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The effects of warming and eutrophication on emissions of methane and its importance in lake food webs

Lakes, being active reactors where organic matter is transformed, stored and transported, play crucial roles in region and global carbon cycle. Organic matter deposited to lakes from the catchment is a main source of in-lake carbon and fuels microbial respiration supplying carbon dioxide (CO_2) and methane (CH_4) to lake waters. Majority of global lakes are considered CO_2 supersaturated and are regarded as source of this gas to the atmosphere. However, climate change and eutrophication may lead to stronger stratification and development of phytoplankton blooms at the surface of many lakes. This may result in CO_2 undersaturation in the upper and oxygen deficits in the lower water column. In such conditions lakes can become a significant sink for atmospheric CO_2 and emit high amounts of CH_4. Methane is an important radiative gas and having global warming potential 27 times greater than CO_2 accounts for about 25% of the planetary greenhouse effect. Lake sediments are 'hot spots' for methane production in the landscape and lakes are globally significant natural source of this gas to the atmosphere. Methane, via methane oxidizing bacteria (MOB), is also an important source of carbon for pelagic food webs. Its higher concentrations in the water column, resulting from climate warming and eutrophication may result not only in an increase of the global warming potential of lakes but also an increase in the role of CH_4 as carbon source for planktonic food webs.

Methane can be released from the sediments of the lake by diffusion or by ebullition (bubbling). The diffusive transport depends on the concentration gradients at the interface and gas transfer coefficient. The CH_4 bubbles are released in steady or episodic ebullition events depending on the energy inputs, wave motions and seasonal variability in atmospheric pressure The importance of methane as a source of carbon in pelagic food webs may depend on the prevailing methane emission pathway (diffusion or ebullition), on the activity and abundance of methane oxidizing bacterial (regulated by oxygen and nutrients), on the vertical distribution and grazing rates of zooplankton as well as their ability to exploit bacterial food. **This study aims at understanding the mechanisms regulating carbon and CH_4 cycling in lakes affected by increasing trophic status and warming.**

This project will employ an interdisciplinary approach including analyses of seasonal changes in the strength of stratification and mixing in studied lakes, rates of gas exchange between the lake and the atmosphere, determination of carbon isotopic signatures in microbes responsible for methane production and consumption as well as in zooplankton potentially feeding on these microbes. The project will consist of two parts: i) extensive field sampling of CH_4 concentrations and emissions as well as its contribution to the carbon budget of planktonic food webs in undisturbed and warmed-up lakes (Lakes Konińskie receiving heated water from the power plant), ii) closely controlled laboratory and field experiments using zooplankton species with different abilities to collect bacteria and exposed to different concentration of methane related food under stratified and mixed conditions.

The result of this project will allow to answer whether: i) the importance of CH_4 for pelagic food webs increase as a function of increasing ratio of its diffusive to ebullitive fluxes, ii) the importance of CH_4 for pelagic food webs increase as a function of eutrophication and development of oxygen deficits in the lower water column, iii) zooplankton species that are positively selective toward bacterial food benefit from higher MOB food concentrations, iv) zooplankton undergoing diurnal vertical migrations benefits from higher MOB food availability deeper in the water column and v) exploitation of MOB by one zooplankton species provides a significant competitive advantage over other species that are unable to efficiently exploit this supplementary food.