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Nitrogen cycling and N_2O production in the water column of the ferruginous meromictic Lake La Cruz (Spain)

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Ferruginous meromictic lakes are rare systems, considered potential modern analogues for an ancient Archean ferruginous Ocean. They may therefore represent valuable model ecosystems to study biogeochemical processes of early Earth history, in particular, the interaction between the iron (Fe) and other element cycles such as the complex nitrogen (N) cycle. In context of its exceptional water chemistry, we studied the N-cycling in the meromictic, ferruginous Lake La Cruz in the Central Iberian Ranges in Spain, combining i) general water column chemistry and detailed N speciation ii) stable isotope composition and intramolecular ^{15}N distributions (site preference) of dissolved N_2O and iii) ^{15}N-isotope label incubation experiments, to identify and quantify biotic and abiotic N_2O and N_2 production pathways. Nitrification was identified as the main N_2O production mechanism in the oxic zone, based on the N_2O concentration profile and the isomeric composition of N_2O (site preference = 24.7‰) at the depth of maximum concentration relative to the surface water. A second N_2O peak of 23 nmol/L was observed within the chemocline, and relatively low values for the $\delta^{15}N$-N_2O (-1.1‰) and a site preference of 16.1‰ with respect to the oxic water column suggest that here incomplete (nitrifier) denitrification is the dominant N_2O production pathway. However, based on the bulk dual N-versus-O isotope signature, other production mechanisms cannot be excluded at this point. Within the anoxic water column, N_2O is consumed quantitiatively to N_2, consistent with ^{15}N-NO_3^- incubation experiments, showing denitrification (and anammox) activity below the redox transition zone. The overlap of Fe and N-species (N_2O, NO_2^-) in the water column is small, therefore abiotic N_2O production is most likely negligible. The planned analysis of the NO_3^- and NH_4^+ isotopic signatures will provide further insight into the origin of N_2O. Additionally, molecular biological analyses will provide information on the microbial community structure, particularly of nitrifying, denitrifying and anammox bacteria.

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