European Commission

Science for Environment Policy

Phosphorus recycling technologies: study explores economic viability and environmental benefits

27 March 2019
Issue 523
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Source: Sampat, A.M., Martín-Hernández, E., Martín, M. and Zavala, V.M. (2018) Technologies and logistics for phosphorus recovery from livestock waste. *Clean Technologies and Environmental Policy*. 20(7): 1563–1579. DOI: 10.1007/s10098-018-1546-y.

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To cite this article/service: "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

A new study explores how to weigh up the costs and benefits of technologies that extract phosphorus from livestock waste for re-use as fertiliser. Findings from a US case study suggest that recycling phosphorus in this way can cut both water pollution levels and the costs of cleaning up the mineral. However, the technologies' long-term economic feasibility depends on the yield, quality, and market value of the recovered phosphorus.

Phosphorus is widely used in agriculture and is an essential component in fertiliser and feed, but it is a non-renewable resource. Supplies are limited and much phosphorus is currently wasted, creating concerns about future supplies in the EU and worldwide.

The current use of phosphorus is inefficient at many stages of its life cycle, and can cause problematic water pollution when it is present in excess. In industrial farming, phosphorus from manure runs off the land and enters ground and surface water, where it can lead to eutrophication: an excess of nutrients that can trigger toxic blooms of algae that are harmful to both aquatic life and human health. It is a basic legal principle of the EU that it is best to tackle environmental problems at source and on many small, more sustainable farms manure naturally fertilises soils.

Technologies for phosphorus recovery are being developed and will become more economically interesting as phosphorus costs will increase. In this context, research on the economics of phosphorus recovery are needed to prepare for the necessary move toward a more sustainable use of this limited resource.

These technologies can mitigate eutrophication caused by industrial farming by extracting phosphorus from livestock waste to be used as fertiliser elsewhere. They may, therefore, also help create a closed cycle for phosphorus, and contribute to more sustainable food production. However, even where the technologies are cheap and environmentally beneficial, they may not be economically sustainable because they generate little or no revenue.

This new study presents a framework to help policymakers assess the costs and benefits of nutrient recovery technologies. The framework assesses different stages of the supply chain for recovered phosphorus from livestock waste, including its transport, extraction technique, and re-sale. The researchers applied it to the case of recovered phosphorus from the 100 largest intensive dairy farms in the US state of Wisconsin, which produce between 18 and 100 tons of livestock waste per day, per farm.

The study does not intend to provide definitive answers on the technologies' sustainability and cost; the researchers caution that data are scarce on both the performance of the technologies considered, and the market price for recovered phosphorus. Instead, it aims to help policymakers analyse the complex trade-offs that arise in nutrient recovery.

The results of the Wisconsin analysis suggest that transporting manure away from the farms in itself (without re-using or treating it) could significantly cut the costs of remediating waterways. For instance, an annual transport budget of US$13.8 million (€12.08 million) could cut the cost of remediation by US$77.7 (€68.02) million per year. Spending more than this would not bring any additional benefits for water quality.

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This transport-alone option does not provide revenue and would need to be funded by government subsidies, most likely generated from taxes on farms or local residents. Furthermore, the improved water quality would come at the expense of greater CO_2 emissions from the intense truck hauling.

For instance, 74% of the manure may need to be transported to achieve maximum reductions; transporting this amount is estimated to produce 11,406 tons of CO_2 per year, compared with just one ton if 2% were transported.

There is potential to generate income from recovered phosphorus which is in the form of 'cake' (a mixture of phosphorus, nitrogen, and other solid compounds) using low-cost filtering technologies, the study further suggests. Processing waste in such a way before hauling it would also reduce transportation costs. However, the market value, and thus income, from cake strongly depends on its phosphorus content, which varies according to how the cake was produced. Cake produced using filtration methods has a higher phosphorus content and value than cake made using a chemical treatment method (coagulation-flocculation) or mixing process (centrifugation).

The analysis also reveals further complex trade-offs between transport, investment, and the technology's performance. For instance, a small investment budget leads to fewer technologies being installed, which means that more waste must be transported offsite for processing in order to make a profit. A larger budget allows for more onsite processing and less trucking.

Despite its high investment and operational costs, the most economically attractive technology assessed appears to be fluidised bed reactors that produce struvite, a phosphate mineral used as fertiliser. However, these are a new technology, and the researchers caution that it is still unclear how much struvite can be produced.

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