Mineral element and organic carbon transport from permafrost soils to a headwater stream under contrasting flow regimes and permafrost degradation

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Organic carbon transport from permafrost soils to headwater streams is an important vector in the quantification of permafrost soil organic carbon (SOC) stocks, with 5.4 % of SOC lost per year by lateral transport at Eight Mile Lake, Alaska[1]. A portion of SOC is transported as dissolved organic carbon (DOC), comprising micron to nano-sized organic carbon and organic carbon bound with mineral elements. These DOC pools are transported unaltered into headwater streams or transformed, (e.g. by metabolism and photo-oxidation) perturbing the initial SOC composition. Here we ask: how do temporal changes in hydrology and permafrost degradation effect mineral element-bound DOC transport from permafrost soils to streams at Eight Mile Lake, Alaska?

Fe, Al and DOC concentrations were determined in the colloidal (0.22 µm – 1 nm) and truly dissolved (< 1 nm) fractions of a headwater stream before, during and after snowmelt in May 2018 and in a headwater stream and active layer groundwaters during and after a summer rain event in August 2019. Fe, Al and DOC concentrations are highest during peak flow events (snowmelt and rain event) and mainly transported in colloidal form. When comparing Fe, Al and DOC size separation in active layer ground waters and stream, ~ 90 % of Al and DOC are transported as colloids in soil waters and stream during the rain event, but only ~ 60 % of Al and DOC transported in colloidal form in the headwater stream under baseflow conditions, evidence for the transformation of colloidal SOC during transport. The relatively brief snowmelt and rain events are the hydrological drivers connecting mineral element-bound DOC in soils and headwater streams.

Fe, Al and DOC concentrations were determined in soil pore waters (< 0.2 µm) sampled during spring thaw (depth of 20 cm) and maximum thaw (depth of 120 cm) at sites of extensive and minimal permafrost degradation. There is a factor of 5 - 10 decrease in DOC, Fe and Al in soil pore waters from degraded soils compared to minimally degraded soils suggesting that long-term permafrost degradation has depleted the pool of Fe and Al available to form complexes with SOC. When the hydrological driver (snow melt and rain event) occurs synchronously with permafrost soil degradation, the transformed pool of colloidal SOC may be detected in headwater streams.

[1] Plaza et al., 2019; *Nature Geosciences*, 12