

The influence of manganese redox cycling on soil carbon stability

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Soil organic matter (SOM) is the largest reservoir of potentially dynamic carbon (C) on Earth, with more than three times the quantity as in the atmosphere. Even a small tip of the balance between SOM formation and SOM decomposition can have disproportionate effects on the concentration of CO₂ in the atmosphere, and so on climate. Most C in SOM is in pools that turn over slowly, due to chemical recalcitrance and/or physical protection. Evidence suggests that manganese (Mn) can enhance SOM decomposition, including pools thought to degrade slowly. This influence depends on the metal's abundance and oxidation state. When soil redox conditions fluctuate, Mn cycles through Mn(II), Mn(III), and Mn(IV). Microbes can couple Mn reduction and oxidation across oxic-anoxic interfaces in soil pores, generating Mn(III), a potent oxidizer that can degrade SOM and release C. Mn(III) is unstable, however, and must be coupled to low-molecular-weight organic acids to persist long enough in soil to interact with SOM. Studies on the relationship between Mn and soil C stability have investigated Mn in forest litter. It remains unclear what environmental conditions promote the tight coupling of Mn cycling and POM oxidation and if the same relationship between Mn and litter degradation observed in forests exists in other ecosystems.

We address these questions using the Kohala climate gradient on the Island of Hawai'i (<300 to >3300 mm/yr rainfall). We hypothesize that climate is the dominant control of Mn oxidation state and availability, and so of Mn-cycling microbial community compositions and activities on the Kohala gradient. To test this hypothesis, we analyze how Mn availability, Mn-cycling microbial gene abundance and activity, and soil C abundance and composition change with climate.

Preliminary data (ICP-OES, XANES, TOC, and fungal-enzyme-activity measurements) indicate bioavailable Mn negatively correlates with soil OC where Mn cycling is most active. These data and our further research will clarify the mechanisms and environments that potentiate Mn redox cycling, indicating how much and where soil C is most vulnerable to Mn oxidation. Such information will offer insight as to how and where soil C previously thought protected may be lost.