Research Project

NoLaMa “No laughing matter – N2O cycling in lacustrine environments”

Third-party funded project

Project title NoLaMa “No laughing matter – N2O cycling in lacustrine environments”
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Nitrous oxide (N_2O, also known as laughing gas) has become the third most important anthropogenic greenhouse gas, after CO_2 and methane. Oceanic N_2O emissions to the atmosphere represent up to 35 % of the global natural sources. Freshwater N_2O emission are less well constrained, due to high spatial and temporal variability of aquatic N_2O fluxes from inland waters. The exact biogeochemical controls on N_2O cycling are still poorly constrained. In order to understand changes in the magnitude of N_2O fluxes from aquatic ecosystems in response to fluctuating biogeochemical conditions (i.e., redox state, dissolved nitrogen, and organic substrates), it is imperative to determine the individual contributions of the microbial (ammonium oxidation/nitrification, nitrifier-denitrification, and denitrification) and abiotic N_2O production pathways and their sensitivity to changing environmental conditions. The potential niche overlap of denitrifiers and nitrifiers along oxygen gradients, or between ammonium oxidizing bacteria and archaea in freshwater, make it difficult to distinguish between the different N_2O sources and their process-specific controls. For example, an increasing number of studies suggest that denitrification, mostly known as N_2O sink in anoxic waters, is a largely overlooked N_2O source in the suboxic water masses overlaying open ocean oxygen minimum zones. At the same time, despite the canonical view that N_2O reduction is an anaerobic process, high abundances of N_2O reduction genes and transcripts have been found in marine oxic waters indicating a potential unknown N_2O sink in surface waters. Whether such an aerobic N_2O sink exists also in lakes remained unaddressed. As for nitrification in surface/subsurface lake waters, the role of dissolved organic N compounds (i.e. urea and cyanate) as potential substrate and precursor in N_2O production is uncertain.

The aim is to identify and quantify specific N_2O production and consumption pathways in lacustrine environments, and to provide insight into the key microbial players, pathways, dynamics and environmental controls on N_2O cycling. We will shed light on the blurring redox boundaries and environmental controls (e.g., nutrient availability) that modulate net N_2O production in a lacustrine environment, where autotrophic denitrification is the dominating N loss pathway (Lake Lugano, Switzerland). The main objectives of the proposed project are to:

1) Identify the seasonal and vertical variability of N_2O consumption, on the relative importance of N_2O production processes in the water column, the abundance of process marker genes/transcripts, and the N_2O producing/consuming microbial community composition in the studied lake.

2) Assess the sensitivity of N_2O production and reduction processes to changes in dissolved nitrogen substrate and oxygen availability.

3) Determine the importance of underappreciated organic N-sources such as urea and cyanate for biotic and abiotic N_2O production in the lake water column.

We will use $^{15}N/^{18}O$-tracer incubation experiments for potential-rate estimates along with natural abundance isotope measurements of N_2O, NO_3^-, NO_2^-, and NH_4^+, which will provide an integrated signal of overlapping processes that affect the stable isotope pools of these molecules over short and longer time periods. We will combine isotope-biogeochemical results with data on abundance and community composition of N_2O producers and consumers. The results that we expect to come out of the proposed project will provide essential knowledge about the mechanistic regulation of different N_2O production pathways in aquatic environments, and will thus help to improve and validate existing and future global models predicting lacustrine N_2O emissions.

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