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Policy Brief

Baltic Sea Centre

Stockholm University

The internal phosphorus load – recycles old sins

The accumulated pool of phosphorus on land receives much less attention than the pool in the Baltic Sea, despite being substantially larger and the ultimate source to the sea. Actions taken to reduce the internal load will not address the causes of eutrophication. Instead, actions must focus on improving both nutrient use efficiency in agriculture and sewage treatment.

Eutrophication constitutes the greatest threat to the Baltic Sea ecosystem, affecting marine animals, plants, and habitats and limiting opportunities for people to enjoy the sea. How to address eutrophication is a hot topic in the debate in many countries around the Baltic Sea.

Lately, phosphorus released from the pool in the Baltic Sea ecosystem – the internal load – has been brought forward as the main cause of eutrophication. Some argue that the magnitude of recycling from this accumulated stock is so huge that actions on land will not have any effect. Others go further and suggest different geo-engineering actions as the best way to save the Baltic Sea ecosystem.

Unfortunately, the ongoing debate on how to best address eutrophication in relation to internal load is characterised by a number of misconceptions. The most common one is to refer to internal load as a new source of phosphorus to the Baltic Sea. It is not.

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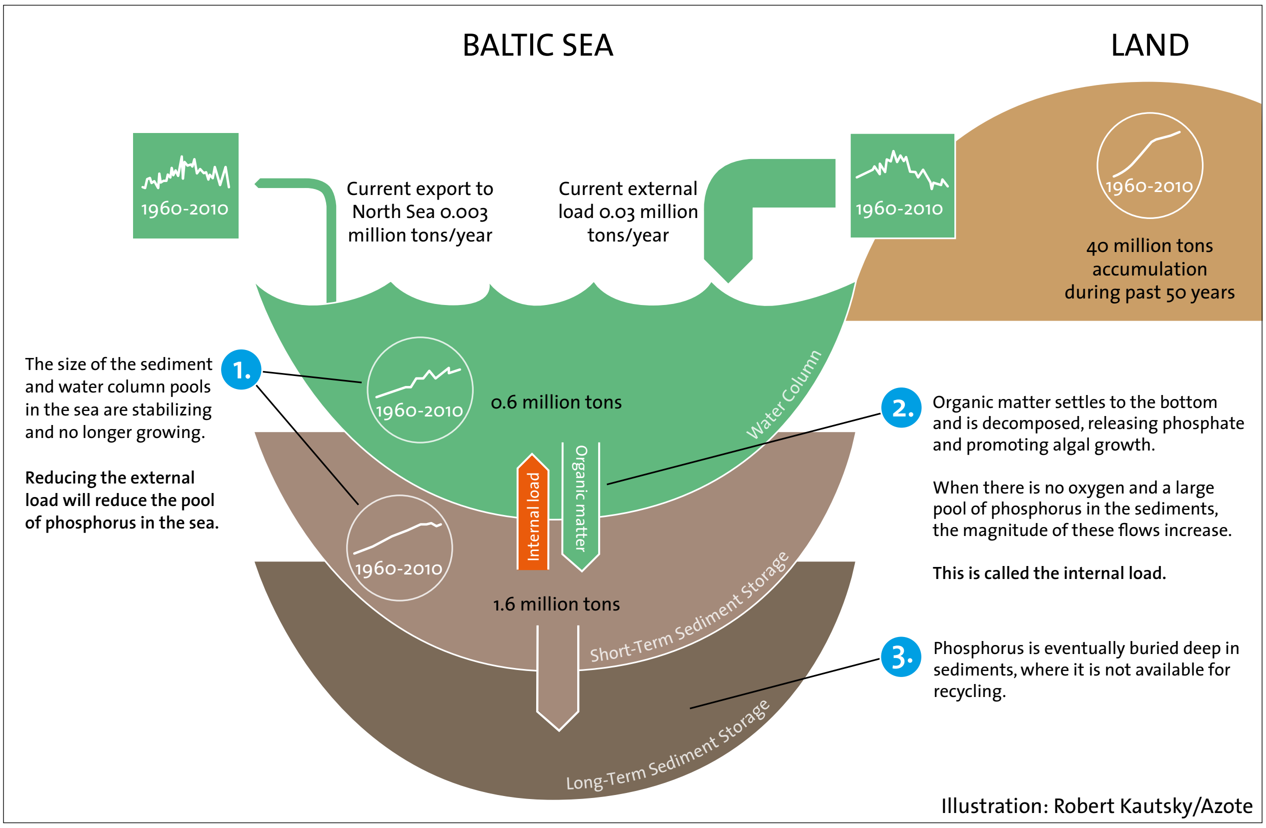

Internal load is a release of phosphorus, originating from the land pool, from the sediments to the water column. Sources: Gustafsson et al. (2012) *Reconstructing the Development of Baltic Sea Eutrophication 1850-2006*, Ambio, 41:534-548, and Baltic Eye compilation of FAOSTAT data.

Much more phosphorus on land

In the past 50 years, countries around the Baltic Sea have imported 4 million tons of phosphorus in animal feed, human food, and detergents and applied about 35 million tons of mineral phosphorus fertilisers to agricultural soils. Soils in many regions contain so much phosphorus that further fertilisation does not increase harvest.

This has built up a huge pool of new phosphorus on land – nearly 40 million tons. Today, this accumulated land pool is about 20 times greater than the one in the sea. And it keeps growing.

Recycling old sins

Some of the phosphorus on land is transported with water that moves through soils, rivers, and lakes, eventually reaching the sea. In balanced marine ecosystems, inputs of phosphorus are compensated by long-term storage in sediments and export of phosphorus to adjacent water bodies. In the Baltic Sea that balance has been severely disturbed by excess inputs for a long time, building up the pools of phosphorus in the sediment and water column. Recent modelling results indicate that external load reductions are starting to restore the balance and the size of the pools are stabilising.

With major contributions from agriculture, industry, and sewage, the Baltic Sea ecosystem has been loaded with 4 million tons of phosphorus during the past century. Over the same period, 1 million tons have accumulated in sediments, while 0.4 million tons have accumulated in the water column. The rest has been flushed out to the North Sea. So in reality, the internal phosphorus load is recycling old sins that have accumulated in the sediments and is not a new source.

Avoid build-up on land

The land pool of accumulated phosphorus is still growing and can continue to leak to the sea for decades to come. Baltic Eye estimates that the accumulated land pool could contribute up to half (0,015 million tons) of the annual phosphorus river inputs to the Baltic Sea.

Strong land-based measures are therefore essential for reducing further build-up of the phosphorus pool on land that will otherwise contribute to eutrophication in the future.

Symptoms and causes

Referring to internal load as a “source” is not only an etymological mistake, but also shifts attention from the causes of eutrophication to the symptoms.

Several geo-engineering actions have been proposed to restore the Baltic Sea: removing phosphorus-rich sediments, adding chemicals to bind phosphorus in the sediments, and pumping oxygenated water down to deep, oxygen-poor waters. These actions only focus on the symptoms and will have no effect on the external phosphorus inputs to the Baltic Sea. Additionally, there are still major scientific uncertainties. For example, some research suggests that artificial oxygenation can restore the sea in a decade. Other research argues that artificial oxygenation could increase the short-term storage of phosphorus in sediments and result in a massive release of phosphorus during subsequent low oxygen events.

Redirecting societal efforts and funds towards large scale geo-engineering at sea, at the expense of dealing with land-based sources, would be very unfortunate for the Baltic Sea ecosystem and seriously hinder its recovery.

EFFECTS OF INTERNAL LOAD ON EUTROPHICATION – A COMPLEX PROCESS

WHAT IS INTERNAL LOAD?

The flux of phosphorus from sediments to the water column is often called the internal load. The magnitude of the flux varies in a complex way, depending on, for example, the amounts of organic matter, biological activity, minerals, metals – and oxygen.

Microbes are dominant in decomposing organic matter in a process that consumes oxygen and release phosphorus in a form (phosphate) that is readily available for algae. Low oxygen concentrations slow decomposition, but cause the microbes to release a greater portion of phosphorus.

If there is oxygen at the sediment surface, a significant amount of phosphorus is stored in the top sediments bound with iron oxides. When there is little or no oxygen, the bonds break and phosphorus is released back into the water column. In the Baltic Sea today, up to 0.1 million tons of phosphorus can move back and forth like this, numerous times.

Thus, the internal load is actually the recycling of a portion of old sins. Reducing the external load will eventually reduce the internal load, because phosphorus will over time move from short-term to long-term storage pools.

DEAD ZONES

The accumulation of phosphorus in the sediments is closely linked to the accumulation of organic matter (living or dead plant and animal material) that contains nitrogen and phosphorus.

After algae, fish, and other organisms die, they sink and start to decompose. While microbes decompose this organic matter, they consume oxygen and phosphorus is released into the water column. In some areas at the sea bottom there is so much organic matter to decompose, that all oxygen is consumed. This results in a "dead zone" where for instance cod cannot spawn.

ALGAL BLOOMS AND PHOSPHORUS

Just as nitrogen and phosphorus fertilisers boost crop production on land, they contribute to growth in the sea. There is an intrinsic connection between algal blooms and the amount of nutrients in the water.

Algal blooms include different types of algae, including cyanobacteria that can produce harmful toxins. If there is not enough nitrogen in the environment, cyanobacteria can fertilize themselves by taking nitrogen from air. As a result, cyanobacteria blooms in some parts of the Baltic Sea, such as the Baltic Proper, will not be affected by nitrogen reductions. In such cases it is essential to focus on reducing phosphorus inputs. Once phosphorus inputs are reduced enough, then nitrogen load reductions can further reduce algal blooms.

Illustration: Robert Kautsky/Azote

Currently, the Baltic Sea is home to the world's largest dead zone (in black), which has dramatically reduced the area where cod can spawn and has altered the food chain in deep waters. The light blue represents the catchment area.

Photo: Andre Maslennikov/Azote

A newly built wastewater treatment plant in Estonia.

WHAT CAN WE DO?

Progress has been made in reducing nutrient inputs to the Baltic Sea. Since 1995, nitrogen inputs have decreased 17 % and phosphorus inputs have decreased 20 % according to Helcom. Although the eutrophication status of most parts of the Baltic Sea is still poor, improvement is nowadays seen in some large areas, such as the Eastern Gulf of Finland, Kattegat, and Danish Straits.

This shows that reducing the nutrient input from land works in the long run. And in the Baltic Sea region, there are still great opportunities to achieve major reductions – by aiming for the main input sources:

IMPROVING PHOSPHORUS USE EFFICIENCY IN AGRICULTURE

Around the Baltic Sea, only about 60 percent of the phosphorus in fertilisers and manure is converted into harvested crops. The remainder can be stored in soils for future use by crops, but some is lost to the environment. Improving the nutrient use efficiency of agriculture, especially in the former eastern countries, can further reduce river loads.

The circular economy promotes more efficient use of nutrients. The proposed EU regulation on fertiliser trade can become an important tool for recycling available nutrients, closing the nutrient cycle, and reducing the input of new nitrogen and phosphorus sources.

IMPROVING SEWAGE TREATMENT

Improving sewage treatment is a very effective way to remove phosphorous from wastewater entering in lakes and rivers that drain to the Baltic Sea. However, a recent EU Court of Auditors report found that not all countries around the sea have complied with the urban waste water treatment directive. Fulfilling the current requirement is urgently needed. The next step is to review the directive and sharpen it.

The Baltic Sea is on the threshold of recovery. Continued nutrient load reductions will further enable recovery not only of the sea, but also of inland lakes and streams. It took decades for the Baltic Sea to become eutrophic, and it will take decades to recover. But it can be done.

Photo: Bengt Ekberg/Azote

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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We analyse and synthesise scientific research on the Baltic Sea and communicate it to stakeholders in the decision-making process.

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