Universität Basel

Research Project

The "methane paradox" in Lake Lugano – understanding methane production in oxygenated waters of lacustrine environments

Third-party funded project

Project title The "methane paradox" in Lake Lugano – understanding methane production in oxygenated waters of lacustrine environments

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Methane (CH_4) is a potent greenhouse gas with a 25 times higher global warming potential than CO_2. Vast amounts of this gas are produced in natural wetlands and lakes. The multiple factors that control the balance between CH_4 production and consumption, and in turn regulate the emission to the atmosphere, are still not fully understood. With this proposal, we seek funding for a continuation of SNF projects 121861 and 137636, the main objectives of which were to understand the modes of, and controls on, CH_4 oxidation in the hypolimnion of eutrophic Lake Lugano. The previous efforts provided evidence for high rates of CH_4 oxidation below the oxic–anoxic interface, which was primarily attributed to micro-aerobic CH_4oxidation within the redox-transition zone in the mid-hypolimnion. Due to this efficient biological filter, only traces of CH_4 from the sediments escape into the upper water column of the lake. However, our previous work also revealed subsurface accumulations of CH_4 at the thermocline, leading to its net emissions from the lake surface into the atmosphere (up to 4600 mol day^{-1}). The "methane paradox", i.e., the persistent CH_4 supersaturation in oxic waters, was previously reported also for other lakes and the ocean, implying some unknown source of CH_4 directly in the upper water column of these environments. The C-isotopic signature of subsurface CH_4 in Lake Lugano points to biologic origin, yet the mechanisms leading to its formation remain unclear. The proposed research will aim at testing concurrent hypotheses with regards to the potential source of epilimnetic CH_4, and at understanding the controls on the spatio-temporal dynamics of CH_4accumulation in Lake Lugano. Combining field and laboratory measurements, along with the employment of stable isotopic, radio-label, and molecular analyses, we will test for: **i) CH_4 production in association with phytoplankton productivity and anoxic microsites in sinking organic matter, ii) anaerobic CH_4 production within the digestive tracts of zooplankton, and iii) the light-induced decomposition of dissolved organic carbon (photomethanification).** We will specifically investigate CH_4 production related to the exploitation (as nutrient source) and decomposition of methylated organic compounds. Some of these compounds (e.g., methylphosphonate and dimethylsulphoniopropionate) have been identified as components of phytoplankton biomass and/or metabolites during phytoplankton growth in the ocean, but their relevance in lacustrine ecosystems is unknown. Possible association between methanogens and zooplankton and/or phytoplankton aggregates will be elucidated by functional gene and lipid biomarker analysis. We will verify anticipated links between epilimnetic CH_4 accumulation, the production of methylated compounds and other substrates used during methanogenesis, as well as trophic state (i.e., nutrient availability),

phytoplankton productivity and community structure. Alternative explanations for the epilimnetic CH_4 accumulations (e.g., transport of CH_4 from the littoral zone and dissolution of CH_4 bubbles) will also be examined. We hypothesize that the epilimnetic CH_4 is primarily produced *in situ*, and that the release of CH_4 into subsurface waters of Lake Lugano is modulated by the seasonal cycle of biological production and respiration.

The proposed research will result in the first comprehensive characterization of epilimnetic CH_4 production in a deep alpine lake. It will provide a milestone in our efforts to understand the "methane paradox" in lakes, helping us to gain insight into the biogeochemical controls on global CH_4 emissions from terrestrial and aquatic environments. Finally, established links between CH_4 production and biological productivity in the modern lake can provide the basis for temporal extrapolation. The proposed work may thus grant tools to augment our ability to predict future changes in the lacustrine CH_4 emissions

Keywords methane paradox; methane oxidation; stable isotope probing; biomarker; dimethylsulphoniopropionate; methane production; zooplankton; methanogenesis; lakes; carbon isotope fractionation; phytoplankton community structures

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