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ENVIRONMENTAL FACTORS REGULATING SOIL ORGANIC CARBON STORAGE IN PERMAFROST ECOSYSTEMS

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On predicting effects of climate change on permafrost ecosystem carbon, soil organic carbon (SOC) storage could account for considerable fraction of ecosystem C pool. The biomass production and SOC storage can generally be regulated by climate, but their responses to climate change can be variable between ecosystem types. Soil organic carbon storage can be influenced by water drainage of active layer as well as cold climate. In addition, decomposition rates of organic matter can also be influenced by substrate quality (roots and bryophytes) and microbial decomposition activity in permafrost soil. We analyzed environmental factors regulating SOC storage across different ecosystem types in Northwest Territory, Canada; white spruce forest (WSF) on the upland soil derived from glaciofluvial sands, black spruce forest (BSF) and tundra (TND) in lower position on fluvial sediments. We measured SOC storage, soil temperature and moisture, aeration index [Eh, reducible iron (Fe) oxides] of soils, and the decomposition rates of litter (lichen, moss, and root litter) and cellulose filter paper buried in the soils. Episodic flooding events were observed following spring snowmelt. Rapid snowmelt and water percolation enhanced aeration in the sandy soil in WSF, while the BSF and TND soils were saturated by water flooding on impermeable permafrost layer. The seasonal cycles of reducing- and oxidizing- conditions were recorded as accumulation of free Fe oxides (oxalate-extractable Fe). Mass loss rates of cellulose filter paper and root litter were lower in the BSF and TND soils than in the WSF soil. Water flooding and cold climate retarded decomposition of organic matter in lower position of BSF and TND. The development of hummocky soil micro-topography, which was recorded as the tilting of drunken forest, resulted in accumulation of sparingly-decomposable lichen debris in the drier position and accumulation of moss debris in wetter position. The thick layers of lichen and moss debris in BSF appeared to limit deep melting of permafrost soil during summer. The warmer and aeration condition in sandy upland soil of WSF enhanced organic matter decomposition and contributed to rapid turnover of organic layer. The SOC storage in BSF and TND soils under cold and unaerated conditions were significantly ($p < 0.05$) greater than in WSF soil. The contribution of organic layers to SOC storage increased with decreasing temperature and elevation. When the regression analysis was conducted using the dataset from the other eleven soil profiles, there was a positive correlation between SOC storage and free Fe oxides. The low temperature and water saturation can increase SOC storage in permafrost soils. The content of oxalate-extractable Fe in soils can be a proxy for drainage condition and SOC storage of permafrost ecosystems.