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Molecular signatures of soil-derived dissolved organic matter constrained by mineral weathering

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Dissolved organic matter (DOM) in soil consists of a diverse mixture of water-soluble soil organic matter (SOM) molecules that are highly mobile and reactive [1]. These molecules play various roles with different capacities in biogeochemical processes [2]. Theoretically, persistence of DOM molecules in soils is controlled by interactions between i) DOM leaching and desorption that release DOM from plant residues and SOM and ii) sorption and decomposition that remove DOM [1]. However, there is still no consensus on the dominant factor(s) or dimension(s) driving the yield and molecular signatures of DOM in soil environments.

Molecular variations of soil DOM from distinct geographical regions are primarily attributed to variations in geographical climate conditions and soil clay content [3]. Soil weathering condition is highly related to geographical climate conditions [4], such as temperature and precipitation, and could be a reflection of the soil mineral characteristics. However, there is a distinct paucity of information concerning how the molecular signatures of soil DOM vary with different degrees of weathering across wide geographic scales.

Herein, we resolved the DOM molecular signatures from 22 diverse Chinese reference soils and linked them with soil organic matter and weathering-related mineralogical properties. The mixed-effects models revealed that the yields of DOM were determined by soil organic carbon content, whereas the molecular signature of DOM was primarily constrained by the weathering-related dimension. The soil weathering index showed a positive effect on the lability and a negative effect on the aromaticity of DOM. Specifically, DOM in highly weathered acidic soils featured more amino sugars, carbohydrates, and aliphatics, as well as less O-rich polyphenols and condensed aromatics, thereby conferring a higher DOM biolability and lower DOM aromaticity. This study highlights the dominance of the weathering-related dimension in constraining the molecular signatures and potential functions of DOM in soils across a wide geographic scale.

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