The impact of redox fluctuations on soil organic matter decomposition in tropical forest soils

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Redox oscillations prime tropical forest soils for rapid carbon (C) cycling, and constrain the mechanisms of soil organic C (SOC) stabilization (decomposition, mineral sorption) and loss (leaching, CO_2 emissions). However, the fate of SOC under dynamic redox conditions is not well understood. Using a 44-day redox manipulation and isotope (^{13}C) tracing experiment with soils from the Luquillo Experimental Forest in Puerto Rico, we examined patterns of tropical SOC chemistry, metabolites and active microbial decomposers under static and fluctuating redox regimes. The DOC pool was largest under static anoxic conditions, while 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 under consistently anoxic conditions. 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. Proteobacteria, Acidobacteria, and Firmicutes were significantly enriched under anoxic conditions. Quantitative stable isotope probing data suggest that microbial taxa assimilated litter C differentially under different redox conditions and the most "active" microorganisms were not necessarily the most abundant ones. Our results suggest that wet tropical soils are a highly responsive geochemical system, where shifts in local E_h conditions lead to differential soil organic matter decomposition pathways and C flux rates.