Climate change affects lakes. What can we do?

Synthesis

- ✓ **Lake ecosystems provide vital services for humanity, but, due to global climate change, the quality and quantity of these services is decreasing.**
- ✓ Lakes supply us with clean water and fish, they regulate nutrient cycling and modify climate change effects by controlling floods and the amount of CO_2, which is the main cause of climate warming. In an urbanizing world, the aesthetic and recreational importance of lakes for human well-being is increasing.
- ✓ Changes in temperature, precipitation and wind affect lake levels and water availability, alter the distribution of oxygen and nutrients, and impact the survival and abundance of aquatic organisms: algal blooms expand causing massive fish kills.
- ✓ Understanding these mutual interactions through improved climate models, monitoring of water quality, and assessing ecosystem health is crucial for managing and mitigating the impacts of climate change on lakes.
- ✓ As the impact of eutrophication and climate change follow the same pathways affecting nutrient availability and cascading effects in the food web, **establishing stricter control over anthropogenic nutrient loading** is the most efficient adaptive strategy to preserve the ecological integrity of lakes and the services they provide.

Because the impacts of cultural eutrophication and climate change follow the same pathways, stricter nutrient loading limits are needed in a future warmer climate to preserve the ecological integrity of lakes and the services they provide.

Climate change reinforces eutrophication of lakes

According to the worst-case scenario for climate change from the IPCC, water temperatures in Europe's lakes will rise by 2-7 °C by 2100. Longer periods of thermal stratification lead to oxygen depletion, which enhances phosphorus release from lake sediments and boost cyanobacterial blooms causing fish kills. In warmer climates the sensitivity of lakes to nitrogen (N) loadings increases. In northern Europe N loss from agricultural soils is primarily associated with vegetation-free periods, where high soil mineral N concentrations may accumulate and be lost during periods of excess rainfall. Forest conversion to agricultural lands and a greater use of N-fertilizers raise the in-lake NO_3 levels (up to twice the historical mean) and cyanobacteria biomass (up to a four-fold compared to the historical mean) (Cremona et al., 2022). In southern Europe, nitrogen concentrations in lakes increase due to higher evaporation. The food web structure and functioning of cold temperate shallow lakes are expected to become more similar to those of subtropical shallow lakes, as the temperature increase will enhance the top-down controls of omnivorous and benthivorous fish as well as the nutrient cycling.

Role of lakes as sinks of greenhouse gases (GHG) weakens in warmer climate

Lakes play a crucial role in the global carbon cycle. Warmer temperatures can enhance microbial activity in lakes, accelerating the breakdown of organic matter and releasing more CO_2 and CH_4. Estonian lakes are net sinks of both CO_2 alone and the sum of CO_2 and CH_4. This is mainly caused by the predominant CO_2 sink function of Lake Peipsi forming ¾ of the total lake area and showing negative net emissions even after considering the Global Warming Potential (GWP) of other GHGs. Still, by converting CH_4 data into CO_2 equivalents, the combined emission of all Estonian lakes (8 T C day^{-1}) is turned strongly positive: 2720 T CO_2 equivalents per day. CH_4 emissions with high warming potential strongly overrule the CO_2 sink effect of lakes. (Rõõm et al., 2022).

What can we do?

Implementing policies that aim to reduce greenhouse gas emissions is essential for mitigating climate change and minimizing its impacts on lakes.

Developing and implementing adaptation strategies specifically tailored to lakes and their ecosystems can help minimize the negative impacts of climate change. Examples of adaptation measures include implementing water conservation practices, restoring wetlands, and establishing buffer zones to reduce nutrient runoff.

Enhancing water management and governance frameworks can help address the impacts of climate change on lakes. This includes developing integrated water resource management plans that consider updated climate change projections, establishing water allocation mechanisms, and implementing measures to ensure sustainable use of water resources.

As the impact of eutrophication and climate change follow the same pathways affecting nutrient availability and cascading effects in the food web, implementing scientifically based solutions in land-use planning and management strategies can help reduce nutrient runoff, sedimentation, and pollution entering lakes. This involves regulating agricultural practices, promoting sustainable forestry, and implementing measures to control urban runoff.

To reduce the risk of eutrophication and lowering of the water table of shallow lakes in Southern Europe, restrictions on the human use of water are needed. Since more than 80% of the freshwater abstraction in most Mediterranean countries is used for irrigated agriculture, this will imply less use of irrigation water, more effective irrigation and water distribution systems, and improved recycling of water, including wastewater, within catchments.

In Northern Europe eutrophication risk can be tackled best by measures reducing nutrient leakage from fields whereas more efficient water use is required in Southern Europe

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https://pk.emu.ee/struktuur/hudrobioloogiajakalandus/teadustoo/projektid/treiclake/

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