Universität Basel

Research Project

Copper availability, methanobactin production and methan oxidation in two Swiss lakes: Constraints on copper acquisition by methanotrophic bacteria

Third-party funded project

Project title Copper availability, methanobactin production and methan oxidation in two Swiss lakes: Constraints on copper acquisition by methanotrophic bacteria
Principal Investigator(s) Lehmann, Moritz ;
Co-Investigator(s) Zopfi, Jakob ; Niemann, Helge ; Gademann, Karl ; Krämer, Stephan ;
Project Members Steinle, Lea ; Bartosiewicz, Maciej ; von Holtey-Schweitzer, Christian ; Oswald, Kirsten ;
Organisation / Research unit
Departement Umweltwissenschaften / Aquatic and Isotope Biogeochemistry (Lehmann)
Department
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Methane (CH4) is a potent greenhouse gas with a much higher global warming potential than CO2. A vast amount of methane is produced and stored in natural wetlands and lakes. The multiple factors that can control aerobic methane oxidation in these environments are still not fully understood. We propose an international, interdisciplinary research program between the Universities of Basel and Vienna, in which hyphenated HPLC-MS, trace-metal geochemical, isotope, biomarker and molecular microbiological techniques, applied to experimental and field samples, are combined to allow for an in-depth investigation of the role of copper (Cu) as a functional constituent of a key enzyme in bacterial methane oxidation. Of particular interest are the mechanisms of, and controls on, bacterial Cu acquisition through the release of methanobactin (MB), a Cu specific compound produced by methanotrophic bacteria to increase Cu availability and uptake. The existence of such a high affinity Cu uptake system implies that low Cu availability influences methanotrophic diversity and activity in natural environments. We propose to assess for the first time the distribution and temporal dynamics of methanobactin in two Swiss lakes, expecting new insights into the environmental controls on chalcophore production by methanotrophic bacteria and, in turn, methane oxidation under micro-aerobic conditions in lacustrine redox-transition zones. Anticipating the important role of reduced sulfur compounds in modulating Cu speciation in aquatic environments, our main goals will be to (1) address the role of sulfide as an important constraint on Cu-availability in freshwater, (2) to investigate the potential of MB exudation to increase the solubility and bioavailability of Cu- sulfides, and in turn (3) to assess whether MB production can enhance methane oxidation rates under Cu-limiting conditions in lakes. Within the frame of two PhD projects we propose the following research questions:

- Does Cu-availability impact and possibly limit aerobic methane oxidation in lakes?
- Can methanotrophic bacteria actively overcome Cu limitation through the production of methanobactin?
- Can we observe active methanobactin production in lakes and are there links between Cu, methanobactin concentrations, and methane oxidation rates?
- How does Cu/sulfide interaction influence Cu speciation in a fresh water environment, and does the kinetic stability of soluble Cu-sulfide complexes at low oxygen levels decrease the bioavailability of Cu for methanotrophs?

- Can Cu limitation trigger shifts of the lacustrine methanotrophic community composition?
  We will address these questions in a series of laboratory experiments and field measurements in the redox-transition zones of two lakes in Switzerland (Lake Lugano and Lake Cadagno). Established methods for the detection and quantification of MB will be optimized for low-concentrate analysis in the natural environment. We will search for links between Cu availability and speciation, sulfide concentrations, methanobactin production, suboxic methane oxidation rates and microbial population structure, and we will elucidate the geochemical mechanisms of bacterial Cu acquisition from sulfides. The efficiency of Cu acquisition by methanotrophic bacteria may have profound effects on the cycling of carbon and, possibly, the global climate. Furthermore, this study may be one of the starting points for research that addresses whether biochemical strategies developed by aerobic methane oxidizers to overcome Cu limitation may have been the evolutionary response to the competition for methane between anaerobic and aerobic methane oxidation.

Keywords methanobactin; biomarker; microbial community structures; sulfide; copper in lakes; redox transition zone; methane oxidation; nutrient acquisition systems; radio-label incubations; south-alpine lakes

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