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ARC NiCE Hub Newsletter

September 2023

Nutrients in a Circular Economy

Contents

Hub Manager

Ibrahim El Saliby

Editorial board

Chief Content Officer, Editor and writer

Jiaxi (Jade) Jiang

Message from our Hub Director

Dear Colleagues and Stakeholders,

We are delighted to share with you the remarkable progress and achievements of the ARC Research Hub for Nutrients in a Circular Economy (NiCE). Our tireless dedication and collaborative efforts continue to pave the way for revolutionary advancements in sustainable resource management, wastewater treatment, and circular economy practices.

At the core of our mission lies the vision to establish Australia as a global leader in circular economy practices, particularly in the domain of nutrient recycling through human urine separation. Our integrated and multidisciplinary approach brings together experts from diverse fields, fostering innovation and driving the creation of technical knowledge, social engagement, business models, and regulatory frameworks crucial for the successful adoption of this circular economy concept. We are equally proud of our outreach and education initiatives, fostering collaboration, and knowledge dissemination. From engaging with international partners to sharing our progress through conferences, workshops, and site tours, we are committed to promoting a holistic understanding of our research's significance and potential impact.

We extend our heartfelt gratitude to our collaborators, industry partners, and team members for their dedication and unwavering support. Together, we are shaping a future where nutrient recycling and circular economy practices will drive sustainable growth, improve resource management, and positively impact our environment.

For any inquiries or further information, please do not hesitate to contact the respective individuals mentioned in our progress

Assistant Chief Content Officer and writer
Chee Xiang Chen

Veera Koskue

Designer, Co-Editor/writer
Mikel Duke

Co-Editor/writer
Haoran Duan

Niraj Yadav

updates. Let us achieve a green circular economy.

Warm regards,

Hokyong Shon
Director
ARC Research Hub for Nutrients in a Circular Economy (NiCE)

Cara Beal

Annette Nanka

Featured Story

Review of the ARC NiCE hub in 2022

(YouTube channel: Circular Economy for Climate and Environment(CECE

Our Partners

Universities

Industry Partners

International Organisations

Circular Economy For Climate and Environment (CECE) Conference 2023

26 and 27 Sep 2023 | 8:30 am to 5:00 pm AEST
Aerial, University of Technology Sydney

The Circular Economy For Climate and Environment Conference will be held in Sydney in September 2023. Held over two days, the conference will explore recent advances in technologies and industrial approaches with a focus on Nutrient recovery and reuse for sustainable futures.

For more information, please visit conference website

www.nicecece.org

ARC NiCE Hub Third Summit

Time & Location

25 Sept, 9:00 am AEST – 27 Sept, 7:00 pm AEST
Sydney, Sydney NSW, Australia

For more information, please visit ARC NiCE Hub website

https://www.nicehub.org

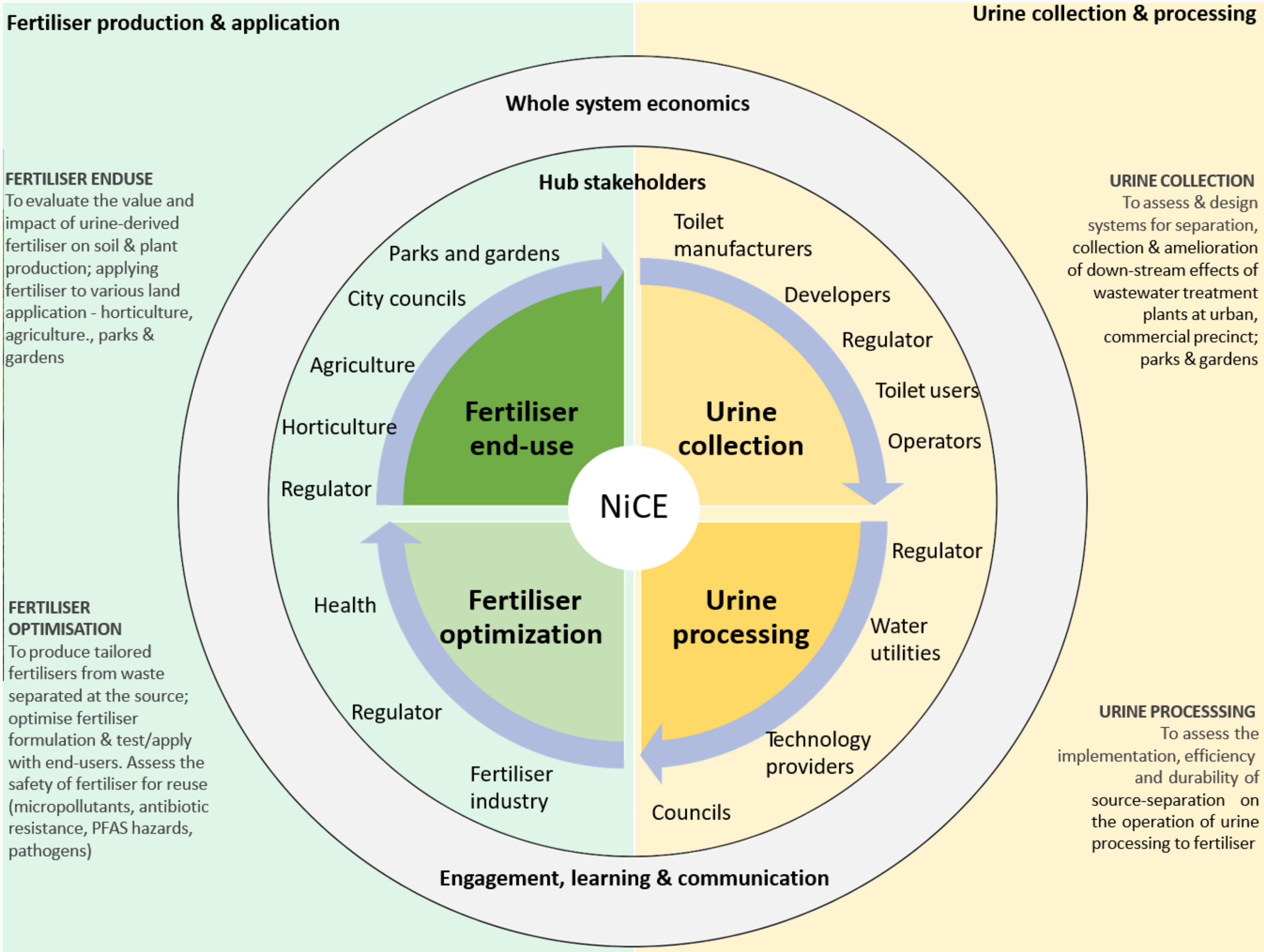
Research Project and Showcase

About Us

The ARC Research Hub for Nutrients in a Circular Economy (NiCE) will make Australia the world leader in a new circular economy, based on nutrient recycling through the separation, collection and processing of human urine into safe and effective fertilisers. It will use an integrated and multidisciplinary approach to create the technical and social know-how, the business models and the regulatory frameworks needed for the uptake of this circular economy concept.

The Hub's outcomes will directly benefit Australia's water utilities, agriculture, and manufacturing sectors. Urine recycling can save up to 50% of sewage treatment operating costs and avoid costly capital upgrades. New technology (toilet designs, sensors and membrane processes for urine) will create new opportunities for Australia's manufacturing sector.

The ARC Nice hub has successfully developed two technologies to convert human urine to safe and nutrient-rich compound fertilisers. Within the NiCE Hub's scope, two groundbreaking fertilizer products have been successfully developed: UrVAL and UGOLD. These products utilize cutting-edge technologies to transform urine into valuable resources for horticulture. In addition, many of our industry partners are also working on the recovery of valuable nutrients from different type of waste material.



ARC NiCE Hub Plan diagram

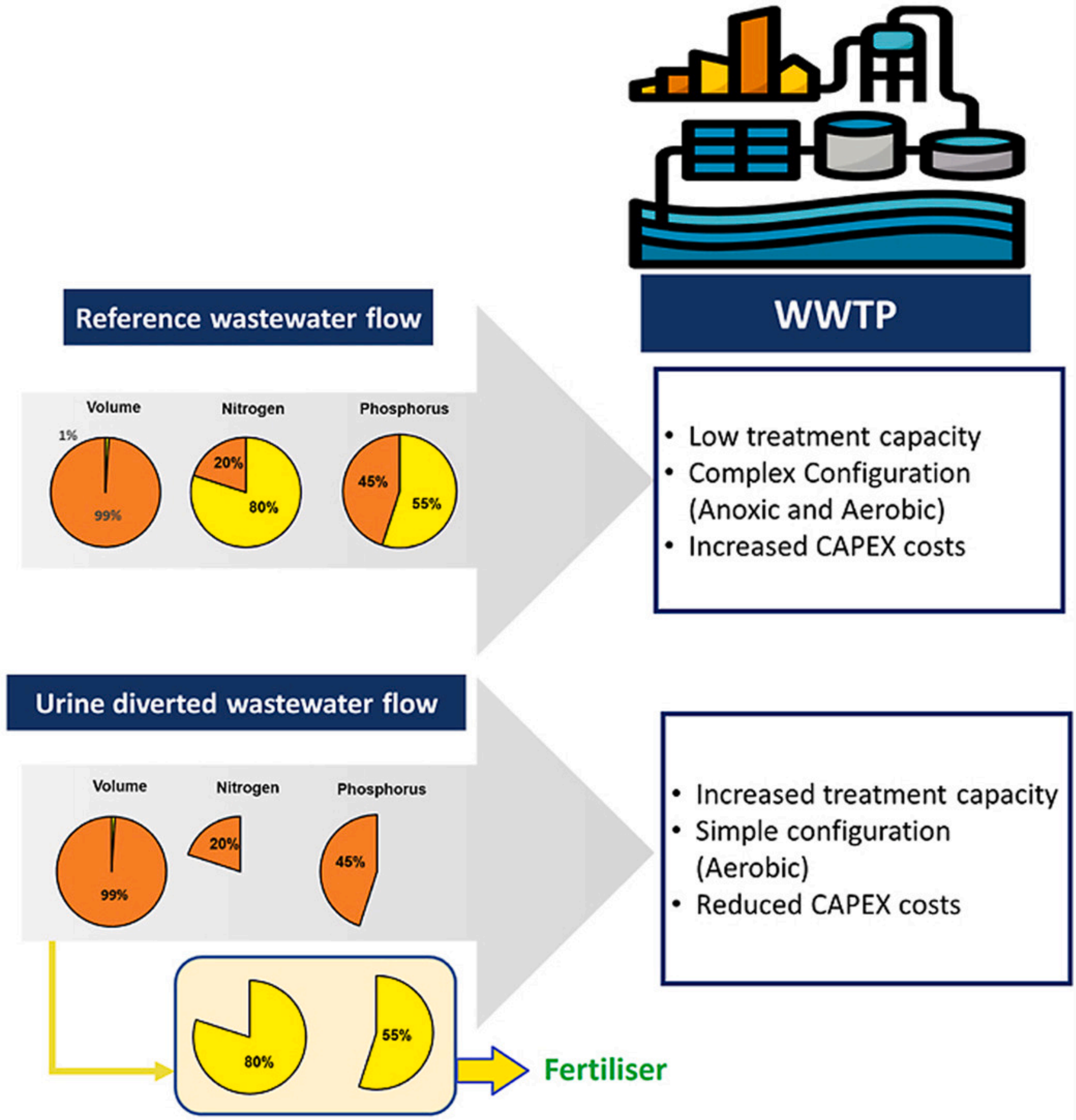
Scientific Progress at Sydney Node

The University of Technology Sydney

UTS is the host University of the Australian Research Council for Nutrients in a Circular Economy and is the first University to implement urine diversion, collection and processing to fertiliser in its Sydney CBD - City Campus. Our research activities at the University of Technology Sudney currently focus on laboratory-scale and pilot-scale experiments aimed at complete nutrients recovery from source-separated urine using UrVal technology. The UrVal or "U are valuable, Urine is valuable" is a plant fertiliser produced by a process where urine stabilisation and sanitation is achieved using ultrafiltration (UF) based membrane bioreactor (MBR) followed by dewatering processes.

1. Sydney Central Park WWTP
Several strategies exist for nutrient recovery from separated urine, and urine diversion aids wastewater treatment by lowering costs, energy consumption, and environmental impact. This concept aligns with the circular economy and is vital for densely populated cities with limited space. A study investigated urine diversion's impact on nitrogen and energy at the Sydney Central Park WWTP. Additionally, another study employed BioWin simulation to evaluate how urine diversion affects a decentralised WWTP's treatment capacity, processes, and capital costs. Real data from a Sydney-based WWTP were used for simulation and analysis. Two scenarios, replacing aerobic MBR with anaerobic MBR and vice versa, were compared to the existing setup. Simulation results show that a 75% urine diversion could double the WWTP's treatment capacity, plateauing after 40% diversion. Beyond 75% diversion, the need for the anoxic denitrification tank decreases. Transitioning to a less aeration-intensive MBR is feasible, reducing capital costs by 24%

without compromising effluent quality. Anaerobic MBR is viable but requires pre-treatment before water reuse through reverse osmosis. Sensitivity analysis indicates that operating the bioreactor at higher mixed liquor suspended solids concentrations could amplify treatment capacity by around 3.5 times at 75% urine diversion. In summary, urine diversion can enhance WWTP treatment capacity and decrease capital expenses by reducing the plant's footprint, with the impact limited by nitrogen constraints above 75% diversion.



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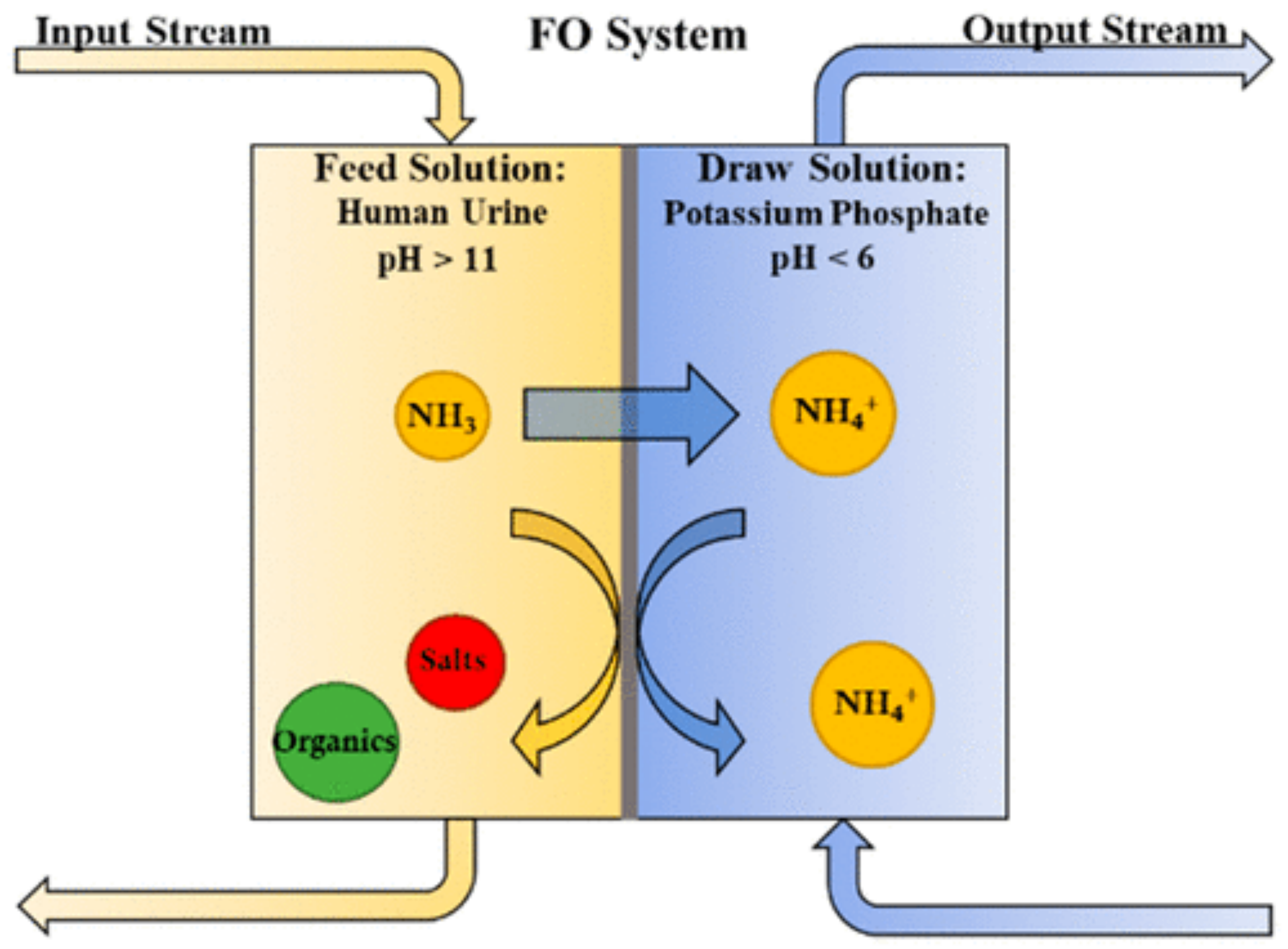
2. Advancing Ammonia Recovery from Source-Separated Hydrolyzed Urine: Dual Membrane Distillation System

Membrane Distillation (MD) shows promise for extracting nutrients from human urine by isolating nitrogen-based compounds, essential for fertilizers. In the MD process, gaseous ammonia is captured through a microporous membrane and then collected on the other side of the membrane using an acidic solution, forming nitrogen-rich compounds usable as liquid fertilizer. However, the MD process faces challenges. The pH of the collected solution is crucial for effective ammonia capture. Maintaining a stable pH around 3 is desirable because at this pH, the ammonia capture rate is optimized. A higher pH leads to less effective ammonia capture. The production of ammonia in urine increases its pH, and transferring this ammonia to the collecting solution raises its pH, affecting fertilizer production efficiency. Prior attempts to control the permeate pH have involved renewing the collecting solution with fresh acid, but this increases acid consumption. Some studies have been limited to shorter durations to avoid pH-related issues. Addressing the pH control issue is crucial for MD to successfully recover nutrients from urine. By optimizing feed temperature and pH conditions, the study quantifies the specific ammonia transfer (SAT) value to make comparative assessments. Although water fluxes were similar in single and dual MD setups, the dual configuration showed higher SAT values and ammonia fluxes. Notably, at pH 13.2, the dual MD setup demonstrated significantly improved ammonia fluxes, exceeding 180 g/m² h—roughly double the single MD setup's output (around 100 g/m² h) under the same conditions. Furthermore, the dual-MD setup increased ammonium concentration, surpassing 200 mg/L around pH 9—twice that of the single MD setup. Crucially, the dual configuration maintained the acid collector's pH at around 3 consistently throughout the experiment, while the single setup experienced a continuous pH rise, reaching over 8 after 4 hours. This innovative design effectively maintains the desired pH range and reduces acid consumption, presenting a promising avenue for advancing nutrient recovery from human urine. Further research is needed to refine technologies, reduce energy consumption, and promote the implementation of urine-based nutrient recovery systems.



Acknowledgments: We express our sincere gratitude to Mr. Mohsen Askari for his invaluable contribution to the writing in the section above.

Contact: For further inquiries, please contact Prof. Hokyong Shon (Hokyong.Shon-1@uts.edu.au)

The Western Sydney University

Our research activities at the Western Sydney University focus on investigating the profound impacts of urine-based fertilizers (UBFs), within the intricate dynamics of continuous processes involving soil, plants, and the atmosphere. This project endeavours to integrate existing knowledge from soil physiochemistry, hydrology, and plant interactions to unveil optimal conditions for maximizing benefits while mitigating potential negative impacts. The overarching objective is to enhance our understanding of the intricate relationships between UBFs and soil health, particularly in degraded environments. The research project is delineated into the following objectives, each aimed at unravelling specific aspects of the interaction between fertilizer and the environment:

1. Predicting Behaviours of Urine-Based Fertilizers in different Soil types
The primary focus of this objective is to explore and predict the behaviour of UBFs across diverse soil types. By conducting experiments involving columns and batches, we will analyse adsorption/desorption isotherms using a batch equilibrium approach. Through this investigation, we aim to clarify the expected impacts of these fertilizers on the cycling of nutrients. The underlying goal is to optimize soil fertility and support more productive soils while skilfully

addressing concerns like salinization and pH fluctuations.

2. Assessment of UBFs for Plant End-Use
This objective encompasses a comprehensive assessment of the effects of this fertilizer on plants that could potentially be grown in these soils. Parameters such as plant productivity, biomass recovery, soil biological fertility, nutrient losses, pH dynamics, and the presence of potential pathogens will be meticulously analysed. Through this comprehensive evaluation, the project aims to uncover strategies that optimize fertilizer outcomes while proactively addressing potential soil- and fertiliser-based constraints. This approach intends to tailor solutions, ensuring enhanced plant performance and sustained soil ecosystem health.

Photos from an experiment. Niraj Yadav and Hanxia Yu are currently performing to compare the effects of urine-based fertilisers (bottom-left and middle) on plants (right and bottom-left) and measuring losses of nitrogen through leaching (top-right) and gas emissions (top-left).

Acknowledgments: We express our sincere gratitude to Mr. Niraj Yadav for his invaluable contribution to the writing in the section above.

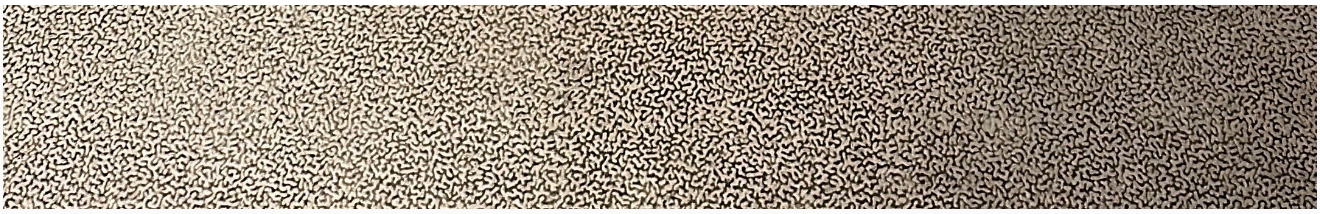
Scientific Progress at Melbourne Node

The University of Melbourne

Our research activities at the University of Melbourne currently focus on laboratory-scale experiments aimed at recovering key nutrients (nitrogen, potassium, and phosphorus) from human urine using different membrane-based technologies. These technologies include two established techniques, reverse osmosis and electrodialysis, and the innovative Ugold system.

1. Waterless urinals can be used for collecting source-separate urine
We have set up a simple waterless urinal in one of the male toilets on our Parkville campus, close to the laboratory facilities where we carry out the nutrient recovery experiments. The urinal facilitates the separate collection of urine without any dilution as no water is used for flushing. The fresh urine is stored for a period of time to allow for urea hydrolysis to occur; this natural phenomenon will break urea into ammonium nitrogen (NH_4^+) and increase the pH of the urine from 6–7 to around 9. This hydrolysed urine is used in the laboratory experiments. The positively charged ammonium nitrogen can migrate through ion-exchange membranes, which we can take advantage of in the Ugold and electrodialysis systems.


Plain Language Statement
Department of Chemical Engineering
ATTENTION
URINE FROM THIS URINAL WILL BE COLLECTED AND USED FOR RESEARCH PURPOSES. PLEASE READ ON BEFORE USING THE URINAL
The special urinal in this toilet may be used like regular urinals. Please do not pour other liquids into the urinals.
Urine will be collected in the tank under the urinal and will be used to drive a system for the production of fertiliser from urine.
The urine will be pooled at the source, therefore no samples from individual users will be collected or analysed.
The pooled urine will be used in lab and pilot reactors for the production of fertilisers. Urine samples will be analysed for nutrients and organic compounds.
Ethics ID Number: 2021-22045-19046-3
Plain Language Statement v1 02/07/2021
Project:
Developing technology for the production of fertilisers from human urine
Dr Stefano Freguia (Responsible Researcher)
Tel: +61 3 8344 2200 Mobile: +61 407 996 634 Email: stefano.freguia@unimelb.edu.au
Chee Xiang Chen (PhD student) Email: cheexiang.chen@student.unimelb.edu.au
Negar Dasineh Khiavi (PhD student) Email: ndasinehkhia@student.unimelb.edu.au
Huilin Xiang (PhD student) Email: xiangwang.202@163.com
Introduction
Thank you for your interest in participating in this research project. The following few pages will provide you with further information about the project, so that you can decide if you would like to take part in this research.
Your participation is voluntary. If you don't wish to take part, you don't have to. In that case, please use the regular urinals located to your left.
What is this research about?
This project aims to produce and test a suite of renewable fertilisers derived from urine using water and wastewater treatment technology.
The urine is collected here in a pooled form, will be later analysed for nutrients, salts and organic chemicals before being used for the development and testing of our innovative technologies for fertiliser recovery.
The data collected from this urine will be perpetually stored in UoM computers and may be used for future projects, including epidemiological studies.
What will I be asked to do?
Should you agree to participate, simply use this urinal! ⇩
What are the possible benefits?
By using this urinal, you will be making a valuable contribution towards the sustainability of food production and towards the resilience of urban water infrastructure.
What are the possible risks?
Your urine will be pooled with that from an unknown number of non-identified users, therefore there is no information that can be extracted about your individual health or lifestyle.
Ethics ID Number: 2021-22045-19046-3
Plain Language Statement v1 02/07/2021
You may be exposed to unpleasant odours during the use of the urinal. In such case, please inform the Responsible Researcher, who will pause the research until the problem is fully managed.
Also, if you find that the urinal or its surrounding are unhygienic, please inform the Responsible Researcher, who will arrange for immediate cleaning.
Do I have to take part?
No. Participation is completely voluntary.
Will I hear about the results of this project?
The abstracts of conference and journal papers arising from this research will be posted on this wall. Please contact the Responsible Researcher if you would like to read the full papers.
What will happen to information about me?
We will not ask for your identity or personal information at any stage during the project.
Where can I get further information?
If you would like more information about the project, please contact the Responsible Researcher: Dr Stefano Freguia, Email: stefano.freguia@unimelb.edu.au
Who can I contact if I have any concerns about the project?
This project has human research ethics approval from The University of Melbourne 2021-22045-19046-3. If you have any concerns or complaints about the conduct of this research project, which you do not wish to discuss with the research team, you should contact the Research Integrity Administrator, Office of Research Ethics and Integrity, University of Melbourne, VIC 3010. Tel: +61 8344 1376 or Email: research-integrity@unimelb.edu.au. All complaints will be treated confidentially. In any correspondence please provide the name of the research team and/or the name or ethics ID number of the research project.
Ethics ID Number: 2021-22045-19046-3
Plain Language Statement v1 02/07/2021
Human Urine
23 June 2023



The simple waterless urinal used for collecting urine for research purposes at the University of Melbourne. (*Photo credit: Chee Xiang Chen)*

2. Optimised start-up strategy for Ugold paves way for pilot-scale trials

The Ugold process is based on bioelectroconcentration. It is an electrochemical system where we place an ion-exchange membrane pair between the anode and cathode electrodes. On the anode, we grow bacteria that can produce electricity from the organic matter in the urine we feed them with. This electricity is used as a driving force to make the ammonium nitrogen (and other nutrients) migrate through the ion-exchange membranes. This way, we produce a concentrated liquid fertiliser between the membranes.

One of the bottlenecks for using a bioelectroconcentration system, such as Ugold, has been the slow growth of bacteria on the anode. The high pH (ca. 9) and ammonium nitrogen concentration (ca. 5–8 g/L) of hydrolysed urine are toxic to most bacteria. Traditionally, researchers have tried different tactics where the pH and/or the ammonium concentration is gradually increased to slowly acclimatise the bacteria to the harsh conditions of real urine. However, this approach is slow and typically takes several months.

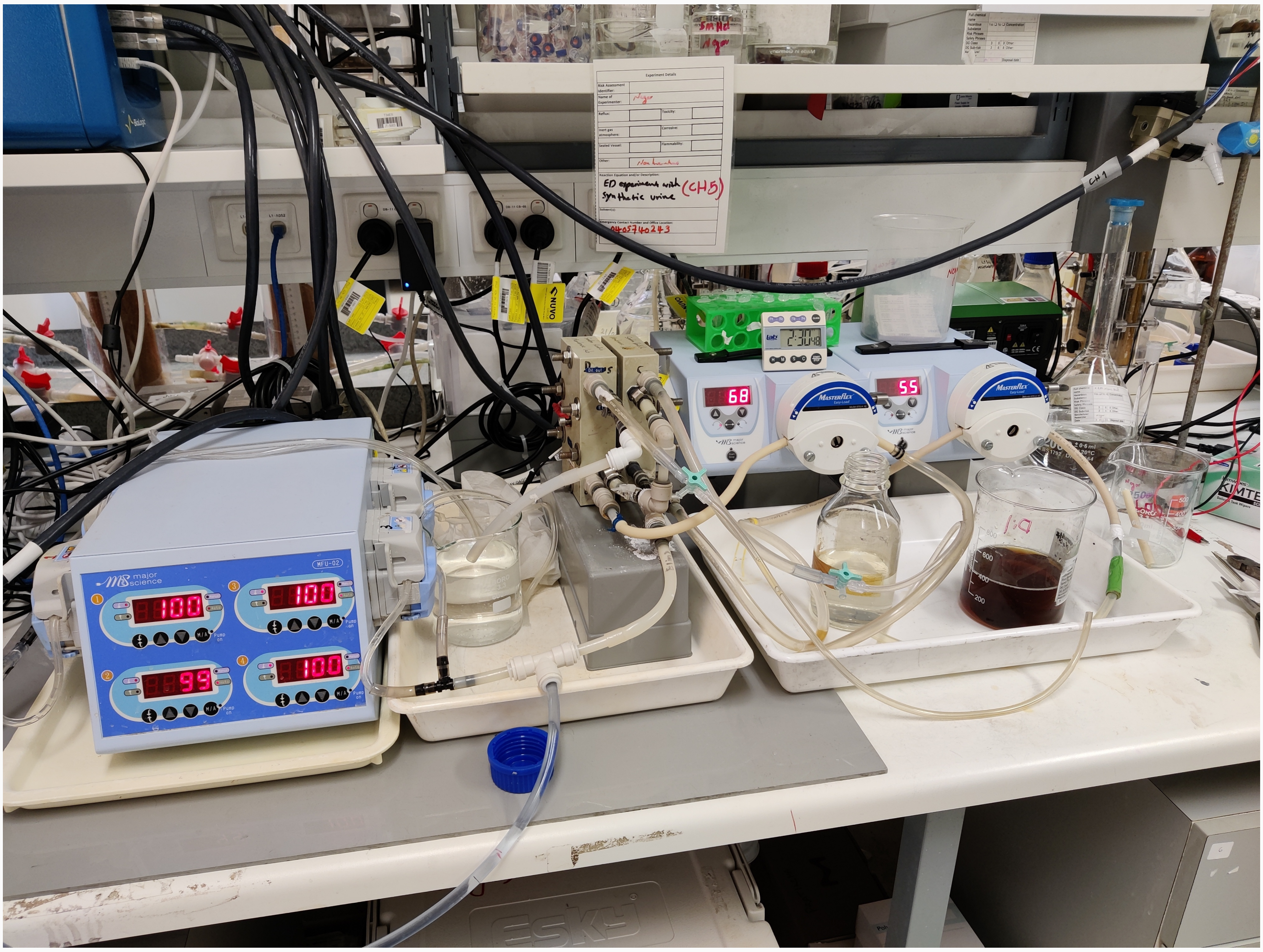
Instead, we aimed at minimising the start-up time by mixing hydrolysed urine with activated sludge used for nutrient removal at a municipal wastewater treatment plant. The activated sludge diluted the ammonium nitrogen concentration and slightly decreased the pH of hydrolysed urine, while also providing a source of a wide range of bacteria. With this approach, we were able to get the bacteria to produce electricity within a week of starting the system. The results from the laboratory-scale experiments will help us start up a pilot-scale Ugold system in Brisbane later this year.

Dr. Veera Koskue is currently collecting data from a laboratory-scale Ugold system to help her start up a larger scale system in Brisbane later this year. (*Photo credit: Chee Xiang Chen)*

3. Electrodialysis recovers nitrogen at low energy consumption

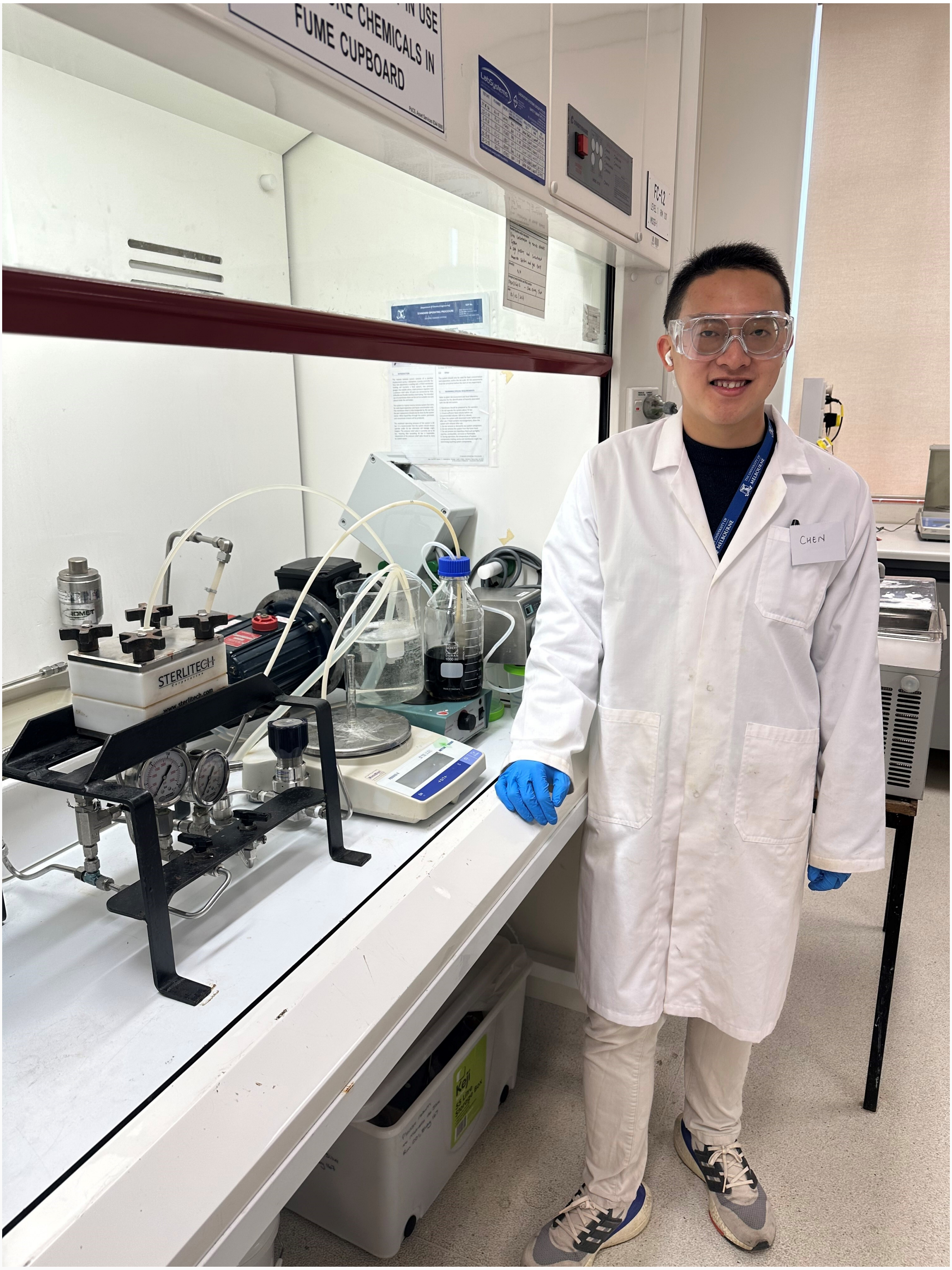
Like Ugold, electrodialysis is a concentration technology that uses ion-exchange membranes. The main difference is that no bacteria are used in the system, which means the technique is purely electrochemical. In other words, electricity

production is not limited by the bacteria and higher currents can be used. This means higher driving force for the concentration of nutrients. There are also typically more than one ion-exchange membrane pair placed between the anode and cathode electrodes.
In our preliminary laboratory experiments, we have been able to recover 80% of ammonium nitrogen from human urine using electrodialysis, while consuming as little as 5 kWh of energy per kilogram nitrogen recovered. This energy demand is less than half of the ca. 12.5 kWh required to produce a kilogram of nitrogen fertiliser using the traditional Haber-Bosch method. The results show that electrodialysis is a promising option for recovering ammonium nitrogen and other nutrients from human urine.



Electrodialysis has potential to recover nitrogen and other key nutrients from human urine at low energy consumption. *(Photo credit: Veera Koskue)*

4. Reverse osmosis efficiently recovers key nutrients from human urine
Another technology we are currently testing for nutrient recovery from human urine is reverse osmosis. It is a process that uses pressure to force urine through a semipermeable membrane. The semipermeable membrane allows water content in urine to pass through, while retaining nutrients, resulting in a more concentrated solution. This research aims to pave the way for more efficient and sustainable resource management.
In this study, we have successfully achieved a 60% recovery for nitrogen, and an 85% recovery efficiency for phosphorus and potassium from source-separated urine. One of the key advantages of this process is the concentration of urine. By removing excess water content through our recovery process, we have effectively reduced the volume of urine. This concentrated form is not only easier to handle and store but also offers enhanced transportability. This advancement opens new possibilities for the efficient collection and distribution of urine-based fertilizers, contributing to a more circular and resource-efficient economy.



PhD Candidate Chee Xiang Chen studies how efficiently nutrients can be recovered from human urine with reverse osmosis. *(Photo credit: Angel Chyi En We)*

Contact: For further inquiries, please contact Dr. Veera Koskue (veera.koskue@unimelb.edu.au) or Chee Xiang Chen (cheexiang.chen@student.unimelb.edu.au).

Victoria University

The project teams from Parkway Process Solutions and Victoria University on the NiCE hub project titled “An integrated water treatment process for valuable nutrient recovery and purification from industrial waste streams” have made good progress towards their research that explores innovative processing schemes to recover products of value from contaminated industrial waste sources. Products that can be recovered include commodity chemicals that could be utilised for fertilisers and other applications. However impurities such as organics and associated colour affecting aesthetics can compromise the final recovered products in meeting required specifications for reuse, and are challenging to remove. An example of a trial concentrated product with high colour is shown in Figure 1. The organics which play a role in the colour often exist at low concentrations (~1000 mg/L) and cannot initially be seen, but must be reduced to much lower levels prior to the downstream product concentration operations otherwise they will become highly concentrated and visible.

Trial product made without colour removal

Three approaches were trialled to remove colour in the initial dilute industrial wastewater, being ozone, UV photocatalysis and low molecular weight (MW) ultrafiltration (UF), all being well known operations in the water industry for colour removal. The wastewater samples collected from the industry site were exposed to an ozone at a dose of 13.1 g O_3/h, but did not decline in colour measured in PtCo units over the test duration. UV photocatalysis was tested using P25 Titania catalyst with UVC light (365nm peak wavelength) also showed no reduction in colour. These oxidation approaches were not considered any further.

Trials were then conducted using low MW ultrafiltration (UF). Two stage treatment was carried out at bench scale, first with a 0.2μm microfiltration (MF) cartridge in dead-end filtration mode, followed by UF with a 10kDa molecular weight cut-off (MWCO) membrane in cross flow mode. The feedwater colour was reduced from 44 PtCo units to 16 PtCo units by MF, then reduced down to 10 PtCo units by UF after reaching 74% volume recovery. A lower MWCO 5kDa membrane was also tested for the UF stage to the target volume recovery of 80% leading to permeate colour of 6 PtCo units. The bench testing was extended to pilot scale with a 4" spiral wound 5kDa MWCO UF membrane. Total organic carbon (TOC) of the feed was reduced by 88% at a volume recovery of 91%, highlighting the favourable effect of organics removal from the wastewater that can then be further processed for product recovery.

Scientific Progress at Brisbane Node

The University of Queensland

Evaluating Environmental and Economic Impacts of Urine Separation in Wastewater Treatment
The global emphasis on environmental sustainability and resource optimization has spurred our group's investigation into the potential benefits of urine separation in wastewater treatment, particularly in terms of Greenhouse Gas emissions. Our study focuses on the vital objectives of minimizing carbon emissions and encouraging nutrient recycling practices. Our research delves into the promising avenue of source-separated urine management as a means to extract valuable nutrients for fertilization. This nutrient-rich composition of urine presents a valuable resource for sustainable agricultural practices. Recent advancements propose novel methods, such as the nitrification membrane bioreactor - membrane distillation process and microbial electrolysis cell (MEC) with membrane stripping, for the recovery of ammonium compounds from urine. Despite these innovative approaches, there is a noticeable gap in the assessment of the associated environmental and economic benefits. Since the inception of our project, we have achieved the following milestones at the University of Queensland in comprehensively evaluating the environmental and economic implications of urine separation within the context of sewage treatment plants.

1. Scenario Analysis: We have meticulously defined six distinct scenarios for urine treatment, incorporating variations in technology and approach. These scenarios encompass the integration of nitrification membrane bioreactors, microbial electrolysis cells, and various urine treatment methods

2. Data Collection: Extensive data collection has been conducted, considering a nominal plant serving a population of 200,000 individuals. Water usage patterns, urine generation estimates, and wastewater characteristics have been scrutinized to ensure accurate simulations.

3. GHG Emission Assessment: Our team has developed a comprehensive assessment of greenhouse gas (GHG) emissions, encompassing both direct (scope 1) and indirect emissions (scope 2). We have also incorporated offset energy considerations to provide a holistic view of emissions.

4. Operational Expenditure (OPEX) Analysis: An in-depth analysis of operational expenditures associated with different urine treatment scenarios has been undertaken. Our calculations account for costs related to various technologies, maintenance, and energy consumption.

5. Environmental Impact Evaluation: We have evaluated the environmental impact of each scenario, considering factors such as energy consumption, waste generation, and GHG emissions. This assessment provides insights into the overall sustainability of the proposed urine separation methods.

Preliminary findings indicate that the High Rate Activated Sludge (HRAS) + Anammox process, coupled with urine treatment through nitrification membrane bioreactor - membrane distillation, exhibits promise in terms of reduced GHG emissions and operational expenditure. Our next steps include:

1. Refined Analysis: Further refinement of our data analysis to ensure accuracy and reliability of results.
2. Scenario Optimization: In-depth exploration of optimization strategies within the most promising scenarios to achieve a balance between environmental benefits and economic feasibility.
3. Sensitivity Analysis: Conducting sensitivity analyses to understand the impact of varying parameters on the outcomes and conclusions of our study.

In conclusion, our ongoing research endeavors to shed light on the potential advantages of urine separation in wastewater treatment. By systematically evaluating the environmental and economic impacts across multiple scenarios, we aim to provide valuable insights for policy decisions and sustainable practices. As we move forward, we are committed to refining our analyses and contributing to the broader understanding of environmentally conscious wastewater management.

Acknowledgments: We extend our gratitude to Dr. Jia Meng for her invaluable contributions to the project. 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. Her dedication and expertise have played a pivotal role in advancing our research.

Contact: For further inquiries please contact A/Prof Liu Ye (l.ye@uq.edu.au) or Dr. Haoran Duan (h.duan@uq.edu.au).

Outreach and Education Progress at Sydney Node

<u>The University of Technology Sydney</u>

1. Our Hub Director, Prof. Hokong Shon, recently had the honor of visiting the Rich Earth Institute in Brattleboro, USA, one of our international partners. The Rich Earth Institute is a pioneering organization dedicated to advancing and promoting the innovative use of human waste as a valuable resource. During the visit, Prof. Shon had a fantastic opportunity to witness their cutting-edge technologies and groundbreaking research, including urine diversion toilets for urine reclamation. Moreover, it was a pleasure to meet and engage in insightful discussions with their passionate team.

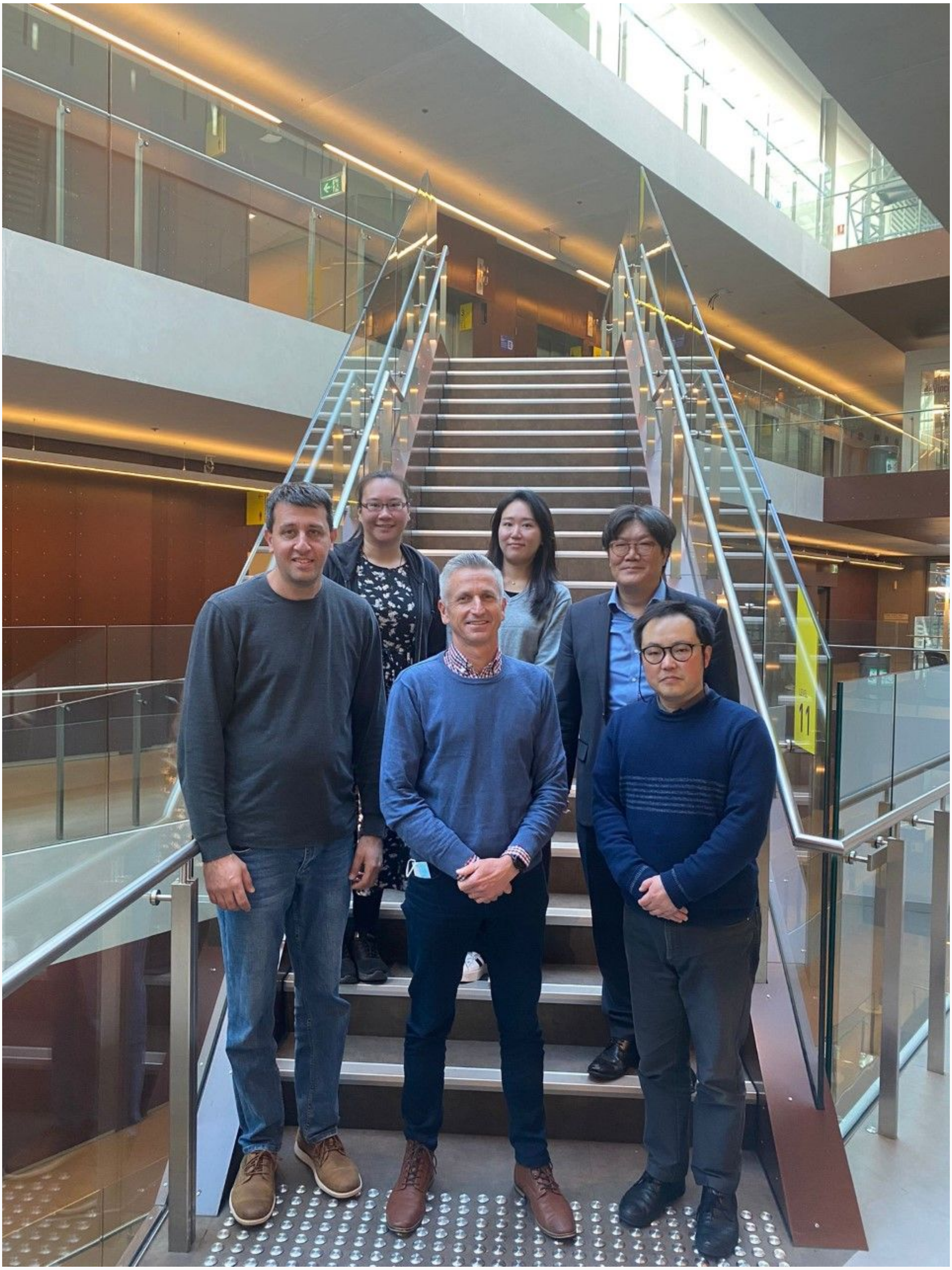
2. The NiCE Hub and the Royal Botanic Garden Sydney-Nursery (RBGS) are working together to test and optimise the use of nutrient solutions derived from the recovery of nutrients through the UrVal technology. In June, the first batch of new trials has started on testing UrVal fertiliser to assess the winter growth and biomass production of Spearmint (Mentha spicata) in an outdoor potted experiment. Since 2019, RBGS has worked with UTS/FEIT to benchmark the performance of UrVal fertiliser in horticulture trials and it was one of the first collaborations of its kind in Australia. In fact, RBGS was the first to initiate the Circular Economy of Nutrients in horticulture trials and provided invaluable contributions in improving this field of research. Today, we have welcomed Juan Lucas (PI NiCE hub) and Brynn Gordon at UTS to demonstrate how we recycle nutrients at Building 11 and what we will be doing in the future to improve our technology.

3. Special lab tour at UTS for a distinguished delegation from India.The visit centred around the theme of "Supporting Water Security, Resilience, and Transitioning to Circular Cities in India." The delegates had the opportunity to explore our research facilities and witness the innovative work being done to address water challenges and promote circularity.

4. Special visit from one of our partners, Urban Ultilities, at our research facilities and laboratories. During the visit, we showcased our urine diversion system and the technology we're developing to treat urine. It was an exciting opportunity to exchange knowledge and explore possibilities for future collaboration. We look forward to continuing our partnership and driving innovation towards circular economy.

5. Site tour for Australian Water Association young Professionals to the UTS Environmental Engineering Lab and Central Park Wastewater Treatment Plants. During the site tour, we had the opportunity to show the wastewater treatment facilities and highlight the ongoing research and innovative projects being conducted at the Center for Technology in Water and Wastewater (CTWW). From state-of-the-art technologies to sustainable resource management strategies, we demonstrated the potential for these initiatives to make a real-world impact.

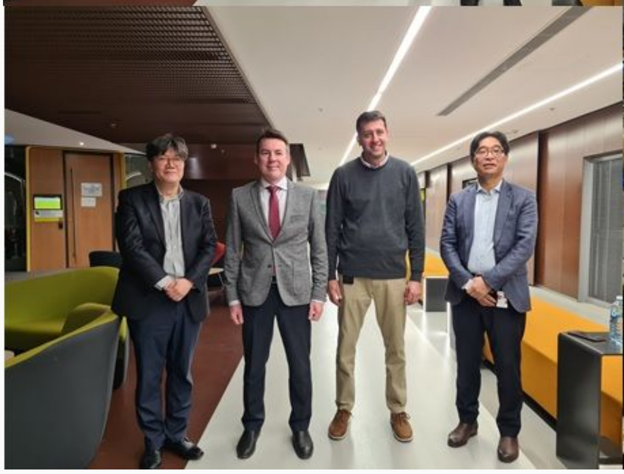
6. UTS/FEIT research facilities and laboratories visiting for David Bergmann and Li Gao from South East Water. It was a great opportunity to show our facilities and discuss our project within the Australian Research Council NiCE hub. We are so excited about the prospect of future collaborations with South East Water and look forward to working together!



7. ARC NiCE hub Director HK Shon and Business manager Ibrahim El Saliby attended the National Biosolids Conference organised by Australian Water Association and Australian & New Zealand Biosolids Partnership on the 8th and 9th of February 2023. It was a great opportunity to witness the advanced technologies and research innovations in this field as well as to meet and chat with many of our hub industry partners i.e. Urban Utilities, Logan City Council, Melbourne Water, Water Research Australia , Icon Water, and South East Water.

8. A special visit from Neil Ruwan Palagedara and Mufid Noufal of the City of Sydney to discuss our future collaboration and projects as well as to kick off our project within the NiCE hub. This was an exciting opportunity to show our partners the UTS/FEIT research facilities and laboratories where our researchers carry our their work.

9. It was our great honour to have the acting Chief Executive Officer of the Australian Research Council (ARC), Dr Richard Johnson, to introduce the ARC Research Hub for Nutrients in a Circular Economy (ARC NiCE Hub) at the University of Technology Sydney (UTS). His visit was a great opportunity to explore innovative ideas, research translation and commercialisation, and seek supports and solutions from his wisdom and experiences. We would like to thank the ARC for its support of the ARC NiCE Hub.



Outreach and Education Progress at Melbourne Node

The University of Melbourne

1. Postdoctoral Research Fellow Dr. Veera Koskue and PhD Candidate Chee Xiang Chen submitted abstracts to the Circular Economy for Climate and Environment (CECE) Conference, to be held in Sydney September 26–27, 2023. Both abstracts were accepted for oral presentations.

2. NiCE Hub project partners involved in the activities taking place in Brisbane met at Roma Street Parklands on August 24, 2023. Participants shared their progress to date and discussed future plans. *Photo credit: Veera Koskue*

3. On August 20, 2023, Dr. Veera Koskue participated in the University of Melbourne Open Day, where she showcased her work on nutrient recovery from human urine as part of the research demonstrations. In total, Open Day 2023 attracted more than 45,000 visitors to the University of Melbourne.

4. We were honoured to host a special visit from Jacqueline Frizenschaf, the General Manager of Water Research Australia, at our research lab on May 2, 2023. Jacqueline met with A/Prof Stefano Freguia and toured the laboratories, where she was introduced to the Ugold and reverse osmosis nutrient recovery systems. Her presence was a significant milestone as we showcased our various research involving urine nutrient recovery, demonstrating our commitment to advancing innovative solutions in nutrient recovery and promoting a circular economy. Jacqueline's support underscores the importance of collaboration in promoting sustainable research and technology.

Outreach and Education Progress at Brisbane Node

The University of Queensland

1. A/Prof. Dr. Jia Meng a visiting academic at the University of Queensland, submitted an abstract to the Circular Economy For Climate and Environment (CECE) Conference, to be held in Sydney in September 2023. This abstract has been accepted for oral presentation.

2. A new PhD student, Ms Xueying Zhang, will be starting her PhD study in October 2023 at UQ. Ms. Zhang finished her undergraduate study at UQ and in her PhD she will be working with the industry Partner Icon Water.

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2022/2023 Publications

1. Jiang, J., Dorji, P., Badeti, U., Sohn, W., Freguia, S., Phuntsho, S., ... & Shon, H. K. (2023). Potential nutrient recovery from source-separated urine through hybrid membrane bioreactor and membrane capacitive deionisation. *Desalination*, 116924.
doi:https://doi.org/10.1016/j.desal.2023.116924

2. Sohn, W., Jiang, J., Phuntsho, S., Choden, Y., Tran, V. H., & Shon, H. K. (2023). Nutrients in a circular economy: Role of urine separation and treatment. Desalination, 116663. doi:https://doi.org/10.1016/j.desal.2023.116663

3. Liu, H., Wang, C., Sohn, W., Wang, Q., Shon, H. K., & Sun, P. (2023). Source-separated urine treatment based on forward osmosis technology: Performance, applications and future prospects. *Desalination*, 116872.
doi:https://doi.org/10.1016/j.desal.2023.116872

4. Afsari, M., Jiang, J., Phuntsho, S., Shon, H. K., & Tijing, L. D. (2023). Ammonia recovery from source-separated hydrolyzed urine via a dual-membrane distillation in-series process. *Chemical Engineering Journal*, 144215.
doi: https://doi.org/10.1016/j.cej.2023.144215

5. Soo, A., Wang, L., Wang, C., & Shon, H. K. (2023). Machine Learning for Nutrient Recovery in the Smart City Circular Economy–A Review. *Process Safety and Environmental Protection*.
doi: https://doi.org/10.1016/j.psep.2023.02.065

6. Badeti, U., Jiang, J., Almuntashiri, A., Pathak, N., Dorji, U., Volpin, F., ... & Phuntsho, S. (2022). Impact of source-separation of urine on treatment capacity, process design, and capital expenditure of a decentralised wastewater treatment plant. *Chemosphere*, *300*, 134489.
doi:https://doi.org/10.1016/j.chemosphere.2022.134489

Contact Us

Level 11, Building11, 81-113,
Broadway, Ultimo NSW 2007
Australia

Email: info@nicehub.org
Website: www.nicehub.org

Australian Government
Australian Research Council