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Uncovering the role of microbial degradation and soil organo-mineral controls on dissolved organic matter composition at the terrestrial-aquatic interface

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Boreal ecosystems house about a third of the Earth's forests whose underlying soils are a major contributor to the global carbon (C) storage. The fate of the organic matter (OM) along the terrestrial to aquatic continuum can represent an important component of the C cycle in boreal landscapes. Fluxes of dissolved OM (DOM) from boreal soils to inland waters are affected by hydrological connectivity and water residence time (WRT) influencing rates of microbial and organo-mineral transformations impacting DOM composition. Understanding how DOM composition relates to these biogeochemical processes would enable tracking of where and how these transformations occur across the terrestrial-aquatic interface. Our research assessed how microbial degradation and soil physiochemical processes mediate terrestrial DOM compositional change. To that end, we devised two incubation experiments using field collected boreal forest soil lysimeter water from the Pynn's Brook Experimental Watershed in Newfoundland, Canada. The first incubation subjected the lysimeter water to microbial degradation tracking its influence on DOM composition. The second experiment exposed mineral soils of different bulk densities to rounds of lysimeter water addition to understand the influence of organo-mineral controls on DOM (i.e. co-precipitation with Al, adsorption to organo-mineral complexes). In both instances we obtained measurements of total hydrolysable amino acids (THAA) and optical properties to evaluate the DOM transformations. Results from both experiments demonstrated overall losses of DOC, and in soils with lower bulk density, i.e., of longer WRT, such loss is dominated by aromatic C-rich compounds. Contrasting with enrichment in aromatic-rich DOC with biological degradation, this indicates a marker useful in tracing organo-mineral controls on DOC transport. Observed trends in THAA composition indicate distinct transformations of DON associated with increased microbial activity and enhanced organo-mineral interactions with longer soil WRT. Losses in THAA occurred with enhanced organo-mineral interactions and lead to a unique pattern in THAA composition distinct from biologic degradation. Our work suggests optical and biomarker approaches that can be combined to evaluate the mechanisms by which WRT controls DOM transformations at the terrestrial-aquatic interface. Application of these approaches can inform on the fate of soil OM and DOM delivery to inland waters in boreal ecosystems.