TROPICAL PEATLAND BIOGEOCHEMISTRY ALONG AN ECOLOGICAL TRANSECT: THE ENIGMATIC FATE OF ORGANIC MATTER

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Introduction

Peatlands play a pivotal role in the global carbon cycle. Despite only covering 3% of the world's surface, peatlands hold 500-700 Gt of carbon (Page & Baird, 2016). These dense carbon stocks are sensitive to direct and/or indirect human intervention and can quickly turn from carbon sink to carbon source when perturbed. Additionally, peat deposits are crucial for our understanding of terrestrial environmental change by recording environmental parameters such as temperature and biogeochemical cycling through geological time (Naafs *et al.*, 2019). Constraining the magnitude and rate of change during past periods of climatic change in the terrestrial realm is essential for accurately predicting the effects of anthropogenic global warming.

Most peatland studies have focussed on reconstructing environmental parameters such as water table depth, temperature, vegetation, and pH, because those are readily available through quick observation or meteorological data. However, changes in the nature of the organic matter (OM) is often harder to characterize but is imperative to the tight balance between accumulation and degradation of peat. Especially in tropical peatlands, the nature of OM is largely understudied. Tropical peats are more carbon-dense compared to boreal peatlands, have a more active methane cycle, and can have a wider range of vegetation, which makes understanding their biogeochemistry vitally important.

We investigated the biogeochemistry of a tropical peat along an ecological transect consisting of 5 sites: mangrove, mixed tropical forest, hardwood tropical forest, stunted forest with sawgrass and ombrotrophic (i.e., rain-fed) sawgrass bog. From each site, a 1-2 meter core was collected and analysed by pyrolysis-GC/MS, GC/MS (of apolar and polar fractions), 16S rRNA genomic profiling and, UPLC-QToF-MS. Our unique dataset allows for a direct comparison of the biogeochemistry of tropical peats under different vegetation and nutrient concentrations, but constant temperature.

Bulk organic matter characterization

Our pyrolysis-GC/MS data reveals that the transition from a forested peatland to an ombrotrophic saw grass bog is not associated with a decrease in lignin content, despite a major change in vegetation. Instead, downcore variation and degradation overwrites the vegetation signal. In future work we hope to explain the weak impact of the vegetation change along our tropical ecological transect.

Vegetation biomarker distributions

Although the bulk OM content appears uniform, there are hints of a different chemical composition on the molecular scale along our tropical transect. In particular, the sedge-specific *n*-alkyl resorcinol occurs in highest abundance in the sawgrass (part of the sedge family) dominated sites, confirming a contribution from these plants to the bulk OM pool. All sites contained abundant leaf waxes (long chain *n*-alkanes, fatty acids, *n*-alcohols), but they mainly occur in shallow horizons and their concentrations dramatically decrease downcore due to intense degradation.

Organic matter degradation

The tropical peats are characterized by rapid degradation of OM, with peat accumulation driven by very high OM production that overwhelms the intense degradation, for example due to high litter production (in contrast to temperate and boreal peatland which are mainly controlled by slow degradation rates). Therefore, we also explored biomarker proxies for OM degradation. One such proxy is the carbon preference index (CPI) for long-chain *n*-alkanes. In our transect, CPIs are lower in the tropical ombrotrophic compared to the forested sites, but the decline downcore are of the same order of magnitude, suggesting that temperature and vegetation as well as microbial degradation impacts the CPI in peatlands.

The C_{31} hopane stereochemistry, specifically the ββ/(αβ+ββ) ratio, undergoes pH-mediated transformation in peats (Inglis *et al.*, 2018). All our tropical sites have a low and stable pH (3-5), such that this transformation was rapid in the uppermost cm of the peat core with low ratios below. More interesting is the 22S/(22S+22R) ratio, which increased (0 to 0.25) between the tropical forest to bog site, implying an additional control influencing the hopane stereochemistry.

Further evidence for intense OM degradation is the high abundance of aromatic triterpenoids. These are derivatives of triterpenoids (ursanoids, lupanoids) often found in angiosperms, and they are formed via microbially-mediated aromatization under acidic conditions. In our sites, this aromatization is very rapid, with aromatic triterpenoids becoming dominant biomarkers in the anaerobic catotelm. This transformation appears to be far more rapid than previously observed in temperate peats, consistent with evidence for very rapid OM degradation and alteration in tropical peatlands.

Microbial community

The microbial community is crucial to the degradation and remineralization of OM in peats. The 16S rRNA data from our sites as well as preliminary intact polar lipid and bacteriohopanepolyol assemblages show a radical change in the microbial community between the aerobic accrotelm and anaerobic catotelm, shifting from a bacteria-dominated community to a archaea-dominated community. Moreover, genomic and biomarker analyses indicate profound differences between the tropical and temperate peatland microbiome. Future work will focus on exploring the competing roles of environment and OM quality on the abundance and diversity of the peatland microbiome. And specifically, the role of OM composition on tropical peatland preservation, biogeochemistry and recovery.

References

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