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# Hydrological processes drive variations in DOM composition in a cold alpine headwater catchment on the Qinghai–Tibetan Plateau

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Owing to permafrost degradation, the vast carbon pool in the Qinghai-Tibetan Plateau region is being mobilized as dissolved organic matter (DOM). An improved understanding of hydrological controls on DOM reactive transport is critical for forecasting the response of carbon release to climate change on the Qinghai-Tibetan Plateau. In a cold alpine headwater catchment there, we demonstrate how variations in physical and hydrogeochemical conditions along different flow paths affect DOM characteristics. Different water types and groundwater at different depths exhibited various temperatures and concentrations of major ions and minor elements. Fluorescence and DOM molecular structure analysis showed that DOM in deeper groundwater in seasonally frozen ground areas was characterized by low aromaticity and higher content of lipids and peptides, suggesting the greatest contribution of microbial-derived DOM. In comparison, suprapermafrost groundwater and stream water in permafrost areas were richer in lignin and featured by high humified and aromatic DOM. Microbial communities in different types of water bodies exhibited strong positive correlations with variations in water chemistry parameters and temperature. Combined microbial network structure with the LEfSe analysis elucidated that physicochemical differences in water between deep and shallow environments led to distinct microbial community structures. At the family level, *Verrucomicrobiae* and *Rhodobacteraceae*, which favor converting inorganic compounds into organic matter, exhibited higher abundance in the deep groundwater of seasonally frozen ground areas than those in other types of waters. The positive correlation between the abundance of *Rhodobacteraceae* and *Verrucomicrobiae* and the molecular composition of DOM in deep groundwater indicated that the presence of these bacteria favored the enrichment of lipids and peptides, underscoring the prominent role of microbial activity in the processing of DOM in deep water flow paths. Permafrost degradation could deepen groundwater flow paths and enhance water-rock interactions, which may promote the formation of stable microbial communities similar to those found in the deeper groundwater here. Consequently, the riverine DOM exported from the seasonally frozen ground areas in cold alpine catchments becomes more biodegradable and has strong feedback to climate warming.