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Natural attenuation processes of nitrate in a saline lake-aquifer system: Pétrola Basin (Central Spain)

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Saline wetlands associated with intense agricultural activities in semi-arid to arid climates are among the most vulnerable environments to NO_3^- pollution. The endorheic Pétrola Basin (High Segura River Basin, Central Spain) was declared vulnerable to NO_3^- pollution by the Regional Government of Castilla-La Mancha in 1998. The hypersaline lake was classified as a heavily modified waterbody, due to the inputs of pollutants from agricultural sources and urban waste waters, the latest are discharged directly into the lake without proper treatment.

Previous studies showed that the aquifer system has two main flow components: regional groundwater flow from recharge areas into the lake, and a density-driven flow from the lake to the underlying aquifer. The NO_3^- inputs derived from agriculture originate from nitrification of synthetic ammonium fertilizers, and afterwards, NO_3^- is expected to be attenuated by denitrification (up to 60%) in the saltwater-freshwater interface around the lake. However, the spatial and temporal pattern of nitrate reduction in lake sediments is not known.

In this study, an isotope pairing technique was used in order to clarify the main pathways for the NO_3^- attenuation linked to the sediment-water interface. For that purpose mesocosm experiments were performed: organic-rich lake sediment (up to 23% organic carbon content) was incubated for 96 hours with the addition of 15N nitrate tracer. During the experiments two factors were modified: light and oxic conditions. Analyzing inorganic N-species (n=20) over time (72 hours) showed that NO_3^- attenuation was coupled with an increment in the NH_4^+ concentration (from 0.8 mg/L up to 5.3 mg/L) and a decrease in redox values (from 135.1 mV up to -422 mV) in the water column.

The main outcome of this study was to elucidate the importance of different microbial pathways denitrification, dissimilatory nitrate reduction to ammonium (DNRA) and anaerobic ammonium oxidation (Anammox), in controlling the fate of NO_3^- in Pétrola Lake. The complete attenuation of 250 μmol of NO_3^- occurred during the first 30 hours of incubation under all the treatments, coupled to a temporal increase in the NO_2^- concentration. The results will support the understanding how hypersaline lakes are able to respond to elevated nutrient loads.