Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36323

Iron-Mediated Transformation of Organic Carbon in Ombrotrophic Peatlands of the Lake Superior Basin

KYOUNGLIM KANG[1,2], CLAIRE SIMMERMAN[1], DR. EDWIN RIVAS MERAZ, PH.D.[1], MATTHEW A MARCUS[2], DAVID SHAPIRO[2] AND BRANDY TONER[1]

[1]University of Minnesota
[2]Lawrence Berkeley National Laboratory

Northern peatlands are carbon-rich ecosystems in which organic matter production exceeds decomposition. These systems store approximately 390–455 Pg of carbon (C), nearly one-third of the terrestrial soil C pool. However, increasing evidence suggests that this balance is destabilizing, leading to increased C export to the atmosphere (e.g., CO_2 and CH_4) and to downstream surface water as dissolved organic matter.[1] For instance, organic carbon (OC) concentrations in peatland-draining waters have increased by 30–80% over the past two decades in North America. Understanding the processes controlling OC composition, reactivity, and stability during transport from organic-rich peatlands to mineral-rich stream and lakes is therefore critical.

The Marcell Experimental Forest (MEF) in the Lake Superior Basin consists of ombrotrophic peatlands characterized by acidic conditions (pH ~4), low mean annual temperature (3.6 °C), variable oxygen availability in outflow waters, high organic matter, and low mineral content.[2] Despite limited mineral inputs, previous studies report that a substantial fraction of OC is associated with iron (Fe).[3] Iron may stabilize OC through complexation and mineral association, but can also promote oxidative transformation. The balance between these competing mechanisms in mineral-poor wetlands remains poorly constrained.

We characterized MEF outflow waters to investigate Fe–OC associations and speciation and compared field samples with laboratory-synthesized Fe–humic complexes using scanning transmission X-ray microscopy (STXM). STXM revealed heterogeneous C–Fe distributions, with Fe localized in C-rich domains while much of carbon remained dispersed. Carbon K-edge XANES showed that Fe-associated carbon exhibited enhanced carboxylate features (up to 8% increase) and reduced aromatic (up to 16.3% decrease) and phenolic (up to 14% decrease) signals, indicating preferential coordination of carboxyl groups to Fe. Iron L-edge spectra revealed mixed Fe(II)/Fe(III) speciation (16% Fe(II), 84% Fe(III)) in outflow samples. Consistent with field observations, laboratory-generated Fe–humic samples showed that C associated with Fe(III) phases displayed enhanced carboxylate signatures and diminished aromatic character. These results suggest that Fe interactions promote selective C transformation, thereby influencing its persistence, reactivity, and downstream availability in aquatic systems.

[1]Hanson, J. et al, 2020, doi.org/10.1029/2020av000163., [2]Sebestyen, D. et al, 2021, doi.org/10.25581/spruce.088/1775142, [3]Curtinrich, J. et al, 2022, doi.org/10.1007/s10021-021-00639-3