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Investigation of water-soluble organic constituents and their spatio-temporal heterogeneity over the Tibetan Plateau☆

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ABSTRACT

Investigating the migration and transformation of carbonaceous and nitrogenous matter in the cryosphere areas is crucial for understanding global biogeochemical cycle and earth's climate system. However, water-soluble organic constituents and their transformation in multiple water bodies are barely investigated. Water-soluble organic carbon (WSOC) and organic nitrogen (WSON), and particulate black carbon (PBC) in multiple types of water bodies in eastern Tibetan Plateau (TP) cryosphere for the first time have been systematically investigated. Statistical results exhibited that from south to north and from east to west of this region, WSOC concentrations in alpine river runoff were gradually elevated. WSOC and nitrogenous matter in the alpine river runoff and precipitation in the glacier region presented distinct seasonal variations. WSON was the dominant component (63.4%) of water-soluble total nitrogen in precipitation over high-altitude southeastern TP cryosphere. Water-soluble carbonaceous matter dominated the carbon cycle in the TP cryosphere, but particulate carbonaceous matter in the alpine river runoff had a small fraction of the cryospheric carbon cycle. Analysis of optical properties illustrated that PBC had a much stronger light absorption ability (MAC_{PBC}: 2.28 ± 0.37 m^2 g^{-1}) than WSOC in the alpine river runoff (0.41 ± 0.26 m^2 g^{-1}). Ionic composition was dominated by SO_4^{2-}, NO_3^-, and NH_4^+ (average: 45.13 ± 3.75%) in the snow of glaciers, implying important contribution of (fossil fuel) combustion sources over this region. The results of this study have essential implications for understanding the carbon and nitrogen cycles in high altitude cryosphere regions of the world. Future work should be performed based on more robust in-situ observations and measurements from multiple environmental medium over the cryosphere areas, to ensure ecological protection and high-quality development of the high mountain Asia.

1. Introduction

Besides their characteristic in hydrological cycle, alpine glaciers dynamically mediated carbon cycle in the cryosphere areas. They store and transport/transform organic carbon. Once released from glaciers, they can be used to sustain downstream microbial life (Singer et al., 2012; Hood et al., 2009). Glaciochemical records from remote and high altitude regions can provide a regional to global-scale signal of past atmospheric chemistry (Twickler et al., 1986; Kang et al., 2016; Winski et al., 2021). Biogeochemical processing of water-soluble organic carbon (WSOC) in glaciers and glacial meltwater runoff constrains aquatic nutrient dynamics, carbon cycle/storage, and energy balance (Lynch et al., 2019). WSOC also plays an important role in affecting photochemical processes of water bodies and nutrient availability of microorganisms (e.g., Xu et al., 2018). Besides glaciers and meltwater, permafrost region can export large amount of WSOC to alpine river runoff due to abrupt permafrost thaw (Gao et al., 2019; MacDougall et al., 2016). Permafrost and glacial meltwater runoff is crucial sources of energy to downstream ecosystems, however, underlying mechanisms regulating WSOC reactivity and cycling in cryosphere areas are still

Abbreviations: TP, Tibetan Plateau; PBC, Particulate black carbon.

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