *], **Anne Roiko**[1*] , Sayed Iftekhar [1], Gam Nguyen [1] Cara Beal[1]

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2 University of Sao Paulo, Engineering School of Sao Carlos, Brazil
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Brief bios

Aldo Ometto leads the Research Centre for Circular Economy (RC4CE) within the Innovation Centre of the University of Sao Paulo, Brazil, and he is a visiting Professor at CRI at Griffith University. Within the RC4CE, he leads a group research and innovation projects focussing on system innovation, sustainability, life cycle management/assessment, circular business models and ecosystems.

Professor Anne Roiko leads the Environmental Health team within the School of Pharmacy and Medical Sciences at Griffith University. Within the Cities Research Institute, she leads a group focussing on assessing and managing water-related health risks, nature-based solutions and on developing systems-based decision-support tools for policymakers.

Abstract

Transitioning towards Circular Economy is considered one of the main ways of addressing sustainability. For enabling and boosting this shift, it is crucial that a systemic and interdisciplinary approach is adopted. A urine-based fertiliser ecosystem case study from the ARC Research Hub for Nutrients in a Circular Economy (NiCE) was analysed through this lens, utilising Subject Matter Experts to identify strategic risks and opportunities for sustainability. Initial qualitative insights' were generated around three main processes: urine collection, urine processing and fertilizer production, and fertiliser use and uptake. These processes are explored with respect to key criteria, including: operation and logistics, climate and environment, health risk, economic feasibility, society and culture, and governance. Preliminary results highlight the importance of social and cultural acceptance of urine-based fertiliser; the potential health risks associated with pathogens, pharmaceuticals, heavy metals and other chemicals; odour; the costs of the specialised 'hardware' (the toilets), processes, and transport; the scalability (which also depends on if it is granular or liquid); environmental aspects and regulations. The cost for the treatment and transport of processed liquid is relatively high, and its bulk presents explosive risks and is logistically complicated. On the other hand, the urine separation prior to piping into a wastewater treatment plant would reduce energy consumption and greenhouses gas emissions, such as CO_2 and N_2O. Attention to those environmental aspects is also important during urine processing and fertilizer production, transport and use, including eutrophication. Modelling the fertiliser dynamics within all system components (plants, soil, and landscape features), training and skills development needed for operators, maintenance of all processes, are essential. For governance, existing regulations need to be broadened to cover the novel aspects of these processes such as the processing of "yellow water" onsite and the application of "waste products". In conclusion, the issues analysed here are inherently interconnected, variably measurable and present multi- level perspectives for a more sustainable urine-based fertiliser ecosystem. The expected outcome of the completed work would be the development of a sustainable CE evaluation framework with indicators that can be mapped and compared across different urine-based fertiliser production systems and application scenarios.

Advancing the Circular Economy of Plastics in Australia through 3D Printing: A Conceptual Framework

Aziz Ahmed[1], Richard Yang[2], Charlotte Craff[3], Samantha Snabes[3], Carolyn Seepersad[4], Michael Webber[4], Britney Blann[5], Faisal I. Hai[1]

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[4]Mechanical Engineering Department, The University of Texas at Austin, Austin, TX 78712, United States
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Brief bio

Dr Aziz Ahmed is a Lecturer in Structural Engineering at the University of Wollongong School of Civil, Mining, Environmental and Architectural Engineering. He is part of an International Team that successfully obtained NSF-CSIRO Convergence Accelerator grant for the project, 'Creating Impact from Local Plastic Waste Using Off-Grid Containerized 3D Printers".

Abstract

This conference paper proposes a conceptual framework for advancing the Circular Economy of Plastics in Australia by leveraging 3D printing technology. With Australia's annual plastic consumption reaching 3.4 million tonnes and a mere 12% recycling rate, there is a substantial value loss of approximately $419 million per year for unrecovered PET and HDPE plastics (Schandl et al., 2020). Conventional large-scale recycling systems face limitations in addressing the unique challenges posed by Australia's geographic dispersion. However, recent advancements in plastic 3D printing, specifically fused granulate fabrication (FGF) or pellet extrusion-based 3D printing, have revolutionized the field by improving print speed and expanding the range of applicable polymers. This concept paper explores the potential of FGF-based 3D printing using recycled plastic waste to achieve a circular economy in Australia. The paper proposes two circular economy models based on FGF technology: one tailored for rural and remote regions and another for urban centres. Additionally, the paper addresses knowledge and research gaps, particularly in assessing the impact of the proposed circular economy framework and proposes a sustainable funding model for long-term project viability. The proposed project also aligns with the vision presented at the second meeting of the Intergovernmental Negotiating Committee on Plastic Pollution (Anderson, 2023), which envisions the transformation of recycled polymers into valuable materials highly sought after by companies, households, and governments. By adopting 3D printing technology as a key enabler, the proposed framework seeks to transform plastic waste into a resource, fostering a paradigm shift towards a circular economy in Australia's plastic sector.

Andersen I (2023). A big step towards ending plastic pollution. [online] UNEP. Available at: https://www.unep.org/news-and-stories/speech/big-step-towards-ending-plastic-pollution [Accessed 31 May 2023].
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Hospital waste management: Autoclave-coupled gasification

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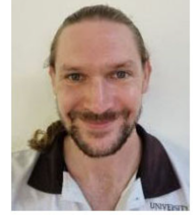

Brief bio

Peter is a post-doctoral research fellow with the Centre for Agricultural Engineering at the University ofSouthern Queensland. Peter has 13 years of experience working in the circular economy space with principal expertise in anaerobic digestion (biogas) and is experienced with several pathways totransform industry waste into value-added products.

Abstract

Australian hospitals produce large quantities of general and clinical wastes which are typically landfilled and incinerated respectively. Clinical waste must be either shredded and steam sterilised or incinerated prior to landfilling. Indeed, due to the high cost of autoclave operation, the most common method of hospital waste management in Australia is incineration and landfilling. However, with only 12 incinerators in the country, accessing these facilities can also be costly and involve transporting waste large distances. Locally installed autoclaves coupled with gasification technology has thepotential to treat both general and clinical hospital waste to regulation standards while returning environmental and economic benefits and significantly reducing trucking distances.

The detailed composition of Australian hospital waste has been unknown and a subject of ongoing investigation. This work presented the first and most detailed breakdown of Australian hospital waste currently publicly available to the best knowledge of the Authors. Waste profiles reported by three hospitals were assessed; general waste and clinical waste contributed and averageof 84.8% and 6.9% respectively. General waste from one hospital was characterised and categorised into 7 major components, with 'plastic' and 'paper & cardboard' representing 74.5% and 13.4% respectively.

Theoretical assessment of gasification of this waste revealed environmental and economic benefits. Environmentally, hospital waste to landfill can be reduced by 95.9% allowing increased landfill lifespan and reducing landfill emissions, improved recycling, and reduced emissions from trucking and incineration. Economically, local gasification of wastes serves to reduce the costs burden of energy and waste management on hospitals and enables more funds to be redirected into hospitals' core business of healthcare. Additionally, this enables the recovery of glass and metals for recycling and yields a char product that may be utilised in other industries. This techno-economic pre-feasibility study determined local steam sterilisation coupled with gasification to be viable in the context of the reported hospitals, with an internal rate of return of 14.6%.

Nickel boride for efficient energy-saving Hydrogen production via Urine electrolysis

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Brief bio

Dr. Zhijie Chen received his Ph.D. degree in Environmental Engineering from the University of Technology Sydney (UTS), Australia in 2022. He now works as a Postdoc researcher at the Centre for Technology in Water and Wastewater (CTWW), School of Civil and Environmental Engineering, UTS. His research work mainly focuses on waste valorization and eco-design of cost-effective materials for advanced energy and environmental applications (e.g., water electrolysis and wastewater purification/reutilization).

Abstract

Urea-rich (waste)water electrolysis is a favourable route for energy-saving hydrogen production, and designing cost-effective catalysts for efficient urea oxidation reaction (UOR) is crucial for realizing efficient urea-rich (waste)water electrolysis. Herein, we have developed an iron-doped amorphous nickel boride electrocatalyst (aFe-NiB) for UOR. Compared with the undoped and crystalline counterparts, aFe-NiB exhibits a higher activity and the benchmark current density of 10 mA cm-2 can be attained at 1.298 V vs. reversible hydrogen electrode (RHE). Coupled with an efficient hydrogen evolution catalyst, the aFe-NiB-assisted urine electrolyzer can attain a 46 times higher H2 production rate than the water electrolyzer at 1.50 V. Further study reveals a crystallinity-dependent structure self-reconstruction process during UOR. aFe-NiB attains complete phase evolution from boride to electroactive Fe-doped NiOOH. In addition, density functional theory calculations imply that Fe dopants can improve intrinsic catalytic activity via electronic structure regulation of the self-evolved NiOOH and forming heterogeneous bimetallic active sites for UOR. This study provides meaningful insights into the crystallinity-dependent UOR performance and effective strategies to develop efficient UOR (pre)catalysts with dual active sites. Significantly, the demonstrated direct wastewater (urine) electrolysis paves the way for net zero buildings - targeted human waste reutilization.

Organic based fertilisers: Agronomic potential and greenhouse gas emissions

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Brief bio

Robert Impraim completed his PhD in Agricultural Sciences at the University of Melbourne in 2020. He currently works with Incitec Pivot Fertilisers as a Research and Development Agronomist and Product Manager. His role focuses agronomic efficiency and greenhouse gas emissions from the use of organic and synthetic fertilisers.

Abstract

Incitec Pivot Fertilisers (IPF) has developed different formulations of granulated organic and organo-mineral fertilisers that can be applied using standard fertiliser application equipment. This allows for the application of the organic and inorganic fertilisers in one step. Many laboratory, glasshouse and field trials have been conducted to evaluate how these organic based fertilisers affect the agronomic performance of various crops in different soils, and the greenhouse gas (GHG) emissions associated with their use.

Glasshouse trials showed that the organo-mineral fertilisers, in addition to adding carbon to the soil, can perform similarly or improve the yields of corn, lettuce and bok choy compared to conventional farmer's practice of using synthetic fertilisers. The yields were higher than the compost or manure treatments. Similar observation was made in wheat trials. Residual trials (repeated use of the same amended soil) indicated that the organo-mineral fertilisers have positive effect on subsequent croppings.

Strawberry runner (transplant) yields were increased by up to 50% in the organo-mineral fertiliser treatments compared to the untreated soil and manure treatments under field conditions. The organo-mineral fertilisers can produce equivalent yields and transplant quality as standard farmer practices based on the use of chicken manure and inorganic fertiliser. Similar observations were made in fields trails at different locations using celery, wheat, canola, potato, cauliflower, and broccoli as test crops.

Greenhouse gas measurements under laboratory and field conditions showed that the organo-mineral fertilisers can significantly suppress the emissions of nitrous oxide when compared to the use of urea fertiliser and organic amendments like manures and composts. This is observation was more pronounced in the organo-mineral fertiliser that contained nitrification inhibitor. Soils treatment with the organo-mineral fertilisers may however stimulate carbon dioxide emissions compared to chemical fertilisers like urea and DAP. This is due to availability of labile carbon from the organo-mineral fertiliser. A soil incubation experiment confirmed that the organo-mineral fertilisers were able to increase the size of soil microbial biomass (bacteria, fungi and protozoa).

Session 2 Theme: Circular economy

Keynote: **Biochar for circular economy: Nutrients recovery for fertilizer production**

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Brief bio

Professor Dong-Jin Kim is a Distinguished Professor and Director of the Institute of Energy & Environment of Hallym University. He received Ph.D in Chemical Engineering at KAIST (1990). His research mainly focused on nutrient removal and recovery from wastewater utilizing biomass derived biochar.

Abstract

Removal and recovery of nutrients in wastewater is critical to protect water environment and circular economy. Especially phosphorus, one of the key nutrient for agriculture, is a limited and irreplaceable substance. Biochar

has been used as a soil ameliorant, carbon storage to mitigate CO_2 emission, and an absorbent for pollutants removal. This study highlighted the importance of surface modification of biochar with metals for the recovery of nitrogen and phosphorus. The mechanisms and adsorption kinetics could further explain detailed phenomenon occurring on the biochar surface during nutrient recovery. When the biochar-fertilizer is applied on agricultural soil, it can act not only as fertilizer by supplying nutrients to the crops but also as a carbon sink reducing carbon emission. This circular economy approach is one of the solutions to overcome the shortage of rock phosphate, leads to sustainable fertilizer industries, and to mitigate climate change.

Exploring biochar applications for nutrient recovery in sustainable aquaculture systems

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Brief bio

Dr Cathryn O'Sullivan studies circular and sustainable agricultural systems in CSIRO Agriculture and Food. Her work explores interactions between plants and microbes in nutrient cycling and plant nutrition, biocontrol of crop diseases, recovering value from solid waste and wastewaters, and biofuel production. Her recent interests include novel farming systems including aquaponics, agrivoltaics and indoor farming.

Abstract

The recovery and reuse of nutrients from wastewaters is critical for building a net zero, circular bioeconomy while meeting increasing demands for food production. Aquaculture is a rapidly growing industry in Australia and is expected to increase from 45% to 64% market share of total seafood production volume by 2027. However, industry expansion is currently limited by nutrient discharge limits and high volumes of nutrient-rich sludge production. Developing circular, waste-based materials that could be sustainably produced to recover and reuse nutrients would address both environmental pollution risks and capture valuable nutrients that could be used as sustainable inputs for crop production.

Biochar is a carbon-rich material that can be produced from a range of organic wastes through pyrogenic carbon capture and storage (PyCCS) processes. Studies have shown biochar has strong sorption properties for a range of ions that vary depending on factors such as the feedstock or input material, thermal processing conditions, and post-treatment modification. There is strong potential for biochar applications in aquaculture systems to mitigate high nutrient concentrations, either as a sorbent media or as a host for microbes to promote rapid nutrient cycling and improve system productivity (e.g., biochar-microbe complexes).

Our study characterised the ammonium and phosphate sorption properties of biochars produced from four organic waste feedstocks (eucalyptus green waste, walnut shell waste, mixed wood waste and nutshell waste, and municipal biosolids or sewage sludge). Biochars were also characterised for their nutrient sorption properties in a real freshwater aquaculture.

wastewater, and for their potential to form biochar-microbial complexes with nitrifying bacteria. While all biochars were able to sorb ammonium and all lignocellulosic biochars sorbed phosphate, the biosolids biochar released phosphate into solution. Biochars also had higher sorption for either ammonium or phosphate, reflecting potential differences in surface mechanisms behind cation or anion sorption processes. This work highlights the emerging opportunities for biochar applications for nutrient recovery in aquaculture wastewaters, which ultimately contributes to a circular economy and developing sustainable bioresources for future industries.

Governing circular nutrient value chains: lessons learnt from precinct governance

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Brief bio

Jordan Roods is a NiCE Hub PhD candidate researching the governance of circular nutrient economies and is located at the Institute for Sustainable Futures (ISF), University of Technology Sydney. Jordan is also part of the Resource Stewardship team at ISF, where he assists industry and government organisations to identify and evaluate opportunities to avoid, reuse and recover waste through circular economy practices.

Abstract

A circular nutrient economy will require increased recovery of nutrients from organic residuals for reuse as fertilisers in agriculture. This would, among other benefits, improve soil health and biodiversity rates, increase harvests, reduce unsustainable water practices, and reduce harmful contaminants from our food systems. One of the problems in achieving nutrient circularity is the lack of coordination among a diverse range of stakeholders (e.g. policymakers and regulators, wastewater treatment providers, fertiliser producers, etc.) along the nutrient value chain. These stakeholders often fail to connect and communicate their operations effectively, which prevents them from realising the benefits offered by a circular nutrient economy. Although Australia has yet to make a clear plan to achieve nutrient circularity, there are already opportunities in eco-industrial park settings to capture and extract value from nutrients such as phosphorous and nitrogen.

However, there are challenges to successfully establishing an eco-industrial park, similar to those of establishing a circular nutrient economy. Eco-industrial parks often develop organically over time, with sometimes limited government oversight, and contain multiple stakeholders with different interests and motivations. A successful eco-industrial park therefore requires an adaptable governance framework that can manage intricate and dynamically evolving social and organisational relationships. There is also a need for a clear hierarchy of roles and responsibilities for different stakeholders that identifies the material flows and economic incentives of those within the eco-industrial park.

This presentation draws from the lessons learnt while conducting research for the Institute for Sustainable Futures, University of Technology Sydney, on the governance of different precinct types, including eco-industrial parks. The research sought to understand how best governance practices can be applied at different precincts across NSW, Australia. The research provided an overview of the principles of good governance, a framework for governance model typologies and an international review of best governance practices in precincts. This presentation will highlight some lessons learnt specifically from the governance settings of eco-industrial parks, which could be translated and replicated to the governance of a circular nutrient economy.

Recovery of ammonium from anaerobic digester wastewater, from lab to pilot scale

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Brief bio

Dr Sydur Rahman is a Lecturer and researcher within the Faculty of Science and Engineering at Southern Cross University (SCU). He is currently the lead technical officer with SCU's Regional Circular Economy Accelerator project. His research interests include industrial and agricultural water management and modeling.

Abstract

The demand for anaerobic digestion (AD) of agricultural wastes is increasing in Australia. While the benefits of biogas production are clear, little attention is being paid to the disposal of the nutrient rich digestate produced during AD. The digestate from AD systems contains both phosphorus and nitrogen (N, mainly as ammonium), but while P is readily recovered, capture of ammonium remains problematic. Here we present the results from a series

of experiments looking at potential mechanisms for recovering ammonium nitrogen from AD wastewater. Lab based trials showed that struvite precipitation was effective at removing phosphorus (P), but not all of the ammonium in the digestate. However the addition of "engineered" biochars to the struvite reactor made significant improvements to ammonium removal. Air stripping of ammonia was the most effective means of removing N from the AD wastewater, but recovery of the stripped ammonia was poor, reducing its appeal as a circular approach. Based on the laboratory trials, a pilot scale nutrient recovery reactor which incorporates both struvite precipitation and engineered biochar addition was constructed and tested on-site at a local dairy processing plant in the northern rivers of NSW. Results from this pilot scale trial will be presented along with recommendations for application to other nutrient rich waste streams.

Session 3 Theme: Climate change/Water, Energy & environment

Keynote: **How wastewater facilities could tackle food waste, generate energy & slash emissions**

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Brief bio

Dr Melita Jazbec is a Research Principal at the Institute for Sustainable Futures, UTS. She leads the Resource Recovery research stream. Melita specialises in Resource, Energy and Water Futures with strong emphasis on the transition to circular economy and waste management. Melita has been developing waste strategies and action plans for Australian councils and for private companies. Melita models, analyses and consults on waste management practice, with particular emphasis on organic and plastic waste.

Melita's work on circular economy policy included development of circular economy best practice and application, review of circular economy procurement and identifying transition pathways to circular economy for water industry. She has developed a paper for WSAA on "*Transitioning the water industry with the circular economy*", and analysed opportunities for circular economy precincts through the nexus of water, waste and energy. Melita is also a member of Australia Circular Infrastructure Taskforce, MECLA Evaluation Working Group and was on the NABRES taskforce in the development of the star rating for Waste.

Abstract

Energy, water and waste sectors share a common policy objective of achieving net-zero emissions by 2050 and a commitment to the Global Methane Pledge of cutting at least 30% of anthropogenic methane emissions by 2030 from 2020 levels. This study investigates steps towards achieving these objectives by exploring the opportunity of co-digestion of urban organic wastes at wastewater treatment plants (WWTP) to generate bioenergy as well as valuable nutrients (phosphorus, nitrogen, potassium).

In this study we explore the potential of using existing anaerobic digestion infrastructure at three Sydney Water WWTPs (Malabar, St Marys and Riverstone) to process urban organic waste from the adjacent local government areas (Penrith, Blacktown, Randwick and Bayside). We developed an analytical and mapping framework that can be applied more broadly across Sydney and potentially NSW and other jurisdictions to showcase the value of anaerobic digestion, which although extensively used internationally has not yet been harnessed in Australia. The methodology includes identification of data sources that can be used to determine quantities of organic waste generation quantities. Multiple approaches are taken to estimate the unknown quantities of organic waste generation and analysed for suitability particularly for commercial and industrial streams. Estimated organic waste streams and energy potentials are mapped, with identified hot-spots for the selected LGAs. In addition, co-benefits such as diversion from landfill, nutrient recovery and greenhouse gas emissions savings are assessed.

This study has shown that WWTPs could fill substantial amount of the identified anaerobic infrastructure capacity gap and could create wide economic benefits. Majority of the urban organic waste is either disposed to landfill or lost in low value applications, such as injection of fats oils and greases into the soil. Some of these wastes could be processed at wastewater treatment plants, generating renewable biogas as well as capturing nutrients and reducing carbon footprint. Generated renewable biogas could be used to generate electricity, as a replacement of natural gas or transport fuel. This solution however is depended on the organics collection method and requires energy, waste and water sectors, that normally operate in silos, to come together to harness the full circular economy potential.

Effectively Tracking Agricultural Emissions to Refine the understanding of Agriculture's Impact on Climate Change

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Brief bio

Tanisha Shields is a Data Analyst at Ruminati, focussing on creating new ways to measure, track and validate on-farm climate action across the supply chain. Tanisha specialises in data management and methodology development, and has over 5 years experience working with farmers across a range of industries.

Abstract

Tracking agricultural emissions is becoming increasingly important for producers, the supply chain, regulators and consumers. Currently we use industry averages to make assumptions about climate impact from an agricultural enterprise, when the reality is producers work in a multivariate landscape. Each farm business has a unique emissions profile which is not captured in industry averages.

The most favourable option is for producers to baseline the emissions of their property themselves, however encouraging them to do this can be challenging. Time is a farmer's most valuable asset, and existing tools are complex and time consuming to use, reducing uptake and leaving significant gaps in data sets.
Ruminati was developed to streamline the baselining process for producers, with the aim of getting large numbers of agricultural enterprises to track their farm emissions, support them to identify areas in which they could reduce emissions, and monitor their impact over time. Ruminati provides the key linkage between research and end-users, focussing on adoption by farmers to collect essential data to refine the understanding of agriculture's impact on climate change.

Capturing specific emissions data from individual farm businesses provides an opportunity to link this data along the supply chain. Climate data from the source quantifies potential mitigation and adaptation options, providing significantly more value than averages alone.

The climate conscious consumer wants to understand the footprint of the produce they consume. The supply chain wishes to reduce their footprint by sourcing high quality, low emissions produce from farmers. The key linkage is farmer data. Ruminati uses a simple interface to capture on farm data, including on livestock, fodder, fertiliser, chemical usage, and electricity and fuel usage. This information is converted into an emissions baseline, as well as stored on the federated Ruminati database.

Ruminati data is self-reporting, similar to that of the ATO. Data validity is a key component of building trust with end-users of the data. There are many ways that this data can be validated, including machine-learning, asking for evidence from the user and third party validation.

Modelling Energy Demand, Supply, and Carbon Footprint Projections for Greenfield Planning Within the Framework of Net-Zero Systems: A Case Study of the Western Sydney Aerotropolis in New South Wales, Australia.

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Brief bio

Dr Gobinath Rajarathnam is a researcher and lecturer of Digital Circular Economy at the University of Sydney, and Founder & CEO of Mercularis. Gobi envisions and leads the development of AI digital platforms aimed at empowering industries, governments and individuals to create and participate in circular economies of various scales.

Abstract

The development of energy hubs within greenfield precincts presents an opportunity for the transition to carbon neutrality. However, a detailed demand model is required, which may not be available during the early planning stages. To assess circular economy implications for materials and energy, a suitable planning tool is required for scoping demand and supply, to serve society. In collaboration, The University of Sydney and Mitsubishi Heavy Industries propose a new methodology and prototype digital tool for building a demand model based on available information. This involves considering the types of zones/sectors present on-site, the historical energy consumption of those sectors at a national level, and energy consumption studies on a floor-area basis. The model also assesses the demand and corresponding emissions associated with the years 2025, 2035, and 2050, in accordance with Australia's Net Zero-time horizon. In a case study, we apply this approach to energize four precincts within the wider Aerotropolis site to be constructed in Western Sydney, New South Wales, Australia. The study demonstrates how demand increases from partial to full operation, while accounting for temperature-dependent demand fluctuations. The generated supply is also estimated, taking into account capacity factors, as well as changes in emissions associated with that demand due to an increasingly "greener" technology mix predicted. These methods and estimates provide a basis for decision-making in government policy-making, energy planning, and technology supply for greenfield sites. Additionally, they provide a platform for stakeholder engagement.

A techno-economic evaluation of urine separation for wastewater treatment plant configurations

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Brief bio

Dr Jia Meng is an associate professor in Harbin Institute of Technology. She is currently a visiting academic in the University of Queensland, focusing on understanding the carbon footprint of wastewater treatment plants.

Abstract

The primary objectives of global environmental policy revolve around creating a society that is committed to two key aspects: minimizing carbon emissions and promoting recycling practices. With this objective, the management of source-separated urine exhibits great potential for effectively extracting nutrients as fertilizers, owing to the exceptionally rich nutrient composition found in urine. Recently, the process of nitrification membrane bioreactor - membrane distillation is proposed to recover ammonium nitrate from urine, in which 50% of the NH_4^+ is converted into NO_3^- in the membrane bioreactor. Alternatively, microbial electrolysis cell (MEC) combined with membrane stripping is also a promising technology to recover ammonium in urine. However, there has been little attempt to assess the consequential environmental and economic benefits of urine separation for wastewater treatment.

This study systematically evaluates the environmental and economic impacts of urine separation (two scenarios for urine treatment) on sewage treatment plant (three scenarios) (Fig. 1). A total of 6 scenarios were studied. All calculations were done assuming a nominal plant receiving the wastewater produced from 200,000 people with the water usage of 250 L/person/day. we used an estimate of urine generation of 2 L/person/day. Fig. 2 shows the total GHG emissions, contributed by the direct (scope 1) and indirect emissions (scope 2), and offset energy. Without urine separation, the AnMBR + zeolite adsorption process produced lowest scope 1 emissions, followed by High Rate Activated Sludge (HRAS) + Anammox process and MLE process in sequence. However, the scope 1 emissions of the AnMBR + zeolite adsorption process was highest even considering the offset energy. The impact of the two urine treatment scenarios on greenhouse gas emissions and OPEX varies. Though the two urine treatment scenarios both increased the scope 2 emissions, the scope 1 emissions were decreased by MEC + membrane stripping but increased by MBR + membrane distillation. As a result, the total GHG emissions were increased with MBR + membrane distillation, and maintained similar with MEC + membrane stripping compared to that without urine separation. The estimated OPEX slightly increased using scenario I for urine treatment, but a significant decrease of OPEX was observed using the scenario II for urine treatment (Fig. 3). This study shows that HRAS + Anammox process with urine treated by MBR + membrane distillation could be the optimal scenario considering both GHG emission and OPEX.

Creating a Comprehensive Hydroponic Fertilizer by Blending Micro and Macro Nutrients from Bio-Digested Aquatic Floating Weed and Nitrified Human Urine

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Brief bio

Swami Palanisami is an academic and researcher in environmental engineering, toxicology, and bioremediation. His research focuses on sustainable resources/bioresources for climate adaptation practices, engrossing environmental management and industrial production processes. Additionally, he has expertise in deriving safe limits for environmental contaminants and pollutants.

Abstract

New South Wales (NSW) has set a target of achieving net-zero emission by 2050, as a stage1 (2020 to 2030) approach limiting organic waste landfill in order to mitigate greenhouse gas emissions resulting from solid waste is one of the priorities. Currently, when landscape cleaners remove aquatic weeds from water bodies and park ponds maintained by the council, these weeds are typically disposed of in landfill sites. The regular removal of these floating aquatic weeds not only helps maintain the water quality by reducing excessive nutrient levels that contribute to the growth of toxic algae, which can lead to fish kill incidents, but also addresses aesthetic concerns related to council-managed water bodies. In this research, we collected aquatic floating weeds from the Blacktown Council area and subjected the biomass to aerobic digestion using a food waste digesting machine supplemented with a commercial composting bacteria preparation. This machine utilizes bacterial action to convert solid organic waste into a liquid, effectively extracting the micro and macronutrients in the aquatic floating weeds. The resulting liquid serves as an excellent hydroponic nutrient solution, providing an opportunity to develop a completely organic hydroponic fertilizer rich in micro and macronutrients. Nitrified human urine contains significant macronutrients and a substantial quantity of micronutrients. By combining these two circular economy products - nitrified human urine and digested aquatic floating weed biomass - we can create a well-balanced nutrient solution for hydroponic liquid fertilizer that is abundant in micro and macronutrients. Our analysis of nutrient profiles revealed higher concentrations of cobalt, iron, molybdenum, zinc, manganese, and magnesium in the digestate of aquatic floating weeds compared to that of nitrified urine. Moreover, it is known that aquatic floating weeds, such as duckweed, have been identified as sources of phytohormones, which act as plant stimulants. Therefore, the combination of nitrified human urine and the digestate of aquatic floating weeds represents a promising approach for developing a well-balanced hydroponic fertilizer that is enriched with plant stimulants.

Views of stakeholders on compliance rating assessment of industrial effluent discharges: A Malaysian context

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Brief bio

Zulaikha Mokhtar is a senior environmental officer at the Department of Environment Malaysia. Currently, she is pursuing a Master of Philosophy at the Australian Centre for Water, Environment, and Biotechnology (ACWEB), School of Chemical Engineering, The University of Queensland. She is primarily interested in managing industry.

Abstract

Assessing industrial effluent discharge environmental compliance is crucial for ensuring safe and healthy waterways for the environment. This study proposes rating assessments for measuring compliance of industries such as Planning and Administration in Legal Compliance (LC), Industry and Community Empowerment (CE), Compliance Operation (CO), System Implementation (SI), Environmental Risk and Emergency Plan (ERP) and Environmental Audit (EA). A questionnaire survey was conducted with 519 Malaysian stakeholders from government agencies, non-government organizations, industries, policymakers, and environmental groups. The internal consistency of the specific sample is acceptable (Cronbach's Alpha = 0.78). The results show that three rating assessments (LC-63%, CO-63%, and SI-66%) were preferred by stakeholders and strongly agreed to be adopted in compliance measurement. From correlation analysis, the study found that LC (r =0.154, P =0.009), CO (r = 0.146, P = 0.001), and SI (r = 0.191, P =0.009) are suitable rating assessments. Seventy nine percent (79%) of the respondents agreed that new parameters for gauging compliance should be implemented, along with 21% not agreed. The study provides valuable insight into drafting policies and guidelines for developing industrial effluent compliance rating assessments and extending compliance beyond adherence to regulations.

Session 4 Theme: Resource recovery from wastes

Keynote: **Reflections on resource recovery within the *waste*-water industry**

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Brief bio

Sanjay is a recognised people manager and a result focussed charted professional engineer. He has held various senior roles within the private and public water utility sectors in Australia and New Zealand, leading teams of technical experts to meet project and operational goals. He specialises in transition phases of utilities, mergers, and has proven track record in operating large and medium scale resource recovery plants. His knowledge and skills include advanced wastewater treatment operation, process engineering, project management, plant management, and environmental management. His career developed at the largest advanced water reclamation facility, Mangere (390 MLD plant) where he was part of the operations team during a $500 million upgrade, Project Manukau. More recently he played a pivotal role for a private utility in embracing sustainability goals, which included developing centre's of operational excellence in water recycling and setting up beneficial reuse pathways for biosolids. A published author and invited presenter on national radio and web portals for schools.
He adds value to teams that he leads and has extensive experience in high-value complex operations management and creating and developing teams that are inclusive and diverse. His contribution to the profession includes mentoring, communicating through technical publications, presenting to audit groups, and being a guest panel member at many industry events. He utilises his strategic leadership skills within many registered charities for causes such as preventing youth suicide, fair trade, governance, and achieving the sustainable development goals.

Abstract

Water has many users and uses. Every living being on the planet requires this valuable resource. The need to value the resource continues to be on the agenda at a global scale. Historically water has been valued by indigenous people through appropriate technological, spiritual and cultural practices. With the changes due to population growth, the demand on this resource has increased over the past century. The need to balance the resource to multiple users has become a challenge in many parts of the world, including Australia. Freshwater withdrawals for agriculture, industry and municipal uses — has increased nearly six-fold since 1900. The need to add value to water by reuse has become a conversation worth having in many circles. This talk will offer some insights in valuing water as a resource from an Environmental Engineers' perspective.

Kerbside collection and treatment of household food and garden waste in a Queensland regional local government – is it feasible and socially acceptable?

Christine Blanchard (Invited speaker)
University of Southern Queensland
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Brief bio

Christine Blanchard is the Manager Waste Services with Lockyer Valley Regional Council and is also a PhD candidate with University of Southern Queensland. Her study considers options for regional local governments to divert organic waste from landfill including processing of this material into soil conditioner.

Abstract

Food and garden waste constitutes half of the household waste stream in the Lockyer Valley local government area. When landfilled, this material generates methane, one of the most potent greenhouse gases. The material also consumes valuable landfill space and attracts a Queensland Government waste levy, all costs to Lockyer Valley Regional Council that are ultimately passed onto ratepayers.

In August 2021, Council commenced a twelve-month kerbside food organics and garden organics (FOGO) in 1000 households. The service included providing bins, caddies, and liners to households along with education material on how to use the service. The aim of this service was to remove organic material from the household waste stream and process the material to produce a soil conditioner. Residents were encouraged to place all food and garden waste into the provided bin which was serviced weekly.

Council was the first in regional Queensland to undertake treatment of the collected FOGO material for production of a soil conditioner. The process used a static floor, aerated pile treatment system to produce a product that met the requirements of AS4454 Composts, Soil Conditioners and Mulches. This material was then used in Council's parks and gardens to provide improved soil health and resilience for plantings in public spaces.

Residents participating in the trial were surveyed to obtain social views and knowledge of the trial in addition to feedback on how they understood and used the service. This information will assist Council in determining the future of a similar service across the broader local government area.

The presentation will show how a regional local government with no access to a commercial composting operation can undertake collection and treatment of FOGO material and how the soil conditioner can be used for civic applications. It will also provide an insight into community understanding of the collection system and willingness to pay for and use such a system in the future.

Nutrient Recovery from Hydroponics Waste Nutrient Solution

Dharma Hagare and Suhaib Malkawi
Nutrient, Energy, Water & Materials Recycling Group (NEWMARG) Western Sydney University
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Brief bio

Dr. Dharmappa (Dharma) Hagare is a Senior Lecturer in Environmental, Sustainability and Risk Engineering in the School of Engineering. Dharma has over 20 years of academic and 5 years of industrial experience in a wide variety of areas of Civil and Environmental Engineering. Dharma has published over 150 journal, conference and seminar papers, technical reports and book chapters. His current research activities include liveable urban centres; urban and peri-urban water management; urban and agriculture waste management and water & nutrients recycling. He is the recipient of best technical paper award, and teaching & research fellowships. He has successfully completed several large research projects.

Abstract

Soilless media based agriculture is gaining increased acceptance as a main source of food production in both urban and rural areas. In Australia, food produced by hydroponic system accounts to about 20 % of the total

vegetables and fruits production. In 2022, the Australian hydroponics market was valued at $517 m, incorporating 625 businesses. Hydroponic systems are efficient in the nutrient and water recycling. However, at one stage a portion of the nutrient solution needs to be disposed of. This waste solution is called Hydroponics Waste Nutrient solution (HWNS). The common method of disposal of HWNS includes discharging into sewer system, in the case of urban areas. On the other hand, in the rural areas, HWNS may be discharged into dedicated ponds. Analysis of HWNS indicate the presence of significant amounts of nutrients. It has been reported that phosphorus contraction in HWNS can vary from 15 to 100 mg PO4-P L^{-1}.
This paper proposes a method to recover phosphorus (P) from HWNS and recycle as fertiliser for food production. The proposed P recovery method incorporates a combination of forward osmosis and precipitation processes. Initial results are encouraging. This paper will present some of the results of the initial trials.

Fertilizer recovery from human urine by novel two-stage processes

Zhiqiang Zuo,[1] Min Zheng,[1] Yanchen Liu[2]
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Brief bio

Zhiqiang Zuo is a postdoctoral visitor at the Australian Centre for Water and Environmental Biotechnology, University of Queensland, specializing in sewer management and nutrient recovery from wastewater.

Abstract

Recycling nutrients (nitrogen, phosphorus, and potassium) from human urine can potentially offset more than 13% of global agricultural fertilizer demand. In this study, we developed two-stage treatment processes for converting volatile ammonia in high-strength human urine into stable ammonium nitrate (a typical fertilizer). The first stage of the process involves the rapid conversion of high-strength ammonium present in urine into nitrite, facilitated by ammonia-oxidizing bacteria. This step is crucial as it allows for efficient transformation of volatile ammonia into a more stable form. In the second stage, the generated nitrite is further oxidized to nitrate, which can be achieved through either chemical or biological means.

The study provides comprehensive experimental evidence supporting the feasibility of both approaches. In the case of chemical nitrite oxidation, the effluent from the bioreactor requires pH adjustment to increase the concentration of free nitrous acid (FNA) up to 250 mg HNO_2-N/L in the subsequent biological reactor effluent. This elevated FNA concentration enables a substantially high rate of chemical nitrite oxidation, reaching 15 kg N/(m^3·d). In contrast, the biological nitrite oxidation approach cannot involve the in-situ accumulation of FNA. Instead, it necessitates achieving a delicate balance between nitrite consumption in the nitrite-oxidizing bacteria (NOB) bioreactor and nitrite generation in the ammonia-oxidizing bacteria (AOB) bioreactor. This equilibrium is critical to ensure the normal activity of NOB.

Notably, in these two approaches proposed, the ammonium nitrate solution could retain most phosphorus (75% ± 3%) and potassium (96% ± 1%) in human urine, resulting in nearly full nutrient recovery. Once concentrated, the liquid compound fertilizer of ammonium nitrate was generated. Based on an assessment of economic and environmental impacts at the urban scale, urine diversion for nutrient recovery using a technical combination of nitrification and reverse osmosis could reduce total energy input by 43%, greenhouse gas emission by 40%, and cost by 33% compared to conventional wastewater management. Overall, this innovative two-stage treatment process offers a promising solution for nutrient recovery and reuse from human urine, providing substantial environmental and economic advantages when implemented on a larger scale.

Microbial community in an activated carbon incorporated membrane bioreactor with the biofilm carriers for the nitrification of source-separated urine

Weonjung Sohn, Jiaxi Jiang, Sherub Phuntsho, Ho Kyong Shon

Centre for Technology in Water and Wastewater, School of Civil and Environmental Engineering, University of Technology Sydney, NSW 2007, Australia
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Brief bio

Weonjung Sohn is currently a PhD student at University of Technology Sydney under Prof. Hokyong Shon's supervision. Her main research interests include biological nitrification process in membrane bioreactors for nutrients recovery in a circular economy from source separated urine. She is a Website and Social Media Manager of the ARC NiCE hub.

Abstract

The escalating global population and the subsequent increase in food demand have resulted in a heavy reliance on synthetic fertilizers. This dependency has led to the accumulation of excessive nutrients in domestic waste, posing significant environmental challenges. Addressing this issue, the source-separation of urine as a nutrient-rich waste stream presents a promising opportunity to implement a circular economy by recovering and recycling valuable nutrients, thereby reducing the need for synthetic fertilizers. Nitrification in bioreactors has emerged as a promising approach for nutrient recovery. By employing aerobic microorganisms, nitrification converts ammonia to nitrate, simultaneously decreasing pH without the need for chemical additives and removing organic matter. Key players in nitrification are autotrophic bacteria, such as ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB). Achieving a balanced activity between AOB and NOB is vital for maintaining stable nitrification, which requires proper acclimation and enrichment of these slow-growing nitrifying microbes. Furthermore, the incorporation of biofilm carriers or powdered activated carbon (PAC) in membrane bioreactors (MBRs) has demonstrated significant potential in enhancing nitrification performance. These additives facilitate the attachment of microorganisms to their porous surfaces, promoting the growth of AOB and NOB and improving resilience to shock loading rates. Moreover, they aid in the removal of undesirable organic contaminants. While MBRs treating urine have been investigated at pilot scale, limited attention has been given to the composition of microbial communities and the influence of biofilm carriers and PAC incorporation on these communities. To address this gap, this study aims to investigate the effects of incorporating biofilm carriers and PAC in an MBR system treating source-separated urine, with a specific focus on operational performance and microbial community dynamics. Comprehensive understanding of the microbial aspects of urine treatment in MBRs can optimize system performance and enhance nutrient recovery efficiency.

Membrane capacitive deionization for selective lithium recovery from brines

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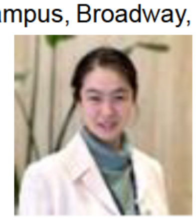

Brief bio

Hanwei is a Ph.D. candidate in the School of Civil and Environmental Engineering, University of Technology Sydney. She began her academic journey by completing her Bachelar's degree at Beihang University and Master's degree at Columbia University. Her current research topic is about lithium recovery using membrane-based technologies and electrochemical processes.

Abstract

The growing demand for lithium (Li) necessitates the exploration of efficient and environmentally friendly methods for extracting Li from aqueous Li-containing sources, moving beyond traditional land mining practices. Membrane capacitive deionization (MCDI), an emerging water treatment technology, has garnered significant attention for its potential in lithium extraction due to its swift adsorption kinetics, cost-effectiveness, minimal environmental

footprint, and high energy efficiency. In our research, we integrated activated carbon (AC) electrodes with ion-selective membranes to facilitate the selective extraction of lithium from multi-cation solutions. By employing metal-organic framework (MOF)-based membranes and ion-exchange membranes with specific functional groups, the ion preferences during electrosorption processes within multi-component brines containing Li, Na, K, Mg, and Ca were altered, as compared to using bare AC electrodes. Our investigation revealed that the primary factors influencing the selective Li extraction were the charge magnitude and ionic radii of competing ions. Additionally, we explored the impact of electric field voltages on MCDI performances in terms of Li selectivity and energy efficiency. This study contributes valuable insights into membrane materials and processes for lithium extraction, with the aim of enhancing Li selectivity and advancing sustainable lithium recovery methods.

Session 5 Theme: Resource recovery from wastes

Keynote: Cost-effective Water Production

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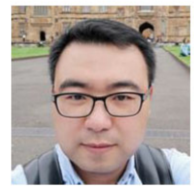

Brief bio

Dr Qiang Fu received his B.E. in Chemical Engineering from Shanghai Jiao Tong University (China) in 2004. He completed his Ph.D in Polymer Chemistry at Fudan University (China) in 2009 before working as a Postdoctoral Fellow at the University of Melbourne. Dr Fu was the recipients of an ARC Super Science Fellowship (2011-2014), an ATSE Emerging Future Leader Fellowship (2012) and an ARC Future Fellowship (2018-2022). He is currently leading a research group in the Centre for Technology in Water and Wastewater (CTWW) at The University of Technology Sydney, focusing on the development of functional polymer materials, two-dimensional materials, metal-organic frameworks, and advanced membrane materials for energy and environmental applications. To date, Dr Fu has published more than 120 research articles with an H-index of 45 (Google Scholar).

Abstract

Water is the basis for the existence and continuation of all life on Earth. The water resources on Earth are extremely huge (*ca*. 1.46×10^{16} cubic meters). However, 99.97% of the water exists in the form of seawater or deep groundwater that is difficult to collect, and only less than 0.03% can be easily used by humans. Due to geographical and climate constraints, the shortage of freshwater is of concern to 2.8 billion people in 48 countries all over the world especially in Africa, the Middle East, and Oceania, and the affected population may rise to 4.0 billion based on reasonable predictions. Consequently, the discovery of the next-generation freshwater production technologies with low-cost, high-water production rate and ease of installation and use is considered a promising solution to this global challenge and has attracted increasing attention all over the world.

Synthetic water-harvesting materials have been rapidly developed in recent years. Solar Vapor Generator (SVG) is a small floating device installed on the sea surface with integrated hydrogels that has customized chemical functions. By incorporating photothermal additives into the hydrogel matrix, SVG greatly enhances the evaporation rate of seawater, thereby achieving a higher collection capacity of condensed water. In addition, the use of novel materials for direct Atmospheric Water Harvesting (AWH) are also considered a promising alternative to conventional methods due to their low cost, low energy consumption, high water harvest capacity, and convenience for installation under the circumstance that fast water harvesting is required, or the electricity support is insufficient.

Our team has developed a series of novel hydrogel materials for fresh water production through SVG and AWH strategies. The systems offer excellent water production performance and high solar-to-steam conversion efficiency compared to state-of-the-art materials.

Unveiling the resource within: Extracting rare earth elements from mine tailings

Shuronjit Kumar Sarker[1], and **Biplob Kumar Pramanik[1]**
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Brief bio

Dr Biplob Pramanik, a Senior Lecturer and ARC DECRA Fellow at RMIT University. His research focusses on water and wastewater treatment along with resource recovery. To date, he has published over 90 articles in international peer-reviewed journals, amassing more than 3500 citations and an H-index of 33. Over the past 5 years, he has received over $2.5 million in research funding.

Abstract

The depletion of economic deposits of rare earth elements (REEs) has sparked interest in reprocessing mining tailings from carbonatite deposits, which are the primary global source of REEs. Reprocessing these tailings has the potential to offer significant environmental benefits and economic opportunities. Consequently, this study aimed to evaluate the recovery potential of REEs from a carbonatite-derived tailing obtained from an Australian mining site by conducting comprehensive characterization and recovery experimentation. The results indicated that the tailing primarily consisted of fine particles, with 50% of its weight below 61 µm. Geochemical analysis revealed that iron accounted for 50% of the tailing, while REEs constituted over 9% of its composition. X-ray diffraction and Scanning Electron Microscopy equipped with Energy Dispersive Spectroscopy analysis identified monazite [$(Ce,La,Nd)PO_4$] and florencite [$(CeAl_3(PO_4)_2(OH)_6$] as the primary minerals containing REEs, with goethite [$(Fe^{+3}O(OH)$] being the predominant gangue mineral. Distribution analysis demonstrated that more than 70% of the mass, REEs, and iron were concentrated in particles sized below 63 µm. Furthermore, mineral liberation analysis revealed that REEs minerals were primarily associated with goethite and were confined within larger particle sizes exceeding 100 µm. However, smaller REEs-mineral grains (<50 µm) were predominantly liberated. These findings suggest that a mild grinding process is necessary to release the locked REE minerals in particle fractions larger than 63 µm. Given the fine-grained nature of the sample, direct hydrometallurgical processing using HCl acid leaching was employed for REE recovery, as physical separation methods were deemed unsuitable. The hydrometallurgical tests demonstrated that up to 95% of the total REEs could be recovered by pre-treating the sample with 5M NaOH for 2 hours, followed by 10M HCl acid leaching under optimized conditions. The optimized conditions included a 2-hour leaching time, a liquid-to-solid ratio of 10, a leaching temperature of 115°C, and a stirring speed of 500 RPM. This study provided valuable insights into the detailed characteristics of REEs-grains in the tailings and demonstrated efficient recovery REEs processes through hydrometallurgical testing.

Selective separation and recovery of rare-earth elements using electrochemical methods

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School of Civil and Environmental Engineering, University of Technology Sydney, Ultimo, NSW 2007
*Youngwoo.Choo@uts.edu.au

Brief bio

Dr. Youngwoo Choo is a Chancellor's Research Fellow in the School of Civil and Environmental Engineering at UTS. He has a comprehensive background in functional nanomaterials, polymers, and electrochemical systems. Currently, his research interest is centred on the selective recovery of rare-earth elements using membrane-based technologies.

Abstract

Rare-earth elements (REEs) are essential components in modern state-of-the-art technologies, particularly in sustainable transportation and energy generation systems. However, conventional mining and downstream processing of REEs often result in the generation of contaminants that pose a significant threat to the environment. Consequently, the development of efficient and sustainable methods for REE recovery from various waste streams, such as mine tailing or e-waste leachate, has emerged as a critical area of research in recent years. In this study, we focus on the investigation of rationally designed REE-selective membranes, which can effectively separate and recover REE ions from mixed solutions. To achieve this, we synthesized highly nanoporous metal-organic frameworks (MOF, Cr-MIL-101) and modified their surface functionality to enhance the chemical affinity of the porous surface for the target REEs. The MOF incorporated mixed-matrix membrane exhibited high

selectivity in ion transport in the presence of DC electric field, effectively retaining the RE metal ions in the feed while allowing other multivalent ions to penetrate the membrane.

Selective recovery of Rare Earth Elements by direct contact membrane distillation and adsorption from acid mine drainage

Charith Fonseka[1], Seongchul Ryu[1], Gayathri Naidu[1], Jaya Kandasamy[1], Harsha Ratnaweera[1] Saravanamuthu Vigneswaran[1,2]

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[2] Faculty of Sciences & Technology (RealTek), Norwegian University of Life Sciences, P.O. Box N-1432, Norway
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Brief bio

My name is Charith Fonseka and Im a PhD researcher at UTS. My primary research interests is identifying and testing novel adsorbents for recovery of Rare Earth Elements from mining waste. Furthermore, I focus on developing systems for simultaneous water and resource recovery from waste.

Abstract

Acid mine drainage (AMD) is considered a major environmental and economic concern due to the associated environmental toxicity and treatment costs. It contains high concentrations of sulphur, heavy metals and an array of valuable metals which can be recovered and reused. In this study, the use of Direct contact membrane distillation (DCMD) was first investigated for recovery of water and concentration of valuable metals such as Rare Earth Elements (REE). A novel adsorbent (SBA15-PMIDA) was then synthesized using amine grafted mesoporous silica and N-(phosphonomethyl) iminodiacetic acid (PMIDA) for selective adsorption of REE from the concentrated DCMD feed solution.

Direct contact membrane distillation (DCMD) experiments were carried out using synthetic AMD at pH 2.2 ±0.1. The system was operated at a feed temperature of 60°C and permeate inlet temperature was maintained at 20°C. The results showed that DCMD attained steady permeate flux of 14.5 ± 0.2 L/m2h (LMH) up to a volume concentration factor (VCF) of 5 with 99.9% solute rejection. Concentration factor of 2 was achieved for Rare Earth Elements (REE) which was subsequently selectively recovered using a novel mesoporous silica material multi-modified with amine and PMIDA.

The pH of concentrated AMD feed solution (pH = 2.2) was adjusted to 4.7 ± 0.1 for adsorption of REE on modified SBA-15. Moreover, increase of pH helped precipitate more than 98% of tri valant ions such as Fe and Al. This was found to reduce competition for active sites on the adsorbent and increased selectivity towards REE. SBA15-PMIDA selectively adsorbed more than 90% of REE in pH adjusted DCMD feed while the uptake of other heavy metals remained below 10%. Detailed characterization of adsorbent revealed that formation of coordinating complexes with carboxylate and phosphonic groups on SBA15-PMIDA was found to be the primary driving force for selective REE adsorption. Furthermore, the adsorbent remained structurally stable over five regeneration cycles, which highlight the practical potential of membrane/adsorption hybrid systems for water and valuable metal (REE) recovery from AMD.

Session 6 Theme: Environmental Pollution/Technologies
Keynote: Carbonisation – a sustainable technology for circular economies

Durell Hammond
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Brief bio

Durell Hammond is a founder of Pyrocal, a Toowoomba-based engineering company designing and manufacturing industrial-scale biochar production systems using continuous carbonisation technology. With a degree in Agricultural Science, Durell's entrepreneurial mindset has seen him build a number of highly successful businesses during his career. He is well regarded in Australian agriculture and the fertiliser industry for his ability to anticipate the market and customers' needs and successfully commercialise new approaches to the application and delivery of soil and plant nutrition systems. He has a strong commitment to working collaboratively to achieve beneficial outcomes that deliver on economic, environmental and social goals. Durell is the Chairman of Rugby Farming Group, Pyrocal, Fertec and is a Director of the Australian Fertiliser Services Association Ltd.

Abstract

Pyrocal designs, builds and operates continuous carbonisation systems that are centred on an oxygen deprived updraft gasifier. The systems are commercialised in biosolids treatment, agroforestry residue biochar production (nutshell, cotton gin trash), along with green and construction waste timber from waste recycling.
Pyrocal CCT systems

- Background of Pyrocal's CCT system and how it can accelerate the net-zero responsibilities of waste and bioenergy markets both in the Australia and overseas.
- It can support the realisation of the circular economy by turning waste, which is often lacking better disposal methods, into value and profitable revenue streams. It also brings a new range of opportunities for collectors and producers of other waste types, including biomass, municipal and non-hazardous industrial and commercial waste. The technology has the potential to produce not only renewable energy, but also carbon-rich materials that can serve as stable carbon sinks.
- Discuss Pyrocal's CCT is commercialised technology ready to scale-up. Discuss the various market opportunities and pilot scale/demonstration sites Pyrocal has here in Aust. and overseas.
- Discuss that its success and ability to scale to become the waste-to-energy/fuel method of choice depends on the levels and type of political, policy, economic and commercial support.

Performance Prediction of Plate-and-frame Forward Osmosis Membrane using Machine Learning Models

Mita Nurhayati[1,2], **Sungyun Lee[1,3*]**

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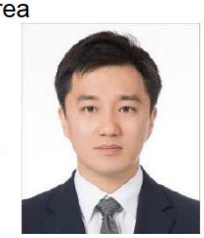
[2]Department of Chemistry, Indonesia University of Education, Indonesia
[3]Department of Environmental and Safety Engineering, Kyungpook National University, Korea
E: sungyunlee@knu.ac.kr **Invited speaker**



Brief bio

Sungyun Lee is an assistant professor in the Department of Environmental and Safety Engineering at Kyungpook National University, Korea. He specializes in membrane processes and organic matter characterization. Recently, he has been researching the application of machine learning in environmental engineering.

Abstract

Forward osmosis (FO) technology has emerged as a promising membrane process for nutrient recovery. By leveraging the natural osmotic pressure gradient between two solutions, FO allows for the selective separation of water and nutrients from wastewater streams with low energy. Mathematical models have been investigated to predict the performance of FO membranes. While mathematical models can provide valuable insights, they are complex or difficult to use due to unknown parameters such as the transport properties of species. In this study, machine learning models for FO performance prediction were developed for pilot-scale plate-and-frame FO module. Representative machine learning models, including Support Vector Machine (SVM), Radial Basis Function (RBF), and Artificial Neural Network (ANN), were developed using pilot-scale experiments data. The permeate flux was predicted as a function of membrane area, feed solution flowrate, draw solution flowrate, feed solution concentration, and draw solution concentration. All machine learning models showed high R2 values, i.e., 0.9558, 0.9961, and 0.9971 for SVM, RBF, and ANN models. Furthermore, the ANN model was applied to predict the response surface plot of the membrane flux to estimate the optimum condition of the FO process.

Improving urban wastewater management by using on-site iron carbonate chemical manufactured with biogas upgrading.

Xiaotong Cen, [1,*], Zhetai Hu,[1] Zhiguo Yuan,[1,2] Min Zheng[1]

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[2]School of Energy and Environment, City University of Hong Kong, Hong Kong SQR, China
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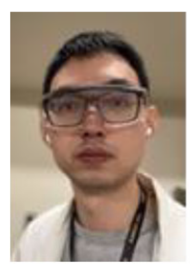
Brief bio

Xiaotong received her Bachelor degree with Honours Class I in Environmental Engineering from The University of New South Wales in 2020. She then started her PhD at the University of Queensland-ACWEB in 2021 where her research focuses on integrated urban wastewater management through multiple reuse of chemicals.

Abstract

Chemicals play a critical role in urban water management. As the high chemical cost and supply chain shortage, water industry increasingly demands more environmentally friendly and sustainable alternative to these approaches. An iron-oxidizing electrochemical technology recently developed by The University of Queensland research team offers a solution, which simultaneously upgrades biogas and produces ferrous carbonate ($FeCO_3$). This in-situ produced $FeCO_3$ can substitute conventional iron salts that have been widely applied in multiple sectors of urban wastewater systems for sewer odour control, nutrient removal and recovery.
In this proof of concept, we aimed to investigate the feasibility of the electrochemical produced $FeCO_3$ for sulfide control in sewer reactors and demonstrate its flow-on effects on downstream wastewater treatment plant. Two continuous flow laboratory-scale reactors comprising sewer reactors, sequencing batch reactors (SBR) and anaerobic digestors (AD) were operated over four months to demonstrate its long-term effectiveness on sulfide removal in sewers, phosphate reduction in wastewater treatment unit, sulfide removal in anaerobic digestors and sludge property enhancement.

After the two systems reached a comparable performance, 10 mg Fe/L of $FeCO_3$ was introduced to the experimental system, whereas none was added to the control. $FeCO_3$ dosing in experimental sewer reactors decreased sulfide concentration by 5.41 ± 0.51 mg S/L in sewer effluent, removed phosphate concentration by 2.48 ± 0.24 mg P/L in SBR effluent, and dissolved sulfide concentration by 18.94 ± 2.36 mg S/L in AD, as compared to the control. Meanwhile, it improves downstream sludge settleability (110.72 ± 7.53 ml/g to 72.30 ± 4.38 ml/g) and digested sludge dewaterability (15.81 ± 0.15 % to 17.22 ± 0.83 %). $FeCO_3$ dosing in sewers does not have any deteriorate effect on sulfate reducing bacteria activities in sewers, nitrogen removal performance in downstream SBR, and biogas production rate in downstream AD. Therefore, the findings of this comprehensive study indicate the multi-benefits of using in-situ produced $FeCO_3$ throughout the entire system, and simultaneously overcoming the challenges of chemical cost and supply chain.



Production of affordable sodium borohydride as a hydrogen carrier

Rui Han, Xin Zhang, Hanwen Liu, Zhenguo Huang

E: Rui.han@uts.edu.au

Brief bio

Dr Rui Han is a research associate in the Boron Lab in the school of Civil and Environmental Engineering, UTS. He works on a CRC-P project related to NaBH4, a hydrogen carrier.

Abstract

Sodium borohydride (NaBH4) as a hydrogen storage material has been extensively studied. NaBH4 features a controllable release of hydrogen via hydrolysis at ambient conditions. In this presentation, I will first present a

synthetic route for NaBH4 that can be potentially commercialised for large scale production. The synthetic method is based on a mechanochemical reaction between inexpensive reactants (Na2B4O7·10H2O, Mg and Na2CO3) at mild conditions. In contrast to the current Brown-Schlesinger process used for NaBH4 production, the new method features low cost, low carbon footprint, and much improved safety. In this method, hydrogen is supplied by the hydrated water in borax (Na2B4O7·10H2O), enabling the production of NaBH4 without hydrogen gas directly. Recently, a Collaborative Research Centre – Project (CRC-P) was granted to Boron Molecular, GrapheneX and UTS, aiming to develop a blueprint for scalable synthesis of NaBH4 based on this technology. We are currently optimising various experimental parameters in the laboratories using different types of ball mills and separation processes. A process and control design will then be conducted based on the experimental data before the construction, installation, and commission of a pilot plant. The success in this project will replace the costly commercial NaBH4 production method, hence giving Australia a competitive edge in hydrogen production, storage and export.

Session 7 Theme: Bioresource/resource recovery

Keynote: Technologies for achieving energy positive wastewater treatment

Qilin Wang, Huan Liu, Xuan Li

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Brief bio

Qilin Wang is a Professor and ARC Future Fellow at University of Technology Sydney. His research interest includes wastewater treatment and sludge treatment. He has won a few awards and published many papers.

Abstract

Wastewater treatment is energy intensive and emits greenhouse gas. While it is possible to recover energy in anaerobic digesters through biodegradation of organic material in wastewater, the energy recovery is low. This presentation will talk about a technology that could unlock the energy potential of wastewater, enabling energy-positive wastewater treatment by enhancing energy recovery from wastewater.

Biomineralization in a high-rate anaerobic distillery wastewater treatment

Lei Zhang[1], Yiyang Yuan[1], ChengYuan Li[1], Yingdi Zhang[1], Huijuan Sun[1], Yang Liu[1, 2]*

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[2]Affilition School of Civil & Environmental Engineering, Queensland University of Technology, Brisbane, QLD, Australia
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Brief bio

Lei Zhang, coming from the University of Alberta in Canada, is an experienced research associate affiliated with Dr. Yang Liu's group. With over a decade of experience in anaerobic digestion, his focus lies in recovering energy and resources from waste for sustainable solutions.

Abstract

This study addresses the pressing environmental concerns associated with the rapidly growing distillery industry, which is a significant contributor to wastewater generation. By focusing on the treatment of distillery wastewater using anaerobic digestion, this research explores the potential to convert organic materials into biofuels, specifically methane. Moreover, the study aims to recover both methane and phosphorus from distillery wastewater in a single anaerobic reactor, which represents a novel and unexplored approach. Laboratory-scale experiments were conducted using up flow anaerobic sludge blanket reactors. A key aspect of the study involved the implementation of a unique strategy: the mixing of centrate and spent caustic wastewater streams. This

approach was intended to enhance treatment performance, manipulate the microbial community structure, and thereby optimizing the overall process.

The findings of this study hold immense potential to revolutionize the design and operation of anaerobic distillery wastewater treatment systems. The integration of the centrate and spent caustic streams yielded remarkable co-benefits, resulting in significant biomethane production and efficient phosphorus precipitation. Impressive methane yields ranging from 80.1 ± 4.4% to 92.9 ± 6.3% were achieved, even under varying organic loading rates from 4.4 to 18.0 kg COD/(m^3d). The study demonstrated a notable phosphorus removal efficiency of 79.1 ± 5.8% throughout the 130-day operation period. The granular sludge developed in the reactor predominantly comprised magnesium and phosphorus, with no heavy metal contamination. The magnesium-to-phosphorus mole ratio in the sludge was approximately 1.0, and the dominant phosphate species appeared to be struvite (MgNH4PO4). The recovery of phosphorus via the reactor sludge offers exciting opportunities for its utilization as a fertilizer or as a raw material within the phosphorus refinery industry.

The biomethane produced during the treatment process exhibits significant energy potential, estimated at 1.5 GJ/(m3d). This renewable energy source can be effectively harnessed on-site, potentially offsetting a substantial portion of the distillery's energy demands and reducing reliance on traditional fossil fuels. The insights gained from this research provide valuable guidance to sustainable wastewater management systems. By embracing circular economy principles and mitigating the environmental impact of the distillery industry, this study paves the way for a more sustainable future.

Novel Anaerobic Fermentation Paradigm of Producing Medium-chain Fatty Acids from Food Wastes with Self-Produced Ethanol as Electron Donor

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Brief bio

Lan Wu obtains her PhD from School of Civil and Environmental Engineering, UTS, under the supervision of Prof. Bing-Jie Ni. Prior to that, she received her BE and MS degrees from Ocean University of China. Her research is focused on liquid bioenergy recovery from organic waste via open-culture fermentation.

Abstract

As food waste (FW) is a largely available and carbon-rich feedstock, bulk production of medium-chain fatty acids (MCFAs) via chain elongation from FW is of great interest to biotechnology. However, the development of this emerging biotechnology is limited by high cost from external electron donor (ED) input. To solve this bottleneck, replacing external ED input with self-produced ED in the system is a key. Therefore, this study provided a novel anaerobic fermentation paradigm of inoculating yeast to internally generate ethanol from FW as ED for subsequent MCFAs production. Batch experimental results demonstrated that cumulative 1540 mg COD/L of MCFAs was produced from FW with endogenous ethanol when inoculating 4.50×10^7 cells/ml-FW *Saccharomyces cerevisiae* in the fermenter over 20 days. In contrast, only very small amount of MCFAs were detected in the control (58.98 mg COD/L). In continuous operation over 61 days, around 1323 mg COD/L of MCFAs was steadily obtained in the long-term fermenter with yeast assisted, which was almost 1.49 times higher than that from the control. A coordinated metabolic route consisted of substrate degradation, on-site ethanol biosynthesis and chain elongation (CE) pathway was established in the yeast-assisted system. The enriching *S. cerevisiae* responsible for on-site ethanol generation and chain-elongating bacteria including *Caproiciproducens* and *Oscillibacter* jointly promoted MCFAs productions from FW. This biotechnology does not require major changes to the design and operation of existing anaerobic fermentation infrastructure, but make a valuable contribution by enlarging the utilization of FW for high-value MCFAs production while waiving the cost of external ED.

Biofouling Control of Reverse Osmosis Membrane Using BiocidalAmmonia from Concentrated Hydrolyse Urine

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Brief bio

Chee Xiang Chen is a PhD student from the University of Melbourne and is under the supervision ofA/P. Stefano Freguia. Chen is currently working on nutrient recovery from source-separated urine using reverse osmosis technology and its subsequent effect on sewerage system.

Abstract

Hydrolysed urine (HU) is a processed waste stream with high concentration of nutrients, containing more than 8g/L of ammonia, 0.5 g/L of phosphorus and 2g/L of potassium (Viskariet al., 2018). Due to its nutrient ratios (N, P and K), HU is suitable for use as fertilizer. However,HU contains 97% water and reduction of its water content is a necessary step to minimise transportation cost. Reverse osmosis (RO) is a technology that is capable in removing water content at low energy consumption. It has been trialled with fresh unhydrolyzed urine, but with limited success due to the rapid onset of biofouling (Courtney and Randall, 2022). Biofouling can be reduced by free ammonia due to its biocidal effect (Liu et al., 2019). However, it was found to occur during the concentration process despite high inherent ammonia concentrationin HU (Ray et al., 2022). While ammonia in HU gradually increases during concentration by RO, its effect towards reduction of biofouling can be enhanced but is yet to be quantified. In this study, we used HU in a fully recirculated RO system for seven days. We examined two scenarios: one without concentration (referred to as 1.0x volume reduction factor (VRF) HU),and HU with 4.0x VRF using the RO. The permeate flux was monitored throughout the experimental period and the biofouling of membranes was investigated after the experiment by recovering membrane foulants and characterising them using flow cytometry, loss on ignition and Fourier-transform infrared spectroscopy. Based on our finding, the permeate fluxof RO that processed 1.0x VRF HU declined by 38%. For the 4.0x VRF HU, the permeate flux declined by 17%. Subsequent flow cytometry analysis showed that the cell number on the membrane surfaces of 1.0x VRF HU and 4.0x VRF HU were 8.1 x 106 cell/cm^2 and 633 cell/cm^2, respectively. The findings of this study show that HU concentration using RO under elevated ammonia - originated from concentrated HU - can reduce the permeate flux declineand the biofouling of the RO membrane.

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Session 8 Theme: Environmental health & risks

Building a Nature-Positive Economy: Opportunities and Challenges

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Brief bio

Liana Downey (GAICD) is the Chair and President of the Australian Conservation Foundation, and an expert advisor on environmental, social, and governance (ESG) issues. Liana was the CEO of the Blueprint Institute, founder Common Ground on Climate, Deputy Secretary for NSW Education and established McKinsey & Company's sustainability practice, where she led the development of Australia's first Greenhouse Gas Abatement Cost Curve.

She holds an MBA from Stanford University (Arjay Miller Scholar), is the author of Mission Control: How Governments and Nonprofits can Focus, Achieve More and Change the World (Taylor & Francis) and taught at New York University's Wagner's School of Public Policy.

Abstract

Globally, we face two pressing crises: climate change and rapid biodiversity loss. These challenges demand a fundamental re-evaluation of economic incentives to acknowledge planetary boundaries. This presentation delves into the possibilities and obstacles on the path to achieving a zero-emissions, nature-positive economy, with a specific focus on Australia. A circular economy emerges as a promising route to realizing a nature-positive, net-zero Australia. By reimagining how we produce, consume, and manage resources, a circular economy not only minimizes waste but also aids in preserving our natural ecosystems and species.

While the Australian government expresses interest in a nature-positive economy, it has yet to define it clearly, set specific targets, or establish mechanisms for achieving it. The Australian Conservation Foundation (ACF) aligns with the global consensus on the need to halt the destruction of nature and promote recovery. ACF suggests that by 2030, Australia should boast richer and more diverse nature than it did in 2020.

To convey this vision effectively, we employ the term "nature-positive," encompassing diverse ecosystems and species, and the idea of human activities that reflect our fundamental reliance on, and connection with, the environment.

In contrast to climate change, where awareness and solutions are increasingly understood, nature's crisis remains less so. Only 37% of Australians grasp the severity of this natural world crisis. Yet, nature protection and restoration are vital to mitigating the climate crisis, contributing to habitat preservation, global warming mitigation, and the control of invasive species.

Despite nature's critical role in combating climate change, it receives less emphasis from governments, researchers and industry compared to climate issues. To realize a nature-positive economy, we must prioritize habitat protection, restoration, and invasive species control alongside climate action. Innovative strategies like fundamentally rethinking economic incentives (e.g., pricing pollution and habitat destruction), promoting regenerative agriculture, and implementing nature risk disclosures are pivotal in this pursuit.

This presentation underscores the urgency of reshaping our economic systems towards nature-positive outcomes. It highlights the necessity of clear definitions, targets, and public awareness. Addressing the nature crisis is not just an environmental imperative but an essential component of tackling our overarching challenges.

Techno Economic Assessment of Urine Diversion and Conversion to Fertiliser Products at Sydney Central Park WWTP

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Brief bio

Umakant Badeti is a PhD student at University of Technology Sydney in the school of Civil and Environmental Engineering. He has been working on source separation and nutrient recovery from urine and its effect on the downstream wastewater treatment plant and processes as part of his PhD work.

Abstract

Urine diversion has been proposed as an approach for producing renewable fertilizers and reducing nutrient loads to wastewater treatment plants. Techno economic assessment was used to compare the impacts of the operations phase of urine diversion and fertiliser processing systems via biological nitrification and transportation via road to the agricultural farms at a decentralised scale to conventional systems. Scenarios in Sydney, Richmond, Wollongong and Lithgow were modelled along with additional sensitivity analysis to understand the importance of key parameters, such as the electricity and fertiliser price, labour cost, flush volume. Urine diversion had better performance than the conventional system and led to reduction of 10-50% of the cumulative energy demand, 10-50% in operating costs while capital costs ranged between 10% decrease to 15% increase. Sensitivity analysis revealed that fertiliser price and flush volume were found to be the most sensitive parameters determine the net savings from urine diversion. This study suggests that urine diversion could be applied broadly as a strategy for sustainable wastewater management and nutrient recovery.

Optimised start-up and mass transfer for efficient nutrient recovery in a bioelectroconcentration system

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Brief bio of presenter

Dr Veera Koskue currently works as a Postdoctoral Research Fellow at the University of Melbourne. She is involved in ARC Hub for Nutrients in a Circular Economy (NiCE), where her research focuses on nutrient recovery from human urine using microbial electrochemical technologies.

Abstract

Bioelectroconcentration is a technique where electric energy is used to drive the concentration of ionic target nutrients, such as ammonium nitrogen, into a liquid fertiliser with the help of ion-exchange membranes. Nutrient recovery from hydrolysed human urine [1,2] via bioelectroconcentration has been successfully demonstrated before. The use of bacterial catalysts at the anode of the nutrient recovery system typically results in a low energy requirement but also low rates, likely due to mass transfer limitations. The enrichment of an electroactive microbial community that tolerates the high pH and ammonium nitrogen concentration of hydrolysed urine can also be time-consuming, with previous work reporting up to 16 weeks for establishment of an effective biofilm using a mixture of acetate-fed bioanode effluent, urine, and anaerobically digested sewage sludge as the inoculum [1]. This study therefore focused on accelerating the start-up and optimising the mass transfer of a bioelectroconcentration system.

First, four laboratory-scale bioelectroconcentration systems were constructed using graphite granules as the anodes with graphite plates as current collectors. 2 mm and 5 mm granules were used for duplicate reactors. The bioanodes were inoculated with mixtures containing differing ratios of real hydrolysed human urine and waste activated sludge, with the expectation that the activated sludge would both function as a source of bacteria and dilute the high ammonium nitrogen concentration of the urine to a tolerable level. The enrichment was started in batch-mode. Within one week, a steady current was observed and a continuous feeding of undiluted hydrolysed urine at a slow feed rate was started (anodic HRT ca. 9 d). After this, the feed rate was stepwise increased to achieve adequately high ammonium nitrogen loading rates to facilitate higher current production, while ensuring that the anode pH remained close to 8 (which had been determined as the preferred pH range for urine-fed bacteria in prior experiments).

After successful bioanode enrichment, the anolyte was recirculated over the anode chamber at varying rates to find the optimised hydraulic conditions for efficient mass transfer. Furthermore, the effect of the granule size (2 mm and 5 mm) on the mass transfer at different recirculation rates was assessed.

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Different sizes of microplastics induced distinct microbial responses of anaerobic granular sludge

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Brief bio

Dr. Wei Wei is an Australian Research Council (ARC) DECRA Fellow and Lecturer at School of Civil and Environmental Engineering of UTS. With extensive research experience, Dr. Wei has led numerous studies on environmental toxicology. She has published extensively on environmental health and risk and is a recognized speaker at international conferences.

Abstract

Recent investigations confirmed the inhibitory effect of microplastics with single sizes on the anaerobic granular sludge (AGS) wastewater treatment system. However, the skyrocketed application of plastic products and the natural weathering of plastic articles contributed the existence of microplastics of different sizes in water systems, but the differences of toxicity from different sizes of microplastics toward AGS and their underlying mechanism are still unclear. In this work, the responds of AGS exposed to different particle sizes of polystyrene microplastics (PS-MPs), representative microplastics appeared in wastewater systems, were reported. The results showed that the increasing particle sizes (from 0.5μm to 150μm) of PS-MPs induced a gradually increasing and distinct inhibitory (from 6.7% to 16.2%) effect on the cumulative methane production by AGS, accompanied by the similar decreasing organic carbon degradation trends. Correspondingly, the integrity and the cell viability of the AGS granules were damaged and the populations of the key acidogens and methanogens were reduced when exposed to PS-MPs, which was particularly evident in the reactors affected by the larger micron-sized PS-MPs. The zeta potential and contact angle indicated that the larger-sized PS-MPs had the stronger dispersive properties and affinity for AGS, causing the higher oxidative stress and leachates toxicity. Further investigation revealed that the tolerance of AGS to PS-MPs toxicity also exhibited size-dependent trend. Larger particles (e.g., 150μm) of PS-MPs inhibited extracellular polymeric substance (EPS) secretion, while smaller particles (e.g., 0.5μm) promoted EPS generation with the release of more humic acid, alleviating their toxicity. This research will provide novel insights into the ecotoxicity of microplastics with different sizes, stimulating appropriate pretreatment methods for reducing the overall toxicity of MPs to functional microbes in biological treatment facilities based on the size range of microplastics.

Poster session

Supply, Demand and the Economic Effectiveness of Urine-diverting Technologies and Products: A Systematic Literature Review

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Brief bio of presenter

Gam T. Nguyen is a PhD candidate at the Department of Accounting, Finance and Economics, Griffith Business School, Griffith University. She is currently working on the whole-of-system economics project of the ARC Research Hub for Nutrients in a Circular Economy (NiCE).

Abstract

The adoption of urine-diverting toilets and urine-source products has been suggested as a strategy to progress towards achieving circular economy in urban areas. There are some studies that have examined the performance of such systems. However, an overall understanding of the interrelated factors of the supply, demand, and economic effectiveness of such systems is lacking. This systematic review contributes to addressing this knowledge gap. Despite a wide search of relevant databases, only 64 papers have been identified. Most studies discussed the technical aspect of such systems on the supply side (72%) and the consumer's acceptance/perceptions of the demand side (41%). 18 out of 64 final papers (28%) explored the economic feasibility of such systems even though only 5 papers applied a Cost and Benefit framework. The main factors affecting the supply side are technical feasibility/performance, the quality of construction, operation and maintenance, financial benefit, regulation, and government subsidies. The demand side is mainly affected by consumer attitude/social acceptance (including consumers' willingness to pay), social incentive systems, financial incentives, and the cost savings of consumers. The positive net present values and possible net benefits highlighted in some reviewed papers provided an optimistic view about the probability of implementing urine-diverting technologies and producing fertilizer from urine-separated sources.

Exploring Sustainable Alternatives: Urine as a substitute for urea in Bio-cementation techniques for improved soil properties

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Brief bio

Niti Bhattarai is a NiCE hub's HDR student at UTS. Her current research focuses on developing a bio-geotechnical process utilizing urine or wastewater for ground improvement in which calcium carbonate is precipitated within the soil porous media.

Abstract

With the rising concerns surrounding sustainability and cost-effectiveness in ground improvement practices, researchers have been seeking holistic solution to address these challenges. In such scenario, bio-cementation has emerged to be one of the promising solutions for enhancing soil properties. Such technique involves the precipitation of calcium carbonate that acts as a cementing material and binds soil/sand particles together contributing to the overall soil strength. Microbial Induced Calcium Carbonate Precipitation (MICP) and Enzyme Induced Carbonate Precipitation (EICP) are two most studied bio-cementation techniques that rely on urea

hydrolysis for carbonate source; the former method uses microorganisms, and the latter uses urease enzyme to catalyse urea hydrolysis. In the light of the environmental risks associated with large-scale urea production and with an aim of promoting a circular economy, this project investigates the feasibility of utilizing urine as a viable alternative for urea and as a nutrient-rich medium for bacterial growth.

Nutrients recovery from human urine and their reuse as fertiliser to grow spearmint (*Mentha Spicata*)

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Brief bio of lead presenter

Juan Lucas is a Nursery horticulturist at the Royal Botanic Garden Sydney, Australia. He is currently managing experiments on the end-use of fertilisers from human urine, focusing on understanding the effect of fertiliser application in contrast with commercial fertilisers.

Abstract

Human urine is a rich source of essential elements required for plant growth and biomass production. Recently, urine to fertiliser conversion is becoming increasingly popular through different processes and technologies. Recovering nutrient from human urine is crucial in a circular economy for many reasons, mainly to create a green loop by growing ornamental plants or urban farming by reducing waste and environmental pollution. UTS has successfully converted human urine to plant fertiliser through the UrVal technology to produce UrVal fertiliser. In this context, the purpose of our experiment is to study UrVal fertiliser effects on plant growth as compared to a commercial fertiliser.

Urine fertiliser performance as nutrient solution is being benchmarked with a commercial fertiliser solution (Cal-Mg Grower, ICL) as nutrient solution tailored for Spearmint (*Mentha spicata*). Three different growing media will be used for the experiment Vermiculite, Coco chips, and Peat/Perlite P400 (1:1). The experiment will be 2 x 3 factorial design with 5 replications. The experiment is carried out at the Royal Botanic Garden Sydney – Nursery to test our hypotheses on plant performance and growth.

On weekly basis, data will be collected on plant height, and total number of stalks for the period of the experiment. At the end of experiments, roots and shoots of each plant will be separated to assess fresh biomass. To measure the dry biomass, leaves and roots samples will be placed in paper bags in a Memmert GmbH oven (Model 400, Germany) at 100℃ for 24 hours and then weighted again. Roots to shoots ratio (RSR) will also be calculated as the ratio between roots dry weight and shoots dry weight.

Harvesting nutrients and clean water from wastewater with biomimetic membranes

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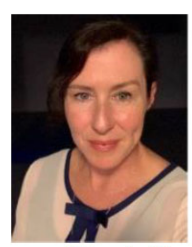

Brief bio

Dr Cathryn O'Sullivan studies circular and sustainable agricultural systems in CSIRO Agriculture and Food. Her work explores interactions between plants and microbes in nutrient cycling and plant nutrition, biocontrol of crop

diseases, recovering value from solid waste and wastewaters, and biofuel production. Her recent interests include novel farming systems including aquaponics, agrivoltaics and indoor farming.

Abstract

Australian agriculture has ambitions to become a $100 billion industry by 2030. A key challenge that needs to be overcome to achieve this involves securing economical and sustainable supplies of water and essential plant macronutrients; nitrogen, phosphorus, and potassium. This collaboration between ANU and CSIRO aims to develop technology for harvesting resources from wastewater by developing biomimetic membrane separation systems.

ANU's Bioderived Element Resource Separation Technology (BERST) system takes inspiration from the membrane separation mechanisms evolved in nature to achieve selective separation of valuable nutrients, elements and water from complex liquid wastes. BERST modules involve selectively engineering protein components that can be embedded into membrane structures to change membrane separation function.

Current commercially available protein-embedded membrane separation technologies enable the isolation of pure water from waste liquids. This project will build on this technology by developing membranes that can isolate valuable target molecules, in addition to pure water, from complex wastewater solutions. A range of resources that are lost in varying industrial processes and wastes can be targeted including ammonium, borate, cobalt, nickel, phosphorus, lithium, potassium, sodium, and urea.

BERST modules can be designed to separate different resources from wastes and can be combined to separate multiple resources from wastewater in parallel as well as generating clean water. Current biomimetic membranes, with densely packed selective components featuring high selectivity, are only demonstrated in proof-of-concept studies and limited to small-scale applications. Significant challenges remain in the engineering of selective protein components and generating large-scale, defect-free biomimetic membranes. ANU and CSIRO are working in partnership to address these challenges and co-create optimized membrane systems, tested in collaboration with industry partners.

Potential nutrient recovery from source-separated urine through hybrid membrane bioreactor and membrane capacitive deionisation

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Brief bio

Dr Jiaxi (Jade) Jiang is a Postdoctoral Research Associate at the School of Civil and Environmental Engineering, Faculty of Engineering and Information Technology (FEIT) at UTS. Currently, she is working at the ARC Research Hub for Nutrients in a Circular Economy (ARC NiCE Hub), utilizing UF-based membrane bioreactor (MBR) technology to achieve complete nutrient recovery and develop next-generation fertilizer from source-separated urine, contributing to sustainability and the circular economy.

Abstract

Human urine is rich in nutrients and an important source of fertilisers, especially when source-separated urine is available. Due to the increasing focus on the need for nutrient removal and recovery, various technologies and processes are being investigated. This study investigated a hybrid membrane bioreactor (MBR) and membrane capacitive deionisation (MCDI) where the source-separated urine was treated in MBR, and the subsequent MBR permeate was used as a feed for the MCDI for further nutrient removal and recovery. Overall, nitrate, phosphate and ammonium removal were 66%, 49% and 58%, respectively, in the treated urine using MCDI. Additionally, the recovery rate of nitrate, phosphate and ammonium were 80%, 64% and 76% in the concentrated brine. The

energy demand for recovery of NH_4^+ was between 3.03-11.25 kWh/kg of NH_4^+-N and between 3.87-14.75 kWh/kg of NO_3^--N for the three different voltages used in the study. The study further demonstrates the viability of MCDI application for nutrient recovery and concentration, effectively using both the adsorption and desorption phases of MCDI operation without using any chemicals.

Graphene oxide-based layer-by-layer nanofiltration using inkjet printing for desalination

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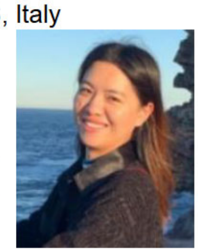

Brief bio

Dr. Chen Wang graduated from University of Technology Sydney in August 2023. Now she is working as a postdoctoral research engineer in UTS. Her major includes the advanced membrane fabrication and modification, organic solvent nanofiltration, resource recovery from seawater, and machine learning-assisted membrane performance prediction and optimization.

Abstract

Nanofiltration (NF) membrane was prepared using inkjet printing assisted layer-by-layer (LBL) assembly of polyethylenimine (PEI) and graphene oxide (GO) on a polyketone (PK) substrate surface then cross-linked with glutaraldehyde (GA). The membrane characterizations confirmed the successful formation of cross-linked multilayer PEI/GO membranes. PEI/GO membrane prepared with three bilayer numbers was found to have the optimal separation performances with the highest permeability and selectivity. The NF performances of the $(PEI/GO)_3$ membrane were evaluated using different molecular weight dyes and different salts. Results revealed that the $(PEI/GO)_3$ membrane exhibited rejections of 99.9%, 98.1%, 94.7%, and 85.1% for Rose bengal (RB), Brilliant blue R (BBR), Eosin Y (EY), and methylene blue (MB), respectively. The selectivity of $(PEI/GO)_3$ membrane for salts followed a sequence of $MgSO_4 > Na_2SO_4 > MgCl_2 > NaCl$. The influences of PEI and GO concentrations on membrane performances were investigated. The stability of $(PEI/GO)_3$ was evaluated by chlorination test and long-term filtration test. The $(PEI/GO)_3$ membrane exhibited desirable chlorine resistant property and excellent long-term filtration stability. Overall, our work provided new ways for the preparation of LBL membranes with good NF performances and excellent stability property.

Enhanced Strategies for Phosphate Recovery from Urine by Magnesium Galvanic Process

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Brief bio

Hao Liu is an exchange PhD student at UTS from the School of Civil Engineering from the Beijing Jiaotong University, China.

Abstract

Magnesium galvanic process (MGP) can be applied to recover phosphate from source-separated urine. However, information on how the urine matrix affects MGP performance is limited. Therefore, this study investigated the mechanism of phosphate recovery by MGP in synthetic and real urine matrixes. Our results showed that the major components in urine (i.e., NH_4^+, Cl^-, and HCO_3^-) all exhibited acceleration effects on corrosion of Mg plate.

However, the underlying action mechanism of each component was distinct. Ammonium facilitated the conversion from MgO to $Mg(OH)_2$, chloride complexed with Mg^{2+} ions, and bicarbonate led to complexation as well as formation of $MgCO_3$. Furthermore, our results revealed an interesting aspect where although bicarbonate alone accelerated the corrosion of Mg plate, its coexistence with other ions inhibited overall performance due to the blocking effect of formed $MgCO_3$ on chloride penetration and reduction in free magnesium ion concentration. After elucidating the interaction of NH_4^+, Cl^-, and HCO_3^- on the passive layer of the Mg plate, we proposed to pretreat urine with HCl, which resulted in a significant enhancement in current production and phosphate recovery. This improved MGP was further tested in a continuous flow reactor, which recovered over 95% of phosphate in real urine for more than 1 h. The phosphate precipitates were confirmed as high purity struvite. Generally, the improved MGP, which simultaneously produced Mg^{2+}, dihydrogen, and electricity with no energy input, is a promising sustainable and green alternative for phosphate recovery from source-separated urine.

Catalytic membrane reactors for energy efficient wastewater treatment

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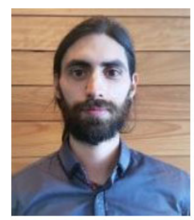

Brief bio

Dr. Andrea Merenda received his PhD from Deakin University in 2019. Dr Merenda specializes in the design and synthesis of functional materials and stimuli-responsive surfaces, with a focus on membrane catalytic reactors applied to green chemistry and water treatment. Dr. Merenda is also Board Director of the Membrane Society of Australasia.

Abstract

The United Nations have identified the availability and access to clean and safe water worldwide as key challenges towards sustainable economic growth, spurring the development of resilient and efficient water supply systems while tackling social inequalities and climate change. Advances in the design and synthesis of photo- and electro-driven catalysts have fostered the design of stimuli-responsive membrane reactors for innovative advanced oxidation processes. Stimuli-responsive membrane reactors can integratemembrane separation with the catalytic removal of pollutants. Renewable energies, such as solar irradiation and green electricity, can be utilized to produce oxidising species on the photo- or electro-active surface of membranes, greatly enhancing the removal of waterborne pollutants. Catalytic membrane reactors are however characterised by low technological readiness levels, with scarce reports of pilot or industrial-scale applications. Here, we investigate the synthesis of catalytic membrane reactors by designing stimuli-responsive materials with controlled nanoscale order and interface. This study focuses on the deposition of ultrathin metal oxide layers (TiO_2, ZnO) on conductive and porous stainless steel membranes by atomic layer deposition. The formation of Schottky barriers and type II heterojunctions results in higher density of charge carriers with mitigated recombination phenomena, enhancing the catalytic performance. The synergy between photo and electrocatalytic degradation phenomena is elucidated by the definition of a new photoelectrocatalysis enhancement factor, which reveals that photoelectrocatalytic kinetics are 2-3 times higher than the respective photo or electro-driven reactivities. Furthermore, type II heterojunctions with controlled thickness and layer ordering achieved kinetic constants up to 75 10^{-3} min^{-1} in the degradation of persistent organic pollutants, corresponding to a 500% increase compared to single metal oxide layers. Photoelectrocatalytic filtration experiments are also discussed, with a focus on bulk and surface degradation phenomena. The rational design of catalytic membrane reactors endowed with cost-effectiveness and competitiveness can lay the foundations of new energy-efficient advanced oxidation processes in wastewater treatment.

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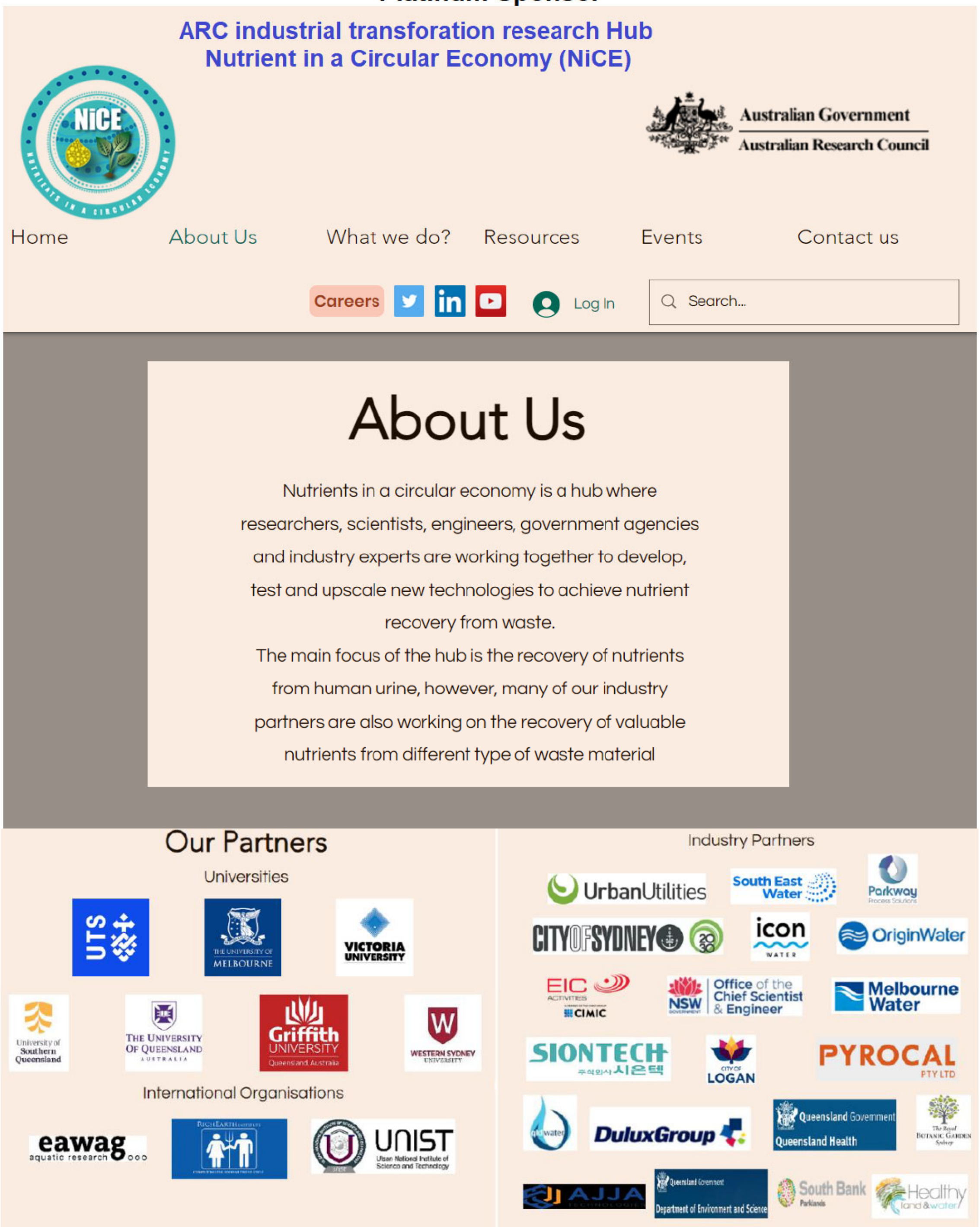

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- To capture current research and industry involvement and highlight future trends.
- To promote collaborative engagements across the community to disseminate membrane technology to end users.
- To be the nexus of membrane science and technology activity in the Australasia region.

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- Providing an open forum for transferring and sharing technologies as well as capabilities within the members, industries and high education organizations.
- Supporting multidisciplinary networking events.
- Providing leadership and mentorship in membrane science for the Australasian membrane community.
- Promoting opportunities for young members.
- Enabling wider understanding of the membrane technologies for public interest.

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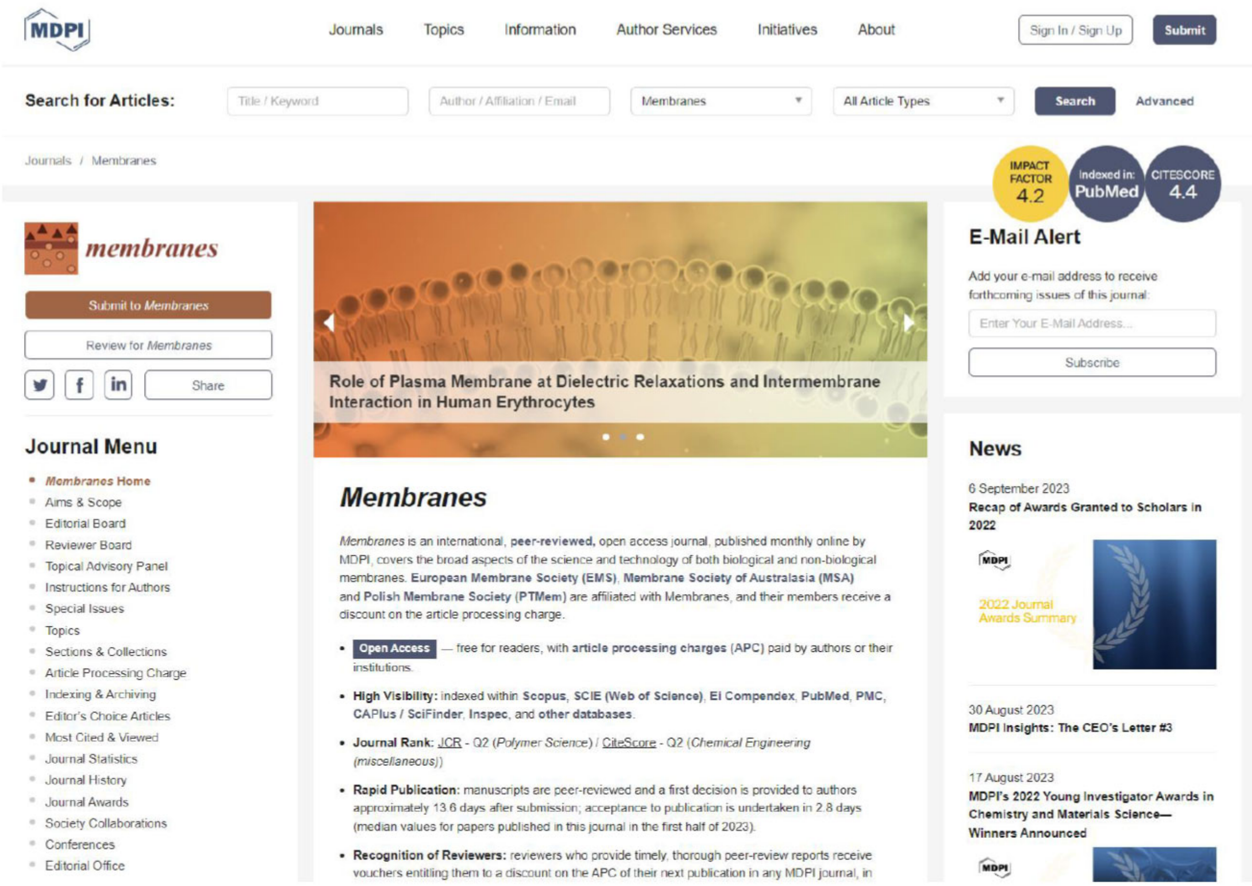

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Deadline for manuscript submissions:
30 December 2023

Message from the Guest Editors

Dear Colleagues,

In our current linear economy, which follows a “take–make–use–dispose” model, raw materials are collected and produced into products and are then thrown away after use as waste. This model prioritizes profitability and is unsustainable. A more sustainable alternative approach is the circular economy model, where the cycles for raw materials are closed, leaving as little an ecological footprint and environmental impact as possible. Thus, a shift from the conventional linear economy into a circular economy is of urgent necessity. The role of membrane technology has grown in importance in the last few decades for many applications such as in water and wastewater treatment, desalination, gas and particle separation, pollution remediation, resource recovery, biomedical field, water–energy nexus, etc. This is mainly due to its more efficient process and cost-effectiveness over conventional techniques. The increasing use of membrane processes in many areas has catapulted membrane technology as an important driver toward a more sustainable society. Thus, membrane technology will play a critical role in achieving a circular economy.

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