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Policy Brief

Baltic Sea Centre
Stockholm University

Phosphorus in the catchment

– actions taken today create tomorrow's legacy

A new study shows that almost half of the phosphorus currently entering the Baltic Sea could derive from accumulated phosphorus on land, so called legacy phosphorus. This legacy originated from sewage and agriculture sectors, mainly during the 1960s to 1990s. The amount of legacy phosphorus that leaks to the Baltic Sea has decreased over the last 20 years, and will decrease further over time. But the size of this reduction will depend on continued actions to reduce the accumulation of phosphorus on land.

The accumulated pool of phosphorus on land – called legacy phosphorus - receives less attention than the pool of phosphorus in the Baltic Sea, despite being much larger and the ultimate source to the sea. The "legacy" results from how phosphorus was handled in the sewage and agriculture sectors in the past. The sources of legacy phosphorus include fertiliser, manure, and human sewage.


Photo: Bengt Ekberg/Azote

A legacy from the past

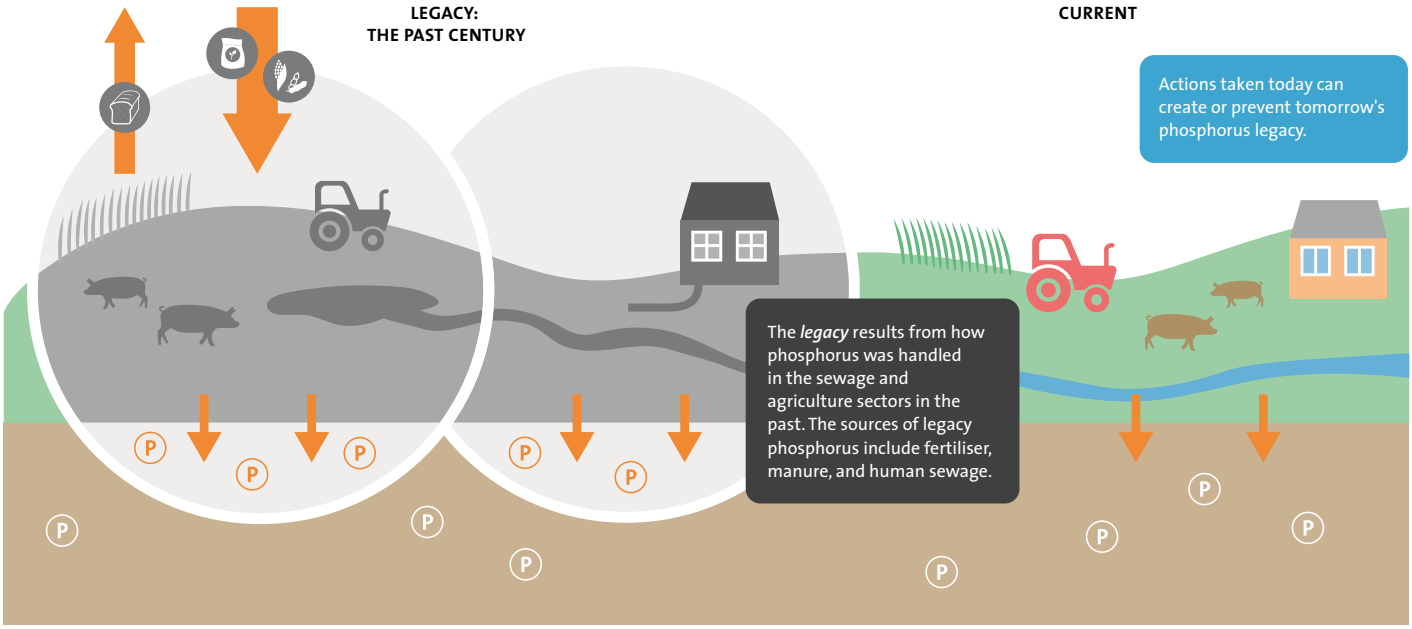
Over the past century, countries around the Baltic Sea have applied more than 44 million tons of mineral phosphorus fertilisers to agricultural soils. Throughout the years, farmers been advised to apply large amounts of mineral fertiliser and manure to increase crop yields. As a result, more fertiliser has been applied than has been removed with harvested crops, and this has led to the accumulation of phosphorus in soils. A more balanced fertilisation is recommended nowadays, but there are still areas with large

RECOMMENDATIONS FOR CONCRETE ACTIONS

- Limit phosphorus fertilisation by setting maximum application rates or maximum surpluses. Account for current phosphorus status in crop soils.
- Increase the proportion of locally produced feed in animal husbandry, as stated in the EU strategy for the promotion of protein crops, in order to reduce phosphorus imports.
- Improve the use efficiency of manure in agriculture by, for example, supporting farm extension on nutrient management, including soil-nutrient mapping.
- Allocate funding to implement measures that reduce the transport phosphorus that escapes from crop land, such as buffer strips and sedimentation ponds. But to be effective, these measures must be adapted to local conditions. Within the Common Agricultural Policy, this could be achieved by reducing income support (Pillar I) and increase payments for public goods, for instance via the Rural Development Programme (Pillar II).
- Facilitate the development and trade of recycled fertilisers.
- Expand current zones that are deemed as environmentally sensitive or vulnerable to nutrient losses to include livestock density limits.
- All countries around the Baltic Sea should urgently comply with the EU Urban Waste Water Directive. The directive needs to be reviewed and sharpened.

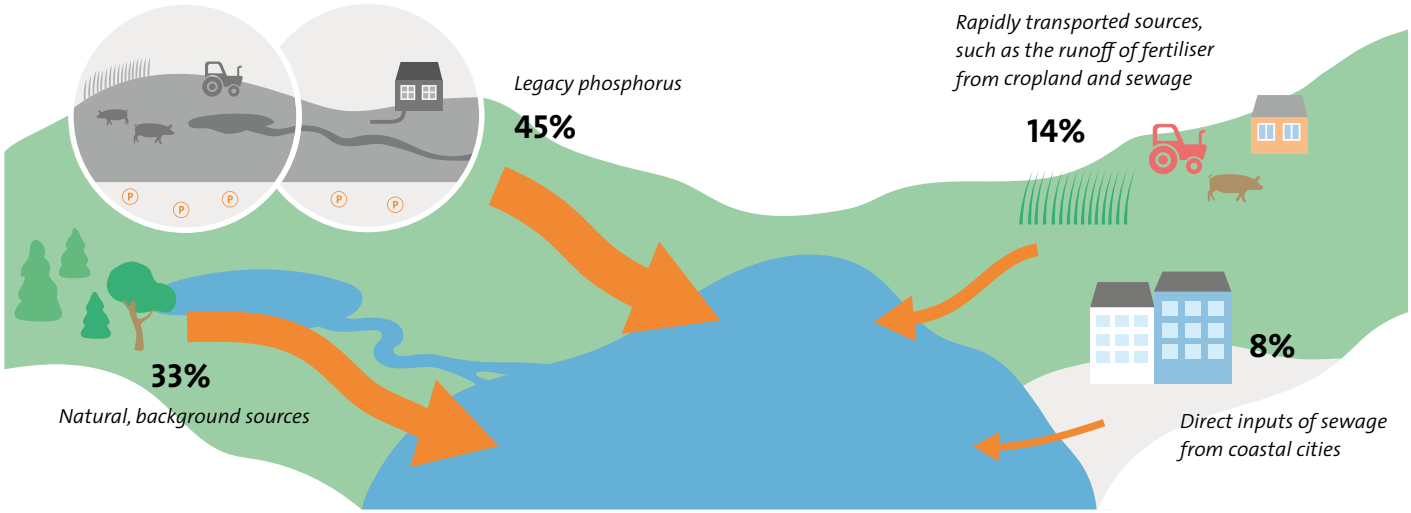
Sources of phosphorus (P) to the catchment

Illustrations: Elsa Wikander/Azote



Over the past century, countries around the Baltic Sea have applied more than 44 million tons of mineral phosphorus fertilisers to agricultural soils. Farmers have been advised to apply large amounts of mineral fertiliser and manure to increase yields. As a result, more fertiliser has been applied than has been removed with harvested crops, and this has led to the accumulation of phosphorus in soils and sediments, lakes and streams. In addition, untreated or poorly treated wastewater was discharged into surface waters prior to modern sewage treatment capabilities.

Sources of phosphorus entering the sea



A new study estimates that 45% of waterborne phosphorus to the Baltic Sea is from legacy sources; 14% is from rapidly transported sources, 8% is sewage from coastal cities. The remaining 33% is from natural, backgound sources.

surpluses. For the Baltic Sea catchment as a whole, the amount of phosphorus that has accumulated in agricultural soils is the same order of magnitude as three decades of crop nutrient needs.

Phosphorus from human sewage wastewater has also accumulated on land. In the early days of flush toilets, wastewater was untreated or poorly treated and disposed of in nearby surface waters. Some phosphorus from this wastewater likely remains in the sediments of rivers and lakes that flow to the Baltic Sea.

The legacy can be described as too much of a good thing, because while phosphorus is critical for all life, it can leak to water bodies and have an unintended fertilising effect that contributes to eutrophication. Even if no more phosphorus is applied to land, legacy phosphorus will continue to leak for decades to downstream lakes and coastal areas where it can cause environmental problems.

A new study estimates legacy phosphorus magnitude

For the first time, legacy phosphorus dynamics have been estimated for the entire drainage basin of the Baltic Sea. Research carried out at the Stockholm University Baltic Sea Centre suggests that leakage from old, legacy sources contributes a substantial amount of phosphorus to the sea. Today, about 45 percent of the phosphorus entering the sea could derive from this source.

Another 33 percent comes from natural, background sources, 8 percent from direct inputs of sewage from coastal cities, and the remainder from rapidly transported sources, such as the runoff of fertiliser from cropland.

A reason for being patiently realistic

The computer model used for estimations suggests that phosphorus leakage from legacy sources will continue for decades, making it difficult to achieve large reductions from diffuse sources like agriculture in the near term. The potential for time-lags is not an excuse for inaction but a reason for being patiently realistic about the time-scale for observing results.

However, the model also suggests that the amount of legacy phosphorus that leaks to the Baltic Sea has decreased by about ten percent in the past 20 years. This decrease is due, in part, to the measures that have already been taken on land to reduce over-fertilisation and remove phosphorus from wastewater.

According to the model, we can expect that the amount of legacy phosphorus that leaks to the Baltic Sea will decrease even further over time, perhaps by as much as one-third compared to today. But the size of this reduction will depend on continued actions to reduce the accumulation of phosphorus on land. In other words, reducing the accumulation of phosphorus in the catchment today reduce future long-lasting inputs from legacy sources.

Total phosphorus loading to the sea has decreased by more than 50 percent since the 1980's. Much of this reduction has been attributed to improved sewage treatment. During the past decades, many actions have also been taken to improve phosphorus management in agriculture. The lack of larger reductions in phosphorus loads to the sea from diffuse sources (i.e. not point sources) is partly due to the leakage of legacy phosphorus.

Actions taken today create tomorrow's legacy

Mineral phosphorus fertilisers derive from phosphate rock, which is a finite resource, like fossil fuels. Unlike fossil fuels, however, there is no substitute. Today, 85 percent of phosphate rock reserves are controlled by three countries: Morocco, China, and Algeria. The European Commission has added phosphate rock to the list of 20 Critical Raw Materials for which supply security is at risk and economic importance is high.

In fact, society currently operates outside the planetary boundaries of the phosphorus cycle. This is not sustainable. Therefore, recycling existing phosphorus within agriculture better and reducing the overall import of new phosphorus to the Baltic Sea region will not only mitigate eutrophication but also lead to the more sustainable use of a finite resource.

Therefore, it is critical that we continue to reduce the accumulation of phosphorus on land because actions taken today create tomorrow's legacy. There is potential to make progress towards the goals of the Baltic Sea Action Plan by increasing the recycling of phosphorus in agriculture, reducing over-fertilisation, and improving wastewater treatment. Policies should aim to reduce the build up and transport of phosphorus already in the landscape.

PHOSPHORUS IN THE BALTIC SEA

In balanced marine ecosystems, inputs of phosphorus equal the sum of export of phosphorus to adjacent waterbodies and long-term burial in sediments.

The balance in the Baltic Sea has been severely disrupted by large phosphorus inputs from land. Over the past century, the amount of phosphorus in the sea has nearly tripled. The increased amount of phosphorus in the sea contributes to a number of environmental problems, including reduced water clarity, cyanobacterial blooms, and "dead zones", which are areas near the sea floor without enough oxygen to support life. The "internal phosphorus load" refers to the pool of phosphorus in the sea that moves back and forth between sediments and the water column as a result of complex chemical reactions. The phosphorus in the water column and sediments originates from previous inputs from land; it is not a new source of phosphorus.

A different computer model study by researchers at the Baltic Sea Centre (E. Gustafsson et al. 2017) found that the size of the total pool of phosphorus in the sea is stabilizing. This means that if we continue to reduce phosphorus loads from land, the pool in the sea will decrease; however, this will take time.

The average amount of time that phosphorus stays in a storage pool before being transported to a different pool is called the residence time. In the case of phosphorus, two studies from the Baltic Sea Centre found that the residence time is about 30 years both on land and in the sea. This means that phosphorus inputs to the catchment stay for an average of about 30 years before entering the sea or long-term storage in soils or lake and stream sediments.

Similarly, once phosphorus enters the sea, it stays in the water or surface sediments for about 30 years before being flushed to the North Sea or buried in deep sediments. As a result, there are unavoidable delays between when actions are taken on land and when the sea will benefit from those actions.

Gustafsson, E., Savchuk, O.P., Gustafsson, B.G. et al. 2017.
Key processes in the coupled carbon, nitrogen and phosphorus cycling of the Baltic Sea. Biogeochemistry.
https://doi.org/10.1007/s10533-017-0361-6

Photo: Dan Karlsson/Azote

HOW THE STUDY WAS CONDUCTED

To understand legacy phosphorus over the past century, researchers at Stockholm University Baltic Sea Centre developed a budget for the entire drainage basin of the Baltic Sea that accounted for imports of phosphorus in mineral fertiliser, food, and feed and exports of phosphorus in food and feed.

Next, the researchers created a computer model to estimate the accumulation and release of legacy phosphorus in the drainage basin. This model included a rapid transport pathway for sources such as runoff from cropland and a slow pathway that represented leakage of legacy sources.

While there is uncertainty with all models, the legacy phosphorus model was able to recreate historical phosphorus loads to the sea reasonably well and this increases confidence in the model's results. The model discussed here is an important first step and there is need for further investigation into the sizes and locations of legacy phosphorus pools in the landscape.

The model cannot tell us the original source of legacy leakage. The HELCOM Pollution Load Compilation reports identify sewage and agriculture as the main sources of phosphorus from land today, and they are likely the main sources of legacy phosphorus.

McCrackin, M. L., B. Muller-Karulus, B. Gustafsson, R. W. Howarth, C. Humborg, A. Svanbäck, D. P. Swaney. 2018.
A Century of Legacy Phosphorus Dynamics in a Large Drainage Basin. Global Biogeochemical Cycles.
https://doi.org/10.1029/2018GB005914

Photo: Bent Christensen/Azote

Photo: Nicklas Wijkmark/Azote

All our actions on land affect the marine environment. It is important to improve the use efficiency of manure in agriculture.

BALTIC EYE – BRIDGING THE GAP BETWEEN SCIENCE AND POLICY

This policy brief is produced by Baltic Eye, a part of the Baltic Sea Centre at Stockholm University.

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CONTACT

Michelle McCrackin, Limnologist
+46-8-16 17 78, michelle.mccrackin@su.se

Annika Svanbäck, Agronomist
+46-8-16 31 50, annika.svanback@su.se

Science and communication with focus on the sea
+46-8-16 37 18 | ostersjocentrum@su.se | su.se/ostersjocentrum

Baltic Sea Centre | Stockholm University