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Hydrodynamic and geochemical controls on denitrification rates and products in wetland soils

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Denitrification requires both organic carbon (C) as an electron donor and Cu as an enzyme cofactor in NosZ. C availability is already a known control on denitrification, but Cu availability in certain conditions could be a limiting factor to NosZ synthesis and lead to enzyme inactivation. In wetland environments, iron oxides are constantly undergoing dissolution and precipitation, all the while generating coprecipitates of C and Cu that alters the availability of these species to microorganisms. Two types of experiments were established, first with microcosms to explore the role of Fe and C coprecipitation on Cu and C availability to denitrifiers, and second, column scale hydrodynamic experiments to measure net denitrification at a fixed Fe:C ratio. Microcosms were established with various ratios of Fe, C (with either humic acids and/or simple sugars), Cu and a fixed concentration of NO_3^- in solution with some wetland soil slurry. Systems were allowed to react for 24 hours, then flushed with He. Measurements of CO_2 and N_2O were taken to measure denitrification and carbon mineralization rates. Under conditions with Fe added, available Cu concentrations dropped by about 85%. Generally, those same conditions resulted in higher N_2O fluxes, in one case with up to 8-fold higher rates, suggesting an impact on denitrification rates due to Cu availability. When establishing soil columns with floodplain soils with fixed typical Fe, C and NO_3^- concentrations and some with added labile C, we examined the difference in denitrification rates over varying flooding hydroperiods. In this case, net denitrification was measured using a membrane inlet mass spectrometer. Results showed that denitrification rates were heavily influenced by hydroperiod and carbon availability, and carbon availability played a larger role during longer hydroperiods. Rates of denitrification after 2 days of flooding increased by about 2-fold, or 5-fold with added C, and after 3 days by about 10-fold and 80-fold with added C. While extended hydroperiods may increase net denitrification, the availability of C and Cu based on the soil Fe conditions play a role in the magnitude of change and the proportion of N_2O produced in the process.