Uranium Immobilization in an Iron- and Organic Matter-Rich Rhizosphere of a Native Wetland Plant

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Discharge of contaminated groundwater to surface waters is of concern at many DOE facilities. It is at this interface where contaminants come into contact with the biosphere. These wetlands exist in humid as well as arid regions. Furthermore, the numerous sharp biogeochemical transitions occurring in wetlands have profound effects on the ultimate fate of redox-sensitive trace metals and radionuclides, including uranium. The hypothesis of this study was that iron plaques formed on the roots of most wetland plants and their rhizospheres create environmental conditions favorable for the in-situ immobilization of uranium. Greenhouse microcosm studies were conducted using native plants (Sparganium americanum) from a wetland located on the Savannah River Site (SRS), Aiken, SC. Bacterial numbers including Geobacter sp., Fe(III), as well as total uranium, were highest on roots, followed by sediments near roots, and lowest in zones without much root influence. Results from the μ-XRF mapping on root surfaces indicated a strong spatial correlation between Fe and U, while the analysis via XANES showed that a significant fraction of uranium was reduced to U(IV), indicating that iron cycling in the rhizosphere also results in uranium reduction and immobilization. Under high iron loading, results indicate that co-precipitation of U(VI) with iron might have been an important U removal process. Depth-discrete diffusion porewater samples are being seasonally collected from a depleted-U contaminated wetland located in Steed's Pond on the SRS. Porewater dissolved U concentration fluxes are consistent with our laboratory findings, indicating that during the growing season when there is more active iron reduction, the dissolved U in the sediment pore water is significantly lower. Characterization of the field sediments was conducted to identify the biogeochemical conditions responsible for the enhanced uranium uptake in the rhizosphere. X-ray computed tomography indicate a highly ordered, albeit thin, layer of minerals adjacent to the roots. Mossbauer spectroscopy identified a significant enrichment of ferrihydrite/lepidocrocite/OM-Fe phases within the rhizosphere sediment, as compared to the iron in the bulk sediment, which was composed primarily of nano-goethite. TEM analyses confirm unique mineralogy and the presence of nano-phases in the rhizosphere. Further characterization of uranium in the sediment rhizosphere is planned.