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MICROBIAL IRON AND NITRATE REDUCTION IN UNSATURATED SOILS FOLLOWING REWETTING

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Microbial iron (Fe) redox cycling has been well studied in saturated systems and is often coupled to nitrogen cycling through processes such as nitrate-dependent Fe(II) oxidation. Few studies have investigated these processes in unsaturated systems, such as agricultural soils impacted by nitrogen fertilization. To determine the impact of these processes in unsaturated systems, soil was collected from an agricultural field with a history of nitrogen fertilization. Homogenized soils, collected following an irrigation event, served as the inoculum in a series of anoxic (100% Ar) batch reactors containing simulated groundwater medium (pH 7) and synthetic ferrihydrite (20 mmol•L^{-1}), a Fe(III) oxide, or reactors with no Fe(III) oxide amendment. The soils were preincubated for 48 hours prior to nitrate amendment (0 mM, 0.25 mM, or 2 mM). No significant increase in Fe(II), indicative of Fe(III) reduction, was observed during the preincubation. Following an anoxic amendment of nitrate, Fe(III) reduction was observed in all treatments with concomitant nitrate reduction. No significant production of nitrite was observed. However, transient accumulation of nitrous oxide was measured resulting in the production of dinitrogen gas. Most probable number enumeration of the soils revealed that microorganisms capable of dissimilatory iron reduction (4.59×10^5 cells•g^{-1}, acetate as electron donor) and fermentative iron reduction (2.62×10^7 cells•g^{-1}, acetate, lactate, and glucose) were abundant, together with nitrate reducers (4.62×10^9 cells•g^{-1}). The observation of concurrent nitrate and iron reduction was not expected as nitrate has been demonstrated to inhibit iron reduction or stimulate oxidation of Fe(II). Given the abundance of fermentative iron reducing bacteria, a subsequent experiment was conducted with an electron transport chain inhibitor, sodium azide (0.65 mM). Batch reactors in which azide was omitted were observed to concurrently reduce nitrate and Fe(III). Whereas azide amended treatments inhibited nitrate reduction while Fe(III) reduction continued, but was lower by ~5 mmol•L^{-1} relative to the unamended control. Together these data suggest that fermentative iron reduction could play a significant role in the reduction of iron in unsaturated soils and could be a factor influencing iron redox cycling following periods of precipitation or irrigation in unsaturated soils.