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Apparent isotope effects of N_2O during denitrification in two basins with differential mixing

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Nitrous oxide (N_2O) is a potent greenhouse gas with increasing atmospheric mixing ratios. Lakes play an uncertain role regarding their contribution to global N_2O emissions due to a large spatial and temporal heterogeneity. A better understanding of N_2O dynamics in lacustrine systems is needed.

Stable isotopes, $\delta^{15}N^{bulk}$ and site-specific $\delta^{15}N$, of N_2O are powerful tools to investigate N_2O production and consumption processes such as nitrification, nitrifier denitrification or denitrification. Towards a better comprehension of N_2O isotope signature generation and fractionation, we studied N_2O isotope systematics in the meromictic North (NB) and the monomictic South Basin (SB) of Lake Lugano, Switzerland, over one seasonal cycle. In the oxic water column of both basins, N_2O carried a clear signal of nitrification, characterised by a site preference ($SP = \delta^{15}N_{center} - \delta^{15}N_{outer}$) ranging from 28.2 to 35.6‰.

Denitrification (i.e. N_2O reduction) dominated N_2O isotope dynamics in the sub-/anoxic water column in both basins, accompanied by normal apparent isotope effects ε for SP (ε_{SP} = 21.6 ± 4.7‰ for NB and 5.4 ± 2.6‰ for SB) and $\delta^{18}O$ (ε_{18O} = 8.0 ± 1.5‰ for NB and 4.1 ± 2.4‰ for SB). An inverse apparent isotope effect for $\delta^{15}N^{bulk}$ of -7.0 ± 1.1‰ was found throughout the entire year in the hypoxic to euxinic waters of the NB. The SB showed an inverse apparent isotope effect for denitrification only during summer stratification, when the bottom water turned anoxic ($\varepsilon_{15Nbulk}$ = -9.3 ± 1.6‰). This inverse isotope effect for $\delta^{15}N^{bulk}$ contrasts pure culture studies and marine field studies commonly yielding a normal $\varepsilon_{15Nbulk}$ for N_2O consumption. The observed inverse isotope effect during net N_2O consumption in Lake Lugano may likely be due to simultaneously occurring N_2O production during net N_2O consumption or potentially caused by a non-canonical/non-bacterial denitrification process producing differential isotopic patterns. This will be investigated in further experiments.