Isotopic signatures of biotic and abiotic N2O production and consumption in the water column of meromictic, ferruginous Lake La Cruz (Spain)

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Author(s) Tischer, Jana; Zopfi, Jakob; Frey, Claudia; Magyar, Paul M.; Brand, Andreas; Oswald, Kirsten; Jegge, Corinne; Frame, Caitlin H.; Miracle, María R.; Sòria-Perpinyà, Xavier; Vicente, Eduardo; Lehmann, Moritz F.
Author(s) at UniBasel Frey, Claudia ; Tischer, Jana ; Zopfi, Jakob ; Lehmann, Moritz ;
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Lakes can be important sources of the potent greenhouse gas nitrous oxide (N 2 O) to the atmosphere, but to what extent abiotic processes may contribute to lacustrine N 2 O production remains uncertain. We assessed pathways of N 2 O production and reduction in the water column of meromictic and iron-rich Lake La Cruz, Spain, including chemodenitrification-induced N 2 O formation via the reaction of reactive nitrogen (N) (e.g.,) with ferrous iron (Fe[II]). In the oxic waters (8-10 m), N 2 O concentrations above atmospheric equilibrium were associated with comparatively low δ 15 N-N 2 O, high δ, and high N 2 O 15 N-site-preference (SP) values (up to 29ý), suggesting N 2 O production by nitrification. N 2 O concentrations were highest (23-33 nM) near the depth of oxygen depletion (11-14.5 m), likely due to production by nitrifier denitrification and/or denitrification, as indicated by decreasing SP values (as low as 12ý). Further below (14.5-17 m), N 2 O consumption was indicated by increasing SP values and a δ 18 O-vs.-δ 15 N relationship (1.8-2.9) typical for stand-alone N 2 O reduction. The coupled N-vs.-O isotope signatures thus highlight the spatial, redox-dependent separation of incomplete and complete denitrification. In incubations with sterile-filtered lake water and 15 N-labeled or unlabeled substrate, was reduced by Fe 2+ to N 2 O, even at low nitrite concentrations (5 μ M). In the water column, the spatial separation of and Fe(II) during our samplings appears to preclude elevated rates of chemodenitrification, but during periods of overlapping and Fe(II) in Lake La Cruz, and potentially in other lakes, its distinct N 2 O δ 18 O-vs.-δ 15 N relationship of 1 : 1, as experimentally determined, could help to detect it.
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