

Iron-rich peatlands as hotspots of organic carbon export to polar aquatic ecosystems

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Northern peatlands store approximately 500 Pg of organic carbon (OC),¹ with iron mineral interactions stabilizing 25% of this pool. As the climate warms, this previously stable carbon sink may shift to a net carbon source, releasing CO₂ and CH₄ and amplifying global warming. While most studies on OC loss in polar soils focus on vertical fluxes (e.g., emissions to the atmosphere),^{2,3} lateral fluxes^{4,5}—where mineral-associated OC is mobilized and transported to aquatic ecosystems—remain understudied. These lateral transport processes, however, are critical for understanding future carbon dynamics in polar environments.

This study examines the riverine export of OC from an iron-rich peatland in Iceland, serving as a natural analogue for thawing peatland-draining rivers. We investigate the formation of natural iron colloids in the wetland and the partitioning and composition of OC in these phases. Fe K-edge X-ray absorption spectroscopy (XAS) and infrared (IR) analyses reveal that Fe-OC flocs consist of short-range ordered Fe nanophases with molecular signatures indicative of microbial-derived OC. Using C K-edge μ -XAS, we show that carboxylic and aromatic OC become enriched as these flocs travel downstream, while bioavailable OC (e.g., polysaccharides) is rapidly depleted. Additionally, size exclusion chromatography (SEC) indicates progressive (bio)degradation of peat-derived humic-like OC along the river transect.

These findings provide new molecular-level insights into key biogeochemical processes in polar peatland-river systems, specifically: (i) the mechanisms governing Fe-OC floc formation, (ii) the transformation of OC during transport from terrestrial to coastal ecosystems, and (iii) the potential implications for nutrient delivery to Arctic oceans.

References:

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