European Commission

Science for Environment Policy

Separate waste-water treatment of urine could have lower environmental impact than centralised, combined waste-water treatment

Municipal wastewater is a major source of pharmaceuticals in the aquatic environment. Results from a recent study suggest that collecting and treating urine separately from other forms of sewage could be a cost-effective way to reduce the harmful effects of pharmaceuticals on the environment, while also providing a source of nutrients for fertilising agricultural crops.

Although urine only makes up about 1% of wastewater entering treatment plants, it is the main source of pharmaceuticals in municipal wastewater, and contributes 80% of the nitrogen and 50% of the phosphorus load. If urine were collected separately from other domestic wastewater streams, it could be treated to remove or destroy pharmaceutical products and recover nitrogen and phosphorus for reuse as fertilisers. However, little research has been done on the environmental impacts of treating urine separately to remove pharmaceuticals.

Using computer modelling, this study compared the life-cycle environmental and economic impacts of removing four non-steroidal anti-inflammatory drugs (NSAIDs) from human urine: diclofenac, ibuprofen, ketoprofen and naproxen. It considered eight possible scenarios of treatment: the current treatment method, whereby combined urine, faeces and greywater are centrally treated using biological methods, an 'advanced' scenario, in which an additional ozonation step[1] is added to the current method, and six centralised and decentralised treatments of urine which has been separated from other types of sewage at source.

The modelling was based on publicly available data on the collection and processing of 11 184 cubic meters (m^3) of urine generated by a university community in North America.

The life-cycle analysis covered impacts associated with a number of processes and steps, including: use of water to flush the toilets, biological treatment and ozonisation of wastewater in centralised wastewater treatment, construction of the new infrastructure needed to separate urine at source (urine diverting toilets and waterless urinals), and storage and collection of urine.

Ten types of environmental impact were considered: ozone depletion, global warming, smog, acidification, eutrophication, carcinogenic human toxicity, non-carcinogenic human toxicity, respiratory effects, ecotoxicity and fossil fuel depletion.

The results suggest that the different treatment scenarios have different trade-offs with regard to environmental impact, effectiveness of removing pharmaceuticals and cost.

Overall, the urine source separation scenarios had the lowest environmental impact — 90% lower than both centralised biological wastewater treatment scenarios. The researchers say this is because they save potable water for flushing toilets and electricity for wastewater treatment, have fewer nutrient discharges and reduce commercial fertiliser production and cadmium pollution associated with phosphorus fertilisers.

For example, based on the treatment of 11 184 m^3 of urine, replacing conventional toilets and urinals with urine diverting toilets and waterless urinals would save 2.6 x 10^5 m^3 of potable water for flushing, cutting annual water costs by US$ 231 000 (€ 217 744). Furthermore, the inflow of sewage to central wastewater treatment plants would be reduced by 17%, reducing the amount of electricity needed to operate the plants.

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Source: Landry, K.A. & Boyer, T.H. (2016). Life cycle assessment and costing of urine source separation: Focus on nonsteroidal anti-inflammatory drug removal. *Water Research*, 105: 487-495. DOI:10.1016/j.watres.2016.09.024

Contact: klandry@ufl.edu

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1. Due to its excellent disinfection and oxidation qualities, ozone is often added during waste-water treatment.

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However, centralised biological treatment with ozonation was the most effective option to remove the pharmaceuticals. This scenario destroyed 53–98% of the pharmaceuticals, but was the most harmful overall to the environment due to the impacts of the ozonation infrastructure and processes. This scenario also had the greatest economic cost of all eight scenarios.

Of the six urine source separation scenarios, collecting and sending the urine by vacuum sewer to a central plant for treatment had the greatest environmental impact and was the most expensive separation option. In general, collecting urine at building level for decentralised treatment and collecting urine by vacuum truck and taking it to be treated at a central plant had the lowest environmental impact and both options had comparable costs.

The removal efficiency differed for the four pharmaceuticals. A higher proportion (98%) of diclofenac was removed than of the other pharmaceuticals, but because of its inherent toxicity (ranked second in this study) it remained the second most important contributor to the overall toxicity (ibuprofen ranked first).

Despite this study focusing on NSAIDs, the researchers suggest that treatment of separately sourced urine may be effective at removing pharmaceuticals in general, given that drugs are typically concentrated in urine. It may be particularly beneficial in areas where water is scarce and water quality is a problem.