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ISEQ Work Summary as of October 2009

The cycles of carbon and minerals are intimately related in soils. This coupling affects both the role of soil in the local to global carbon cycle and the fates of metal contaminants.

1) Carbon-Mineral Complexation in Soils and Its Impact on the Regional Carbon Cycle

The soil's ability to accumulate and preserve organic carbon (C) and thus to counteract the increasing atmospheric CO₂ level has received growing interest in the last decade. For soils to act as a C sink, C needs to be stabilized in stable C pools. Much evidence supports the importance of C complexation onto the mineral surface in controlling C turnover time. Whereas the soil C cycle has been often studied in the context of climate change, erosion and deposition of soils have been largely related to soil conservation, stream restoration, and landscape evolution. Subsequently, C cycle, physical mixing, and soil erosion have been treated as irrelevant. Agricultural conversion of forest is often accompanied by soil plowing and accelerated soil erosion and deposition. Intense plowing creates a thicker and well-mixed Ap horizon. In parallel, C content is reduced in agricultural soil. Thus sediment eroded from the agricultural upland is likely to complex with new primary productivity, and its C could be protected from oxidation when the sediment is buried in wet depositional areas. Those processes have fundamental bearings for C sequestration. In this project, we targeted a mixed land use watershed within the Christina River Basin, where agricultural soils, unlike the neighboring forest soils, have experienced accelerated mixing (by plowing) and erosion, which is ubiquitous in the region since its colonization. Specifically, the focus is on: (1) comparing soil C-mineral complexation within three land use types: forest, agricultural uplands, and floodplains; (2) quantitatively coupling soil mixing with C-mineral complexation; and (3) quantifying the degree that accelerated soil erosion and deposition by agriculture affect C-mineral complexation.

2) Carbon-Mineral Complexation in Soils and Its Impacts on the Fates of Contaminant Metals

As much as C-mineral complexation affects C cycle, it affects the fates of heavy metals. Mercury (Hg) was introduced into the South River from a DuPont Company textile manufacturing plant in Waynesboro, VA, mainly between 1929 and 1950. Mercury was used as a catalyst for making acetate. In 1977, the South River was found to be severely contaminated by Hg, resulting in the formation of a fish consumption health advisory for over 100 miles downstream of the plant. Mercury levels have not declined since monitoring started in 1980, posing a health risk to the fish, wildlife, and humans in this region. Most of the Hg in the South River is associated with suspended particles, primarily due to its association with organic matter and oxide mineral surfaces. Subsequently, Hg contaminated sediments were deposited on banks and floodplains during overbank flooding. As a consequence, floodplains and banks act as a substantial sink for fine-grained fluvial sediments and their associated Hg, which may be remobilized and thus constitute a problem for future river contamination. The objective of the research is to: (1) study the time evolution of Hg contamination in the floodplain and river banks by utilizing the vertical profile of Hg and radioisotopes (¹³⁷Cs & ²¹⁰Pb) at the South River and (2) determine what factors control the vertical soil Hg distribution and mobilization. The results will help further understanding of the behavior of Hg in the solid phase over time and provide insights for restoration plans in the South River.