The Impact of Redox Fluctuations on Mineral-Organic Matter Associations and Microbial Carbon Transformations in Tropical Forest Soils

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Redox oscillations prime tropical soils for rapid C and Fe cycling, and regulate mechanisms of both C stabilization via mineral sorption or loss via leaching. Using a 44-day redox manipulation and isotope (^{13}C) tracing experiment with soils from the Luquillo CZO in Puerto Rico, we examined patterns of tropical soil chemistry, metabolites and microorganisms under static and fluctuating redox regimes. Prolonged anoxia led to the reductive dissolution of Fe oxides, thereby increasing DOC availability. The unique instrumental capability of STXM/NEXAFS in combination with nanoSIMS on ^{13}C hotspots revealed that oxic and anoxic soils differ in C functionalities from the pure ^{13}C litter indicating the differential degree of SOM decomposition. Anoxic soils showed an accumulation of aromatic components and a potential role of Fe-OM interactions. Gross soil respiration was highest in static oxic soils. However, ^{13}C-litter derived respiration was highest in static anoxic soils, suggesting decomposition of pre-existing SOM was O_2-limited in the anoxic soils. Proteobacteria, Acidobacteria, and Firmicutes were significantly enriched under these anoxic conditions indicating an increase in microbial contributions to Fe cycling. These results suggest a highly responsive biogeochemical system, where the periodicity of the low redox moments may control the fate of C in wet tropical soils.