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Harmful algal blooms in the Curonian Lagoon of the Baltic Sea and environmental effects

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Summary

The Curonian Lagoon is the largest lagoon of the Baltic Sea, relating to the most highly productive water bodies of Europe. This lagoon may be characterized as hypertrophic water body with "poor" water quality. In 1990-2000s eutrophication and intensity of algal blooms increased. Warming climate in combination with other factors (nutrients concentrations, shallow depths, slow water exchange, freshwater) creates conditions for "hyperblooms" of Cyanobacteria in July-October that affected seriously on the ecosystem of the lagoon. In choked Curonian Lagoon that leads to accumulation of organic matter in sediments and further eutrophication. During the "hyperblooms" accumulation and decomposition of Cyanobacteria result in deterioration of the water chemical parameters, oxygen deficiency and death of fish. Algal toxins detected in water, sediment, mussels and fish and the concentrations of microcystins in water may exceed safe level. The pathological changes in zooplankton and fish were similar to the symptoms of affected by toxins. This indicates the toxic impact of algal blooms on the ecosystem. "Hyperblooms" of Cyanobacteria is the most dangerous for coastal towns and tourist resorts (UNESCO National Park "Curonian Spit").

Introduction

The Curonian Lagoon is the largest coastal lagoon of the Baltic Sea. During the latest decades, significant anthropogenic changes occurred in the lagoon and watershed area. Ongoing eutrophication and harmful algal blooms are the most important problems. Monitoring allowed to estimate the current level of eutrophication and to identify long-term trends in the lagoon. E.g., the effects of climate change to increase of algae hyperblooms in the Curonian Lagoon.

Materials and Methods

The researches (primary production, chlorophyll concentration (Chl), phytoplankton, nutrients and others) were carried out monthly from March-April to November at 12 stations since 1991 to 2014. Location of this stations corresponds to hydrological and hydrochemical division and covers the entire Russian waters. The database includes 1550 monitoring stations in Curonian Lagoons.

Results and Discussion

The Curonian Lagoon may be characterized as a hypertrophic water body with "poor" water quality on the basis of long-term chemical and biological data. Hypereutrophic status is observed on all water area of the lagoon. Results of environmental studies since 1991 to 2013 did not show significant improvement of indicators of eutrophication. In 2001-2013 increased the number of stations where the average for the growing season (April - October) Chl *a* > 100 μg/l, and at these stations there is an extremely high level of eutrophication and algal blooms. The Chl *a* and phytoplankton production (360-620 $gC \cdot m^{-2} \cdot year^{-1}$) in this lagoon are one of greatest in water bodies of basin of the Baltic Sea.

The initial reason of hypertrophic state the Curonian Lagoon and blooms of Cyanobacteria (*Aphanizomenon flos-aquae, Microcystis aeruginosa*) was intensive external nutrients loading in XX century as the watershed area is located in density populated district with highly developed industry

and agriculture. Reduction of industrial production and fertilizers usage in 1990s resulted in a decrease of the external nutrients loading by 3-4 times. However, in 1980s-2000s biomass of Cyanobacteria in summer was always at the level of intensive bloom (10-100 g/m^3) or the hyperbloom (above 100 g/m^3) (Olenina 1998, Belykh 2013). When the input of nutrients from lagoon's watershed area multiple decreased, hyperbloom of Cyanophyta and hypertrophic level (average for the growing season Chl *a* > 100 μg/l) were observed during 4 years in 1990s and 7 years in 2000s (Figure 1).

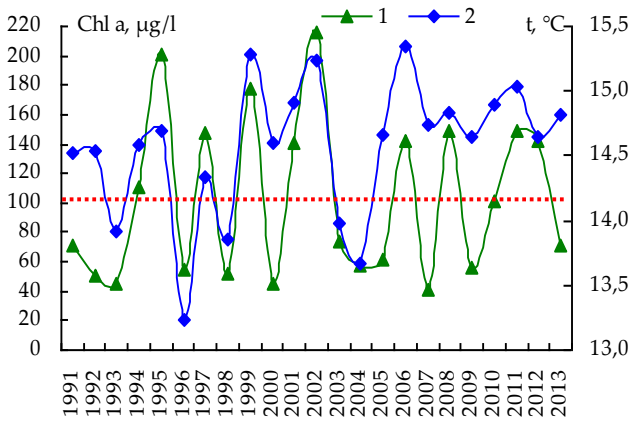

Figure 1. The mean for the growing season (April - October) Chl (1) and water temperature (2) in the Curonian Lagoon

The years with hyperbloom of Cyanophyta coincide with the years of the maximum water warming-up. The water temperature is key environmental factor determining the level of primary production and algae blooms in lagoon. "Hyperblooming" of Cyanobacteria is observed at water warming-up to 20-22°C during several weeks and the mean water temperature above 14.5 °C for the growing season. The local climate warming in the Baltic region is a probable reason of the ongoing eutrophication of the Curonian Lagoon despite of significant reduction of external nutrients loading.

Hyperblooming of Cyanobacteria affects seriously on the Curonian Lagoon ecosystem. During the hyperbloom (July-October) Cyanobacteria biomass (to 1200-2500 mg/l and Chl *a* - 700-3400 μg/l) exceeded the level at which the eutrophication and pollution are observed. Accumulation and decomposition of Cyanobacteria in the coastal zone result in deterioration of the water chemical parameters, oxygen deficiency and death of fish. The concentration of ammonia nitrogen may attain 800-1000 μg N/l, BOD_5 - 10-19 mg O_2/l, and pH of water - 9.8-10.0, i.e. maximum permissible concentrations for fishing water bodies have been considerably exceeded.

Dominant species of Cyanobacteria (*Microcystis aeruginosa*) is the toxic (Belykh 2013, Paldaviciene et al. 2009). Algal toxins detected in water, sediment, mussels and fish and the concentrations of microcystins in water (to 134 μg l^{-1}) may exceed safe level. The pathological changes in zooplankton and fish were similar to the symptoms of affected by toxins of Cyanophyta.

The eutrophication and water "blooming" were most pronounced in the southern and central parts (the Russian zone) of the lagoon (75% of the area), where the environmental conditions (high concentrations of nutrients in silt, continuously resuspension in water, shallow depths, slow water exchange, fresh water) were favored for Cyanobacteria. In northern, Lithuanian part the lagoon the level of eutrophication and algal blooms are usually lower, so this area adjoins to sea strait and is under influence of river flow Neman and Baltic Sea. "Hyperblooms" of Cyanobacteria is the most dangerous for coastal towns (Zelenogradsk, Pollessk) and tourist resorts (UNESCO National Park "Curonian Spit"). Therefore, the warming up of the water resulting from global climatic changes represents a risk for coastal water bodies, as this stimulates hyperblooms of toxic Cyanobacteria.

References

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