

Fish farming gobbles up phosphorus

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Fish farming relies heavily on phosphorus that is incorporated into fish feed.
Credit: Thinkstock

Fish farming is the largest source of phosphorus emissions in Norway, generating about 9,000 tonnes a year. Finding ways to reuse the waste from the fish farming industry could cut consumption of this important and increasingly scarce resource.

The projected growth in aquaculture production in Norway could

drastically increase [phosphorus losses](#) and emissions to water bodies and also make the country more dependent on imported raw materials.

But what if that phosphorus could be reused? Researchers at the Norwegian University of Science and Technology and Nibio, the Norwegian Institute of Bioeconomy Research say that finding a way to reuse this "waste" phosphorus could allow for new business opportunities as well as cut pollution from aquaculture.

One-third of imports of phosphorus go to fish feed

The phosphorus contained in imported raw plant materials destined for fish feed production currently accounts for almost one-third of the phosphorus imported to Norway, and is larger than domestic fertilizer consumption.

In addition, fish farming is the largest source of phosphorus emissions, generating about 9,000 tonnes a year.

Whereas animal manure that is spread on fields partially reuses the phosphorus, virtually all of the fish waste and feed scraps end up in the ocean.

"With current technology, the projected five-fold increase in the aquaculture industry by 2050 will result in a dramatic increase in phosphorus losses to the sea. Norway will also become far more dependent on imported phosphorus," says Helen Ann Hamilton, who is doing her doctorate at NTNU's Industrial Ecology Programme.

The Norwegian Environment Agency has proposed that Norway, in line with several EU countries, establish overarching national resource measures, including a target for phosphorus use in Norway. The Ministry of Climate and Environment has not yet taken a position on the

Environment Agency's recommendation. Requiring phosphorus recycling will, in particular, pose major challenges for the aquaculture industry.

Phosphorus Flow Analysis

Hamilton has conducted an integrated analysis of phosphorus flows in Norwegian aquaculture, agriculture and fisheries industries and also looked at the potential synergies between these sectors. Her study has been published in the *Journal of Industrial Ecology*.

"To my knowledge, this is the first phosphorus flow analysis study to include aquaculture. Although we knew that fish farming was a major consumer of phosphorus, we were surprised that this industry consumes such large quantities," says Hamilton.

The total amount of phosphorus that goes into producing soy and other plant foods for fish feed was outside of the study's scope but it is considerably greater than the phosphorus contained within the imported feed products.. A lot of phosphorus is wasted along the way, says Hamilton, who now wants to investigate phosphorus consumption along the supply chain.

Limited resource

The element phosphorus is essential for all life. Without phosphorus, cell growth cannot occur. Mineral phosphorus, used for chemical fertilizers, comes from phosphate rock. One way that it can be recycled is by spreading livestock manure onto crop fields.

Phosphorus has historically been recognized as a pollutant. Eutrophication, caused by excess phosphorus and nitrogen in water

bodies, leads to algae growth and oxygen depletion in many lakes and rivers. But in recent years, phosphorus has also been discussed as a resource problem. Warnings against a future global shortage of phosphorus has given rise to the concept of "peak phosphorus."

This describes a situation where the known phosphorus resources become exhausted and prices increase drastically, at the same time as the need increases to produce food for a growing world population. Estimates for when we will reach "peak phosphorus" have varied from a few decades to about 100 years. The discussion also has a geopolitical element, owing to the fact that only a few countries have known, commercially viable phosphate deposits, with the largest in Morocco and occupied Western Sahara.

Improve management

Hamilton is less concerned about whether "peak phosphorus" will occur in 30 years or 100 years.

"That can easily become a distraction. The facts are that phosphorus is a finite resource that we are 100% dependent on and we are currently wasting it in a way that creates pollution. The main discussion needs to be around how we can manage this resource in the best possible way through reducing consumption, preventing pollution and building systems for phosphorus recycling," she says.

Possible synergies

The aim of the study has primarily been to obtain the best possible overview of the current and expected future consumption of phosphorus and to see the [fish farming](#), agriculture and fisheries sectors in an integrated way.

"This kind of overview is necessary to see both the challenges and opportunities for synergies across the sectors," says Hamilton.

Assuming that a collection system can be established, aquaculture may produce several times more secondary phosphorus than the fertilizer consumption of the entire agricultural sector.

Hamilton says that the technological and logistical challenges are huge and a lot of thorough research remains to be done to find good solutions.

"But if we succeed, we will reduce both a pollution problem and Norway's dependence on imported mineral phosphorus. Maybe Norway can even develop export products based on secondary phosphorus, given its extensive experience with fertilizer production," she says.

National measures proposed

The EU has added phosphorus to its list of critical raw materials. The European Commission is expected to sharpen demands for recycling in general, which will also apply to phosphorus. Several EU countries have already adopted national goals and strategies for phosphorus.

In a report submitted to the Ministry of Climate and Environment this summer, the Norwegian Environment Agency stated that Norway lacks such a strategy for the use of phosphorus as a resource.

"We've regulated phosphorus as a source of pollution and have spent a lot of money to prevent phosphorus runoff into waterways. This is the first official report that looks at phosphorus as a valuable asset," said Terje Farestveit, Chief Engineer for the Environment Agency's Inspection and Environmental Data Division.

The Agency recommends that the Norwegian Ministry of Climate and

Environment work towards determining a national target for the use of phosphorus as a resource in Norway. A committee of experts should be assigned to study how phosphorus can be better used.

"Without overarching national objectives as a basis, we believe it will be difficult to implement the necessary measures and changes," says Farestveit. A national measure requiring the recycling of [phosphorus](#) will be a challenge, especially for the aquaculture industry, he says.

More information: Helen A. Hamilton et al. Investigating Cross-Sectoral Synergies through Integrated Aquaculture, Fisheries, and Agriculture Phosphorus Assessments: A Case Study of Norway, *Journal of Industrial Ecology* (2015). [DOI: 10.1111/jiec.12324](https://doi.org/10.1111/jiec.12324)

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