Plutonium mobilization from estuary sediments, Ravenglass, UK

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Since 1952, authorized radioactive effluents have been discharged from the Sellafield plant into the Irish Sea. This is by far, the largest source of plutonium (Pu) discharged in all of western Europe, with 276 kg released. In the Irish Sea the majority of the transuranic activity has settled into an area of sediments ("mud patch") off the Cumbrian coast. The radionuclides from the mud patch have been re-dispersed via particulate transport in fine-grained intertidal sediments including the Ravenglass estuary. The Ravenglass saltmarsh presents a unique natural laboratory in which to study the long-term biogeochemistry of Pu under natural environmental conditions. Salt marshes are highly dynamic systems which are vulnerable to external agents (sea level changes and erosion), and there are uncertainties about their stability under current sea level rise. Despite periodic study over the past several decades, understanding of the biogeochemical controls on long-term radionuclide distribution at Ravenglass remains limited. Recent work has indicated redox conditions shift from aerobic at the surface, to Fe(III) reducing within 12 cm depth, and sulfate reducing between 18-28 cm. Changing redox profiles together with changing hydrological regimes have the potential to impact the speciation and mobility of the redox active radionuclides, including Pu. In this work we examine the factors affecting the mobility of Pu in redox stratified soils by conducting desorption experiments of contaminated Ravenglass sediments under both oxic and anoxic conditions. Desorption experiments were conducted over 8 months. The experiments were periodically sampled to determine the amount of desorbed Pu via MC-ICP-MS and redox indicators (Eh, pH and extractable Fe(II)). The microbial community composition was also characterized in the collected sediments, at both the beginning and end of the desorption experiments. The results of this work provide information on the potential mobilization of actinides in biogeochemically dynamic/transient environments over long timescales. Understanding the behavior of actinides in such conditions remains a significant challenge and our lack of knowledge currently limits our progress in developing predictive conceptual and numerical models of actinide mobility in the environment.