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Effect of natural and anthropogenic factors on eutrophication and de-eutrophication and algal blooms in the estuaries of different types (by the example of Curonian and Vistula Lagoons and the Volga Delta)

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Summary

The Volga River is the largest river in Europe and it forms a great delta. The maximum eutrophication and algae blooms of the Volga delta were observed in 1980s. In the modern period in the Volga Delta, de-eutrophication is observed, in particular, noted strong reduction of algal blooms and primary production. At present, productivity of the delta is determined primarily by river runoff. The Curonian and Vistula Lagoons are the largest coastal lagoons of the Baltic Sea. There are hypertrophic water bodies, where harmful "hyperblooms" of Cyanobacteria are regularly observed. Multiple reductions of nutrients loading in 1990s-2000s did not result in ecological improvement unlike Volga delta. Water temperature is the key environment factor determining the summer algal blooms. The reason of the ongoing eutrophication is water warming, which in combination slow water exchange stimulates summer "blooming" of Cyanobacteria.

Introduction

Estuaries characterize by complex ecological structure and they are the most vulnerable to direct impacts of environmental factors. The aim was to analyze the long-term change of eutrophication and algal blooms and the impact of natural and anthropogenic factors in large estuaries of different types (Volga delta, Curonian and Vistula Lagoons).

Materials and Methods

The researches of the lagoons (primary production, chlorophyll, phytoplankton, nutrients and others) were carried out monthly from March-April to November at 12 stations in the Curonian Lagoon and at 9 stations in the Vistula Lagoon since 1991 to 2014. The researches of the Volga Delta (primary production, chlorophyll (Chl), phytoplankton, nutrients and others) were carried out in the Lower part of the Volga Delta and fore-delta on the base of Astrakhan Biosphere Reserve since 1996 to 2007.

Results and Discussion

The Volga River is the largest river in Europe that flows into the Caspian Sea and it forms a great delta. During the XX century, environmental conditions in the Volga Delta changed significantly as a result of anthropogenic regulation of the water discharge, changed input of pollutants and nutrients, and other factors. Hydrology conditions and river runoff are important factors that determine the phytoplankton primary production in the delta. According to the analysis of long-term data (from the 1960s), the maximum eutrophication, primary production and algal blooms of the Volga Delta was observed in the 1980s. On the one hand, the reason is the increase of fertilizers application in agriculture that caused their significant draining into water bodies, on the other hand extra load of nutrients from the areas of floodplain and delta that were not flooded for a long time during the previous years of a small river runoff. In the 1990s, fertilizers use and the input of nutrients into the Volga Delta decreased significantly. Our assessment in the 1990s–2000s revealed that there was a decrease of phytoplankton primary production to 1960s–1970s levels and the process of eutrophication was replaced by de-eutrophication. At present, the trophic status of the Volga delta assessed as mesotrophic. Some of the fore-delta coastal areas are of some eutrophic character. The future trend of phytoplankton biomass and primary production of the Volga delta will greatly depend on the scenario of nutrients loading and river runoff.

Curonian and Vistula Lagoons are the largest coastal lagoons of the Baltic Sea, relating to the most highly productive water bodies of Europe. The Curonian Lagoon is choke mostly freshwater lagoon, while the Vistula Lagoon is restricted brackish water lagoon (Kjerfve, 1986). Algal blooms are one of the most important problems. The initial reason of the blooms of Cyanobacteria was intensive external nutrients loading in XX century. Reduction of industrial production and fertilizers in 1990s resulted in a decrease of the external nutrients loading by 3-4 times. However, in these lagoons, unlike many inland and coastal marine waters, eutrophication of water continues. In the Curonian Lagoon in 2000s, the number of stations increased where extremely high level of eutrophication (Chl *a* > 100 μg/l) and "hyperblooms" of Cyanobacteria are observed (Figure 1).

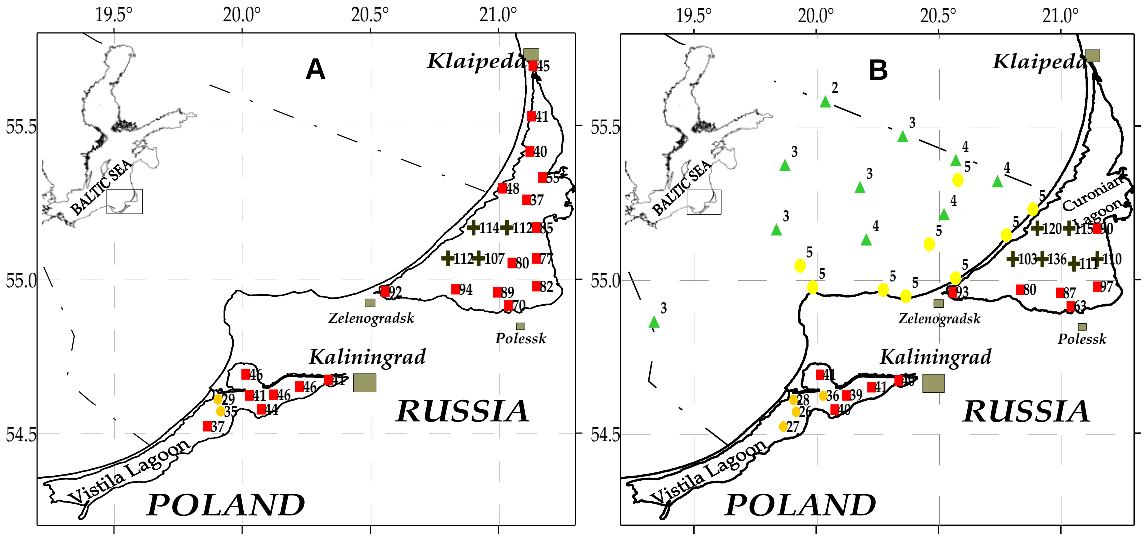

Figure 1. Trophic status of the Vistula and Curonian Lagoons and the South-Eastern Baltic Sea based on mean for growing season (April - October) chlorophyll *a* (μg/l) in 1991-2000 (A) and 2001-2013 (B).

The Curonian Lagoon may be characterized as a hypertrophic water body (OECD 1982). The water temperature is key environmental factor determining the level of production and algae blooms in the choked Curonian Lagoon. More intensive summer warming-up of water in 1990s-2000s due the climate warming in the Baltic region combined with other factors (freshwater conditions, slow-flow exchange, high nutrients concentrations) creates conditions for Cyanobacteria "hyperblooms".

The restricted Vistula Lagoon may be characterized as eutrophic or hypertrophic for different parts. Hydrodynamic activity and brackish water prevent Cyanobacteria "hyperblooms". In the central area, which is under the influence of seawaters, where the salinity is about 4.5 PSU, the level of eutrophication is reduced with "hypertrophic" to "eutrophic".

So, the productivity of the ecosystem and algal blooms are determined primarily by river runoff and external nutrients loading in the Volga Delta, while in the Vistula Lagoon and Curonian Lagoon - the climate warming and water exchange with the sea. In modern period, de-eutrophication is observed in the Volga Delta, whereas eutrophication and algal "hyperblooms" continue in the Lagoons.

References

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