Strikingly Different Form of Organic Carbon in Soils of Temperate and Permafrost Soils: Implications for Carbon and Metal Cycling

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Soils are major reservoirs of organic carbon (OC), and play a central role in the mobility of carbon between the land and the atmosphere. Among different soils, a significant fraction of global soil OC is stored in permafrost soils, and thawing and rapid losses of OC in the form of CO_2, associated with warming of polar regions, raises a serious concern for the stability of carbon in polar soils. Studies have shown that variations in soil mineralogy and biogeochemistry, and climatic conditions can modify the soil OC retention, which in turn alter the elemental cycles. The focus of our research is on how variations in vegetation and soil biogeochemical conditions control the dynamics of OC and associated major and trace elements in soils of different climatic conditions.

In this study, we examined OC forms associated with soils of temperate and polar climates using X-ray Absorption and NMR spectroscopic techniques, and high-resolution FT-ICR ESI-mass-spectrometry. In addition, to assess OC dynamics, we also evaluated the forms of S, P, and Cl bound to OC, and their time-dependent concentration variations. We compared the chemistries of these elements in Arctic soils with soils collected from temperate coniferous and deciduous forests.

Our studies indicate that the organic carbon is rich in lipids, and poor in aromatic and carboxylic carbon in the high Arctic soils when compared to soils of other climates. The O/C ratios of the extractable organic carbon also indicate that it is O-poor. This is in direct contrast to the organic matter found in soils of tropical and temperate climates, which is rich in lignins, tannins, and other condensed aromatics. The abundance of such a lipid-rich OC in high Arctic soils may be attributed to the moss, algae and fungal (or lichen) mats, whereas lignin and other aromatic-rich vascular plants are the common sources of OC in other climatic regions. Such a contrasting composition of OC in Arctic soils when compared to others suggests that these soils respond differently to temperature changes, and also interact differently with major and trace elements. We are evaluating how these different pools of OC modifies the cycling of nutrients, such as Fe, Mn, and the solubility and speciation of contaminants, such as Hg. A discussion on the contrasting forms of OC found in soils of different climates and their role in elemental cycles will be presented.