Nutrient-rich human waste poised to sustain agriculture, improve economies

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A new study from the University of Illinois Urbana-Champaign helps define the global relationship between sustainable agriculture and sanitation technology. Credit: L. Brian Stauffer

The future connection between human waste, sanitation technology and

sustainable agriculture is becoming more evident. According to research directed by University of Illinois Urbana-Champaign civil and environmental engineering professor Jeremy Guest, countries could be moving closer to using human waste as fertilizer, closing the loop to more circular, sustainable economies.

A new study characterizes the spatial distribution of human urine-derived nutrients—nitrogen, phosphorus and potassium—and agricultural fertilizer demand to define supply-demand location typologies, their prevalence across the globe and the implications for resource recovery. The findings are published in the journal *Environmental Science and Technology*.

"The total amount of nitrogen, phosphorus and potassium largely remains constant in our bodies, once we stop growing," said Guest, who also serves as the acting associate director for research at the Institute for Sustainability, Energy, and Environment at the U. of I. "Whatever comes in through food and drink must come out in our urine, feces and sweat. Knowing that, we can estimate how much of each of these nutrients is in a population's bodily waste if we know their diet."

Previous studies by Guest and others have assessed the potential for recovering the nutrients from human waste across the globe and identified locations with a surplus of human waste-derived nutrients relative to the local demand for agricultural fertilizers.

"The new study is the first to describe human waste-derived nutrient supply-demand location relationships using a single mathematical equation," Guest said. "The quality of sanitation infrastructure varies greatly across the globe, as do people's diets and the availability of land suitable for agriculture. Having the means to characterize and quantitatively compare a location's nutrient-recovery potential can go a long way to better inform decision-makers when it comes to future

sanitation and agriculture policy."

The team performed extensive numerical and geographic analyses of dietary, population, sanitation and agricultural data from 107 countries to accomplish this quantitative characterization at the global scale. The investigation revealed three distinct supply-demand typologies: countries with a co-located supply-demand; countries with a dislocated supply-demand; and countries with diverse supply-demand proximities.

The United States and Australia, for example, fall under the dislocated supply-demand typology. They have intensive agriculture in areas far from large cities, thus the human waste-derived nutrient supply is far away from where it is needed, Guest said. Even with advanced sanitation infrastructure in place, this means that nutrients would need to be transported over large distances, either as heavy fluids or converted into concentrated crystalline products. Economically speaking, Guest said, it would make sense to work with a concentrated product to implement a human waste-derived fertilizer in these countries.

The study reports that in countries with co-located supply-demand typologies like India, Nigeria and Uganda, human populations are more substantively in the proximity of agricultural areas, making local reuse possible. In many communities with co-located supply-demand, however, there is a need for improved sanitation infrastructure. Guest said implementing a human waste-derived fertilizer program could be highly beneficial to sanitation and agriculture in these places.

Countries like Brazil, Mexico, China and Russia exhibit a continuum of co-location to dislocation of nutrient supply and demand. The study reports that policymakers would need to approach human waste-derived nutrient use with more regionalized strategies and a range of local reuse and transport approaches. "Higher income countries in this group may have the infrastructure and economic support for various technologies,

but those with limited financial resources would require prioritization of resource-recovery technology in some areas," Guest said.

The team was surprised to find the typologies corresponded closely to the United Nations Human Development Index.

"Higher HDI-scoring countries like the U.S., Western Europe and Australia tend to fall in the dislocated supply-demand typology and lower HDI-scoring countries tend to fit the co-located supply-demand typology. Of course, there are exceptions, but we did not expect to find such a strong correlation," Guest said.

The team hopes this research will help clarify the salient economic, sanitation and agricultural characteristics of countries across the globe so that decision-makers can prioritize investment, policies and technologies that will advance goals for a circular economy and the provision of sanitation to all, Guest said.

More information: Desarae Echevarria et al, Defining Nutrient Colocation Typologies for Human-Derived Supply and Crop Demand To Advance Resource Recovery, *Environmental Science & Technology* (2021). DOI: 10.1021/acs.est.1c01389

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