Biogeochemical Cycling and Environmental Stability of Pu Relevant to Long-Term Stewardship of DOE Sites

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The overall objective of this research is to understand the biogeochemical cycling of Pu in environments of interest to long-term DOE stewardship issues. Central to Pu cycling (transport initiation and immobilization) is the role of microorganisms. The hypothesis underlying this work is that microbial activity is the causative agent in initiating the mobilization of Pu in near-surface environments through the transformation of Pu associated with solid phases: production of extracellular polymeric substances (EPS) carrier phases and the creation of microenvironments. Also, microbial processes are central to the immobilization of Pu species, through the metabolism of organically complexed Pu species and Pu associated with extracellular carrier phases and the creation of environments favorable for Pu transport retardation.

Materials and Methods: Soil Incubations

The concentration of \(^{242}\text{Pu}\) in the filtrate (\(<0.45 \mu\text{m}\) of amended samples increased due to microbial activity and remained at \(<10 \text{ pCi g}^{-1}\) dry wt.

Iron reduction and dissolution occurred to the greatest extent in unspiked soil (pH 6). An advantage of static columns over more traditional batch experiments is that they allow the assessment of the potential for Pu transport at solidification rates appropriate for saturated groundwater systems without the complexity of full-column studies.

Characterization of Bacterial EPS

The neutral monomeric acids in this EPS consist of mannose, fucose, ribose, arabino, rhamnose, xylose, mannos, galactose and glucose. The acidic groups in this EPS are mainly composed of carboxylic acid and minor polymeric groups, e.g., sulfate and phosphates. Up to 70% of total carbohydrates are uronic acids, and total carbohydrates make up 26-31% of organic carbon. The neutral and acidic sugars in the EPS: FES also contain 2% of proteins in terms of carbon, which makes the EPS amphoteric (amphiphilic).

Analytical methods development: labeling NOM, EPS with \(^3\text{H}\).

Observing the behavior of Pu / EPS complexes at environmentally-relevant concentrations requires a means of monitoring EPS below the limit of traditional DC analytical procedures. Below is a summary of a new method for radiolabeling NOM with \(^3\text{H}\).

Schematic summary of the primary biogeochemical processes that are being investigated in this work: a. The release of sorbed Pu through either direct or implied microbial action (extracellular) through the destruction of the host phase (regular disk) b. Sorption of Pu from the immobile phase by microbially-produced ligands. Alternatively, the ligands, by settling onto the immobile phase, may impede Pu by blocking decoration; c. Biodegradation of Pu / organic ligand complexes; d. Mobilization of Pu under aerobic and anaerobic conditions by microbially-produced EPS.