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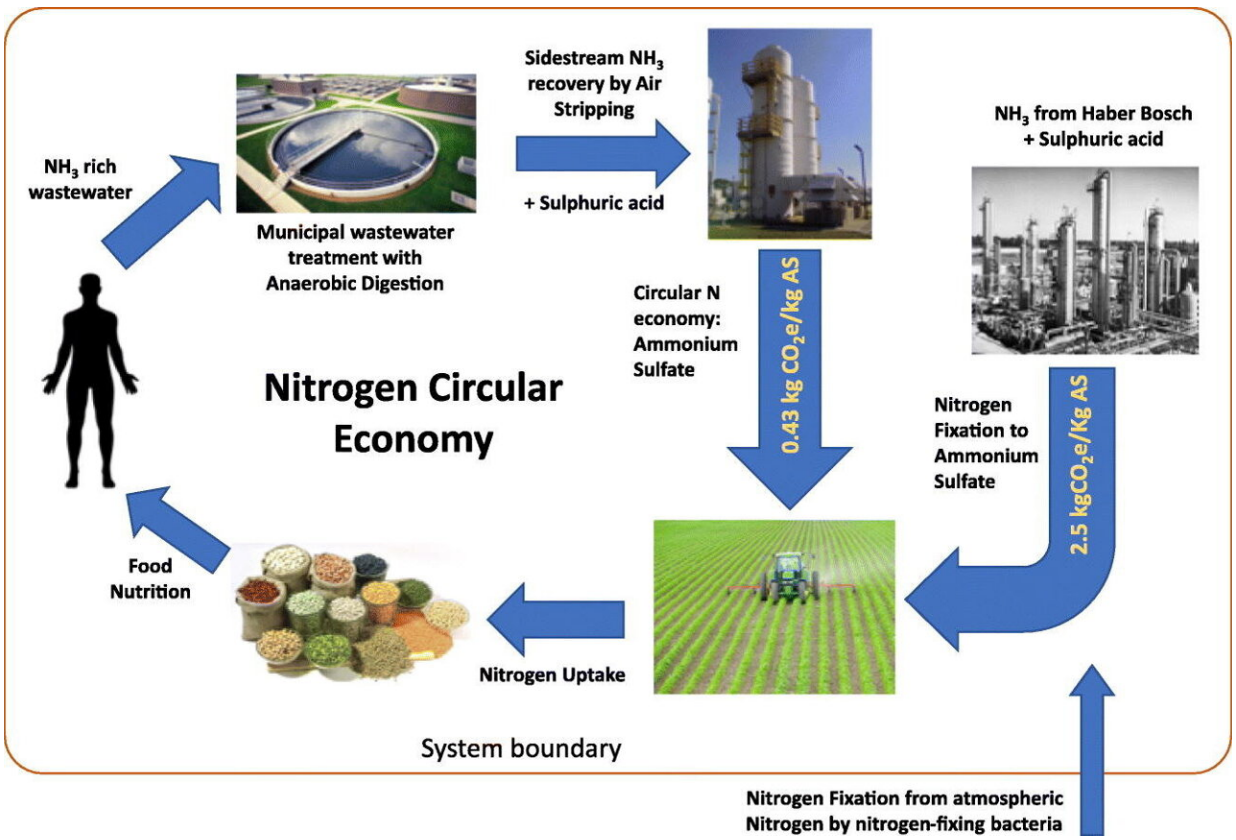
Turning wastewater into fertilizer is feasible and could make agriculture more sustainable

November 18 2022



Graphical abstract. Credit: *Science of The Total Environment* (2022). DOI: 10.1016/j.scitotenv.2022.159499

The wastewater draining from massive pools of sewage sludge has the potential to play a role in more sustainable agriculture, according to environmental engineering researchers at Drexel University.

A new study, looking at a process of removing ammonia from wastewater and converting it into fertilizer, suggests that it's not only technically viable, but also could help to reduce the environmental and energy footprint of fertilizer production—and might even provide a revenue stream for utilities and water treatment facilities.

A sustainable nitrogen source

The production of nitrogen for fertilizer is an energy-intensive process and accounts for nearly 2% of global carbon dioxide emissions. In the last several years researchers have explored alternatives to the Haber-Bosch nitrogen production process, which has been the standard for more than a century. One promising possibility, recently raised by some water utility providers, is gleaning nitrogen from the waste ammonia pulled from water during treatment.

"Recovering nitrogen from wastewater would be a desirable alternative to the Haber-Bosch process because it creates a 'circular nitrogen economy,'" said Patrick Gurian, Ph.D., a professor in the College of Engineering who helped lead the research, which was recently published in the journal *Science of the Total Environment*.

"This means we are reusing existing nitrogen rather than expending energy and generating greenhouse gas to harvest nitrogen from the atmosphere, which is a more sustainable practice for agriculture and could become a source of revenue for utilities."

A cleaner way to clean

Under the Clean Water Act of 1972 municipal water treatment facilities have been challenged to meet water quality standards for water that they discharge into waterways. Increasingly ammonia is seen as both a concern for aquatic environments as elevated levels of ammonia can result in overgrowth of vegetation in streams and rivers which can endanger fish species. The options for removing ammonia are generally time and space consuming and can be energy-intensive undertakings.

One option being explored by several facilities in North America and Europe is a process called air-stripping. It removes ammonia by raising the temperature and pH of the water enough to convert the chemical into a gas, which can then be collected in concentrated form as ammonium sulfate.

But deciding on making the investment to convert to air-stripping requires a complex study—called a lifecycle analysis—of its technological and financial viability.

Exploring the option

The team, led by Gurian and Sabrina Spatari, Ph.D., from Technion Israel Institute of Technology, regularly perform these analyses to take stock of the full environmental and economic impact of various options for recycling and reuse of waste or side-stream products as sustainable solutions. Their analysis of this wastewater scenario suggests there is a complementary relationship that could result in a more sustainable path for both farmers and water management authorities.

"Our analysis identifies a significant potential for environmental mitigation and economic benefit from implementing air-stripping technology at wastewater treatment plants for producing ammonia sulfate fertilizer," they wrote.

"In addition to ammonia sulfate production as a marketable product, the benefit of reducing the ammonia load in the side-stream before it is recycled into the wastewater stream at the wastewater treatment plant provides an additional justification for adopting air stripping."

Using data from Philadelphia's water treatment facility and several others across North America and Europe, the team conducted its lifecycle assessment and economic feasibility studies. They looked at factors ranging from the cost of installing and maintaining an air-stripping system, to the concentration of ammonia and flow rate of the wastewater; to the sources of energy used to drive the collection and conversion process; to the production and transportation cost and market price of the fertilizer chemicals.

Promising results

Findings of the life-cycle analysis show that air-stripping emits about five to 10 times less greenhouse gas than the Haber-Bosch nitrogen-producing process and uses about five to 15 times less energy.

From an economic perspective, the overall cost of producing fertilizer chemicals from wastewater is low enough that the producer could sell them at a price more than 12 times lower than Haber-Bosch-produced chemicals and still break even.

"Our study suggests that recovering ammonia can be cost-effective even at low concentration," they write. "Although high ammonia concentration is environmentally favorable, and can simultaneously support marginal production of ammonium sulfate with lower environmental impact, particularly for life cycle energy, greenhouse gas emissions, and several human and ecosystem health indicators, compared to the Haber-Bosch production."

In addition, the study suggests that water treatment facilities may enjoy energy savings by air-stripping the ammonia to reduce levels before the water it reenters the waste treatment process. This is because it would cut the time and processing needed to treat the water and fits in well with softening processes that help to slow chemical deposition on the treatment plant infrastructure.

While the team acknowledges that air-stripping would churn out fertilizer in smaller amounts than the industrial Haber-Bosch process, being able to collect and reuse any quantity of resources helps to improve the sustainability of commercial agriculture and prevents them from becoming water pollutants.

"This indicates that air-stripping for recovery of ammonium sulfate could be a small part—but an important step—toward recovering and reusing the massive amount of nitrogen we use to sustain global agriculture," Spatari said.

"And, significantly it presents an alternative for chemical production that does not have the same level of deleterious environmental and human health effects as the current process. This research suggests that water utility providers could also consider investing in technologies that would capture phosphorous and recycle it for agricultural use."

More information: Saurajyoti Kar et al, Life cycle assessment and techno-economic analysis of nitrogen recovery by ammonia air-stripping from wastewater treatment, *Science of The Total Environment* (2022). DOI: 10.1016/j.scitotenv.2022.159499

Provided by Drexel University

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