Iron, manganese and aluminum solubility with permafrost thaw in an Arctic peatland: coupled geochemical and geophysical measurements

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With permafrost degradation due to the increase in air temperature in high latitudes, previously frozen soil organic carbon (OC) becomes vulnerable to mineralization which reinforces the global warming through the release of greenhouse gases. Between 30 and 80% of soil OC in permafrost environments can be stabilized by interactions with mineral surfaces or metals such as iron (Fe), manganese (Mn) and aluminum (Al). The objective in this study is to quantify the influence of permafrost degradation on the solubilization of Fe, Mn, Al and the associated OC released in soil pore water. Along a thaw gradient in Abisko, Sweden (palsa-bog-fen), the following geophysical parameters were collected: elevation, active layer depth, soil water content (SWC), soil temperature and soil electrical conductivity (EC). They were measured continuously for 20 days and coupled with the chemical composition of the soil pore water. The results suggest that (i) at the profile scale, elevation, active layer depth and SWC are relevant geophysical parameters to distinguish palsa from bog from fen; (ii) permafrost degradation leads to the solubilization of iron (1 $mg.L^{-1}$ for palsa, 10 $mg.L^{-1}$ for bog and 13 $mg.L^{-1}$ for fen) and DOC (44 $mg.L^{-1}$ for palsa, 55 $mg.L^{-1}$ for bog and 71 $mg.L^{-1}$ for fen) in soil pore water; (iii) at the slope scale, landscape areas can be classified as palsa, intermediate or fen based on the three relevant geophysical criteria found at the profile scale. The classification can hence be used to identify correlations between iron and DOC (r^2 = 0.11 (palsa), 0.22 (bog), 0.60 (fen)) and further for Mn et Al. The data support that physical changes in soils caused by permafrost thaw and subsequent changes in SWC from palsa to fen controls the stability of mineral-OC interactions.

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