Investigating nutrient controls over microbial activity in tropical soils

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The Amazon rainforest is an important sink for atmospheric CO₂ counteracting increased emissions from anthropogenic fossil fuel combustion and land use change storing large amounts of carbon in plant biomass and soils. However, large parts of the Amazon Basin are characterized by highly weathered soils (ultisols and oxisols) with low availability of rock-derived phosphorus (and cations), which are mostly occluded in soil or bound in organic matter. Such low phosphorus availability is thought to be (co-)limiting plant productivity. However, much less is known whether low phosphorus availability influences the activity of heterotrophic microbial communities controlling litter and soil organic matter decomposition and thereby long-term carbon sequestration in tropical soils.

In tropical soils high temperature and humid conditions allow overall high microbial activity. Over a larger soil phosphorus fertility gradient across several Amazonian rainforest sites, at low P sites almost 40 % of total P was stored in microbial biomass, highlighting the competitive strength of microorganisms and their importance as P reservoir. Across all sites soil microbial biomass was a significant predictor for soil microbial respiration, but mass-specific respiration rates (normalized by microbial biomass C) rather decreased at higher soil P. Using the incorporation of 18O from labelled water into DNA (i.e., a substrate-independent method) to determine microbial growth, we found significantly lower microbial growth rates per unit of microbial biomass at higher soil P. This resulted in a lower microbial carbon use efficiency, at a narrower C:P stoichiometry in soils with higher P levels, and pointed towards a microbial co-limitation of phosphorus and carbon at low soil P levels. Furthermore, data from a multi-year nutrient manipulation experiment in French Guiana and from short-term lab incubations suggest that microbial communities thriving at low P levels are highly efficient in taking up and storing added P, but do not necessarily respond with increased growth.

Soil microbial communities play a crucial role in soil carbon and phosphorus cycling in tropical soils as potent competitors for available P. They also play an important role in storing and buffering P losses from highly weathered tropical soils. The potential non-homoeostatic stoichiometric behavior of microbial communities in P cycling is important to consider in soil and ecosystem models based on stoichiometric relationships.