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Trailblazing study investigates human urine treatment to make liquid fertiliser

Dr Caitlin Courtney Photo: Lerato Maduna

Getting across the line in only four years – and during a pandemic – takes a form of tenacity that's been well worked in PhD graduate Caitlin Courtney. In the acknowledgements that preface her highly praised thesis on a novel human urine treatment to make liquid fertiliser, Caitlin names many whose support lit her way. And among them is a dog called Ralph.

Her dissertation describes a novel urine treatment and concentration process for liquid fertiliser production. It brings together the results of five published, peer-reviewed journal papers, each describing the efficacy, energy requirements and economics of different treatment processes.

Caitlin trailblazing study also makes a valuable contribution to the growing field of urine treatment and resource recovery in the world's burgeoning circular economy, where waste is recycled and completely reintegrated back into the economy.

Human urine has long been treated as a waste product, but it's rich in nitrogen in the form of urea, which is an ideal fertiliser. But millions of litres are flushed away using drinking water.

Over the past 20 years, much work has been done to integrate and normalise urine as a resource. But urine treatment processes have proved tricky, and success lies in finding treatment methods that facilitate efficient resource (nutrient) recovery from urine.

"This is because urine is 97% water, making the logistics of using urine as a fertiliser challenging. In addition, without treatment, the major nitrogen source in urine (urea) breaks down to ammonia and is lost to the atmosphere," Caitlin explained.

Her thesis investigated the technical feasibility of using different membrane and freezing techniques to concentrate the urine and recover these nutrients. Her work assessed different stabilisation methods to prevent urea breakdown, urine pre-treatment techniques, and process configurations to produce fertiliser products with different compositions.

First, Caitlin investigated reverse osmosis (RO) to concentrate the pre-treated urine. This is the same technology used to desalinate sea water. This technique achieved 60% water removal while retaining 85.5% of the urea in the product stream. The water removal using RO has since increased to 70%.

Second, she tested a hybrid nanofiltration and RO process to remove pharmaceuticals *from the urine* and produce a purer urea stream. With this method, up to 99% of the pharmaceuticals tested can be removed. She showed that the urea purity can be increased to 89%, but that only 32% of the urea is recovered.

Her third investigation was a first when she investigated and confirmed experimentals that eutectic freeze crystallisation (EFC) could be used to further concentrate human urine while simultaneously precipitating undesirable salts. These could then be filtered and removed.

Results showed that 95% of the water can be removed. This is also the same technology (EFC) that her supervisor, associate professor in water quality engineering in the Department of Civil Engineering and the Future Water Institute, Dr Dyllon Randall, investigated in his PhD, but to treat mining wastewater.

Finally, Caitlin looked at the energy and economics of this process and showed that RO and a hybrid RO–EFC process could use substantially less energy than the other urine treatment methods.

Caitlin's research contributed to five peer-reviewed articles published in high-impact journals. Her work is also core to UCT's Future Water Institute's (Randall and Caitlin are both members) commercialisation activities with regards to the urine treatment processes in development.

"A real surprise from Caitlin's research was finding commercial liquid fertilisers in a nearby plant nursery that matched the composition of all the fertilisers they make from urine," said Randall.

"The sale price varies from approximately R100/L to R480/L, with a strong linear dependence on nitrogen content," he said. "That's a lot of potential profit from urine, something we flush away every day, and with drinking water."

Story by Helen Swingler, UCT News.

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