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Oxygen Variability Elicits Differential Responses in Microbial Carbon Mobilization across Wetlands: Implications for Wetland Resilience Under Hydrological Regime Shifts

LINTA REJI AND XINNING ZHANG

Princeton University

Presenting Author: lreji@princeton.edu

Wetlands disproportionally store ~30% of the terrestrial carbon stock despite covering only ~7% of the land area. Microbial activity can release this carbon, and thus, contribute to the emission of potent greenhouse gases (GHGs) such as methane (CH_4) and carbon dioxide (CO_2). A direct control on wetland GHG emissions is hydrology – variable oxygen (O_2) saturation resulting from dynamic hydrological conditions (e.g., water-table movement, dry-wet oscillations) can alter microbial metabolic interactions, leading to significant changes in carbon mobilization and GHG emissions. Here, we examine the effect of O_2 exposure on GHG emissions in diverse wetland types spanning a range of organic carbon content and composition, including organic-rich peat, mineral-soil marsh, and saltmarsh. We utilize a microcosm perturbation approach involving temporally resolved geochemical measurements coupled with molecular characterization of the microbial community dynamics.

In microcosm incubations of Tree Moss (*Climacium dendroides*) peat and mineral soil marsh sediments subjected to a week of O_2 exposure, we observed little change in CH_4 yields as a result of the redox shift. This was in stark contrast to *Sphagnum* peat, in which transient O_2 exposure significantly altered the microbial community structure and led to a 55-fold higher CH_4 yield compared to continuously anoxic controls. Geochemical data point to a fundamentally different microbial mechanism regulating the flow towards CH_4 in Tree Moss peat and marsh systems compared to that in *Sphagnum* peat. CH_4 was not detected in the saltmarsh incubations, however, O_2 shift led to significant, long-lasting changes in both geochemistry and the microbial community structure, indicating lower resilience to redox fluctuations. While Tree Moss peat and freshwater marsh systems appear to be much more resilient to O_2 shifts compared to saltmarsh and *Sphagnum* peat, ongoing work is examining the threshold disturbance level (i.e., the duration and strength of O_2 exposure) required to shift the resilience patterns in these wetland types. Our data suggest that microbial community composition can be a powerful indicator of wetland responses to pulse disturbances, in this case, hydrology-associated changes in O_2 saturation. We discuss the implications of our results on wetland function under anthropogenic influences of climate change, pollution, and conservation.