Ecology

Healthy Rivers, Healthy Baltic

How does inflowing river water affect the quality of water in the Baltic Sea? Why are the chemicals used in agriculture so dangerous for seas, and what future lies in store for the Baltic?

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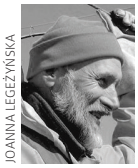
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Although Earth's oceans hold vast volumes of water, marine ecosystems are nevertheless heavily affected by rivers. Fresh river water extends many kilometers beyond river mouths, continuing to form a distinctive layer above the denser, salty seawater, thereby limiting gaseous and thermal exchange between the sea and the atmosphere. Rivers also bring in high volumes of deposits and biogenic salts which regulate primary production in shelf seas. The coastal ecosystems of open oceans are highly dependent on major rivers, for example the Amazon in the central Atlantic and the Ganges in the Indian Ocean. The Arctic Ocean is surrounded by land, therefore the major Siberian rivers have a major impact on its entire area. The only marine region entirely unaffected by rivers is the Antarctic, the southern ocean being fed by low volumes of fresh water from melting ice sheets, mountain glaciers and lands of Australia and Oceania. Given that rivers are so important for marine ecosystems, even on the oceanic scale, it becomes even easier to understand why the small, almost landlocked Baltic is so heavily affected by processes occurring in its tributaries.

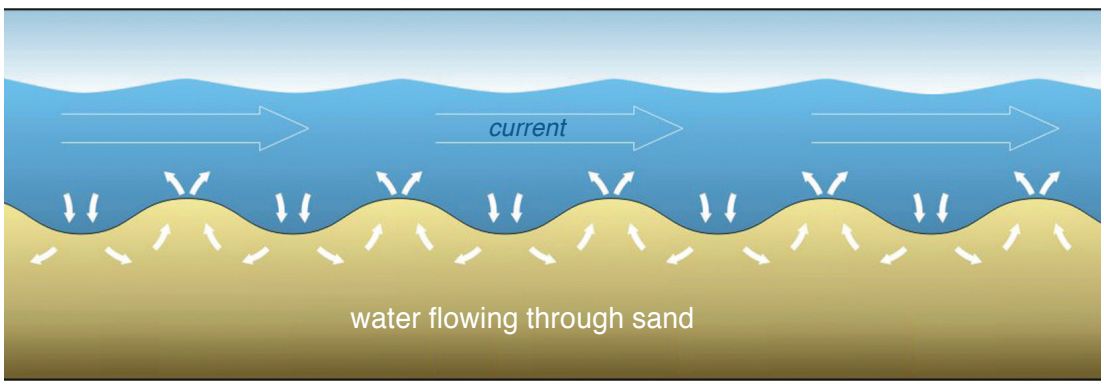
History of the Baltic

As a semi-enclosed, brackish sea, the Baltic is especially sensitive to inflow from rivers. Following the end of the last glaciation episode, the Baltic went through several phases: starting as a freshwater ice lake, its salinity varied across the eras as its connection with the wider sea changed, to reach today's form as a brackish reservoir. The Baltic has channels linking it to the North Sea, and it is fed by major river runoffs on its eastern and northern coastlines. The catchments of two of the three largest Baltic rivers (the Oder and the Vistula) cover Poland almost entirely. The largest river which flows into the Baltic is the Neva, discharging northeast of Poland's border.

Since the Second World War, the Baltic has been described as eutrophic (overly enriched with minerals and nutrients). This is the result of intensive farming using high volumes of artificial fertilizers, in particular in Poland and Russia. Although since 2000 volumes of nitrogen and phosphorus compounds originating from agriculture have been significantly lower per head in Poland than Denmark, Germany or Sweden, the large farming areas and high population numbers mean that biogenic substances entering the Baltic from Poland are still the main culprit of this eutrophication. This problem is the subject of international debate and controls aiming to restore good ecological status, carried out as the HELCOM Baltic Sea Action Plan.

Pollutants in the Baltic

The role of rivers discharging into the Baltic in controlling the production of marine microorganisms (phyto- or microplankton) is key in the transport of phosphorus compounds and silicates. Nitrogen is largely brought in by precipitation (an estimated 25% of the annual supply of the element into the Baltic). The most problematic marine microorganisms, cyanobacteria, are able to assimilate nitrogen from the atmosphere and are not affected by river influx. While nitrogen and phosphorus compounds are transported by rivers from arable fields, the third chemical element key in marine primary production – silicon – is naturally washed out by fresh water from soil and rocks. It is essential for these three biogenic elements to be balanced in rivers so that a major component of marine phytoplankton will be made up of diatoms – organisms containing the most valuable organic compounds in the marine trophic network. Cyanobacteria, which respond positively to excess phosphorus,



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The mechanism whereby a natural filter is formed in any location where a current of water flows over permeable sediments (sand, gravel) and surface waves form on the bottom

are not an attractive food source for other organisms, and they can emit toxic compounds directly into their environment.

Estuaries with transition zones, sometimes known as marginal filters, are especially significant for the relationship between rivers and oceans. As river water reaches the sea, it floats atop the denser seawater, while some seawater also flows upriver along the riverbed. At the boundary between fresh and seawater, there occur violent physicochemical processes followed by phenomena such as flocculation – the clumping together of fine organic particulates. Depending on the size of the estuary, this is followed by subsequent processes: first physical precipitation of particulates when the river flow loses speed on entering the sea, and then physicochemical and electrochemical processes when fresh water mixes with seawater full of ions. This also initiates many biological processes during which complexes of bacteria and other microorganisms settle and develop on newly formed aggregates of organic compounds. As a result of all the processes which occur in river estuaries, the water which flows down the river is not the same as that which reaches the sea. A significant part of suspensions reaching the sea, including pollutants, remain in the zone where river and seawater meet, which means that measurements taken further upriver (for example, at a bridge over the Vistula in Tczew) are not representative of what the river actually discharges into the Baltic.

It has been shown that marine ecosystems, especially those as highly dependent on inflow of river water as the Baltic, are highly affected by the condition of the water of tributaries. Changes occurring on the local scale, such as regulation of rivers under the current system, agriculture and extensive use of fertilizers, all bear serious consequences. The dissolved fraction of biogenic compounds, added artificially to soil, is quickly taken by rivers to seas where it causes eutrophication, while silicon compounds, linked with free water filtration by soil, are captured. The relationship between natural inflow of river water to the sea via a meandering route, filtering through sediment such as sand and gravel and flowing through vegetation, and the quality of water reaching the sea, has only been elucidated relatively recently. The result has been the creation of a major European program of renaturalizing rivers as part of which reinforcements, dams and groynes are being removed from dozens of waterways, mainly in France, Germany and the UK, and meanders are being restored. This aims to slow down the waterflow and enable natural filtration by the riverbanks and the riverbed. At the same time, waterborne organisms such as bacteria, meiofauna and plants and larger animals process organic matter, use nutrients and absorb many contaminants. In terms of the quality of the Baltic, the most important issue is plants absorbing phosphorus and nitrogen in rivers, in particular in swamps and wetlands and everywhere where rivers flow slowly and meander through vegetation. Slow river flow is what is of fundamental importance, since holding water in dammed reservoirs does not provide effective purification.

A forest river

The Baltic facing change

Changes occurring on the global scale also affect the relationships between rivers and seas. The inevitable rising of ocean levels will result in a restructuring of river deltas and estuaries. According to advanced climate and geochemical models for the Baltic, developed a few years ago in Stockholm, the northern Baltic will experience increased river inflow and a corresponding desalination, while the southern parts of the sea are predicted to be affected by droughts and decreased river inflow. While the land of the northern Baltic is still rising following the last glaciation, balancing out the overall sea levels there, we can predict that in the coming centuries, Poland's coast – in particular the estuaries of the Oder and Vistula rivers – will evolve into a highly complex coastline with many bays reaching far inland. To reduce the chances that future generations will have to confront such massive change, we must act now to improve the conditions of rivers and strive to return them to a more natural state. All this will have an impact on the condition of the Baltic Sea in the future.