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Upscaling urine-to-fertiliser treatment systems

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ABSTRACT

Nitrogen, phosphorus and potassium fertilisers are essential for agriculture but produced from finite resources or with enormous carbon footprint. To mitigate environmental harm and improve circularity in fertiliser and agricultural industries, nutrients already processed into fertiliser should be reused more efficiently. Up to 25% of fertiliser nutrients used in agriculture end up in human excreta, particularly urine, creating an interesting opportunity for nutrient recycling.

While existing centralised sewage collection and management systems do not facilitate separate urine collection, portable toilets are ubiquitously used across Australia at public events and construction sites, providing easy access to vast volumes of urine if fitted with urine-diverting chutes. Diverting and separately treating urine would subsequently decrease nutrient loads to centralised wastewater treatment plants, resulting in cost savings and reduced greenhouse gas emissions [1,2].

Unprocessed urine is still largely water and contains harmful pharmaceutical residues. An emerging option for processing urine into a safe, concentrated liquid fertiliser is microbially catalysed electrochemical concentration, or bioelectroconcentration (BEC). BEC utilises electricity, partly generated in situ by electroactive bacteria, to drive the migration of ionic target nutrients, such as ammonium nitrogen, through ion-exchange membranes into a liquid fertiliser, while micropollutants are retained in the reject stream. BEC has been demonstrated to be highly suitable for nutrient recovery from human urine in laboratory scale, capturing up to 70% of nitrogen into liquid fertiliser [3,4].

In this study, we scaled up our BEC nutrient recovery system from laboratory-scale – treating 2 L of urine per day – to pilot-scale, treating up to 100 L of urine per day. Partnered with Composting Toilet Systems (Victoria, Australia), we processed thousands of litres of urine collected from music festivals into liquid fertiliser. Chemical analysis showed that removal of pharmaceuticals varies depending on the chemical structure of compounds. In preliminary glasshouse cultivation tests with ryegrass, the urine-derived fertiliser achieved 53% and 46% higher dry matter yield compared to commercial urea in two different soils. Further research should focus on exploring the long-term effects of urine-derived fertiliser application on soil physico-chemical properties and nutrient cycling, as well as optimising

application rates, timing and placement for different crops and soils.

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KEY WORDS

Circularity; fertiliser; nitrogen; nutrients; resource recovery; wastewater

BIOGRAPHY

Dr Veera Koskue is an expert in reclaiming urine and other wastewaters as liquid fertilisers using bioelectrochemical and electrochemical methods. She obtained her PhD in Environmental Engineering from Tampere University, Finland in 2022 and currently works as a Postdoctoral Research Fellow at the Department of Chemical Engineering, University of Melbourne, Australia. Dr Koskue has several years of research experience in nutrient recovery from wastewaters in close collaboration with the water industry. She is currently working towards scaling up and commercialising urine-to-fertiliser treatment systems.

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