How Redox Fluctuation Shapes Microbial Community Structure and Mineral-Organic Matter Relationships in a Humid Tropical Forest Soil

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Project Goals: **This Early Career research examines the genomic potential and expression of tropical soil microorganisms as they experience shifts in soil temperature, moisture, and depth and oxygen availability. By also tracking the degradation and fate of organic carbon compounds, this work will increase the accuracy of predictions about how microbial processes affect whether organic carbon is retained or lost from tropical systems. The mechanistic understanding produced by this research will directly benefit attempts to improve the predictive capacity of mathematical models that forecast future tropical soil carbon balance.**

Wet tropical soils can alternate frequently between fully oxygenated and anaerobic conditions, constraining both the metabolism of tropical soil microorganisms and the mineral-organic matter relationships that regulate many aspects of soil C cycling. Tropical forests are predicted to experience a 2–5°C temperature increase and substantial differences in the amount and timing of rainfall in the coming half century. Yet we have a poor understanding of how soil microbial activity and C cycling in these systems will respond to changes in environmental variability caused by climate change. Using a 44 day redox manipulation and isotope tracing experiment with soils from the Luquillo Experimental Forest, Puerto Rico, we examined patterns of tropical soil microorganisms, metabolites and soil chemistry when soils were exposed to different redox regimes - static oxic, static anoxic, high frequency redox fluctuation (4 days oxic, 4 days anoxic), or low frequency redox fluctuation (8 days oxic, 4 days anoxic). Replicate microcosms were harvested throughout the incubation to understand how changes in redox oscillation frequency altered microbial community structure and activity, organic matter turnover and fate, and soil chemistry. While gross soil respiration was highest in static oxic soils, respiration derived from added fresh litter was highest in static anoxic soils, suggesting that decomposition of preexisting SOM was limited by O_2 availability in the anoxic treatment. Microbial communities responded to shifting O_2 availability in the different treatments. Specifically, community composition in the anoxic treatment enriched for many members in Proteobacteria and Firmicutes relative to the initial community. Additionally, we measured significant differences in DOC concentration and molecular composition (measured by FTICR-MS) corresponding to O_2 availability. DOC and Fe^{2+} concentrations were positively correlated for all four redox treatments, and rapidly increased following oscillation from oxic to anoxic conditions. Prolonged anoxia led to the reductive dissolution of Fe oxides, thereby increasing DOC availability. Fe reduction coupled to OM decomposition may help to explain the rapid turnover of complex C molecules in these soils. These results, along with parallel studies of biogeochemical responses (pH, Fe speciation, P availability), suggest a highly responsive microbial and geochemical system, where the frequency of low-redox events controls exchanges of C between mineral-sorbed and aqueous

pools. Our findings highlight the need for a more explicit representation of soil redox dynamics in our understanding of C cycling in dynamic tropical forest ecosystems.

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