Unexpected behavior of radionuclides associated with natural organic matter in the environment

SANTSCHI, P.H[1*]., XU, C.[1], KAPLAN, D.[2], YEAGER, C.[3], ZHANG, S.[1], SCHWEHR, K.A.[1]

[1]Texas A&M University – Galveston, TX
[2]Savannah River National Laboratory, Aiken, NC,
[3]Los Alamos National Laboratory, Los Alamos, NM
(*correspondence: santschi@tamug.edu)

Radionuclides that reach the environment from natural or anthropogenic sources are equilibrating over time with different phases through sorption and precipitation reactions onto inorganic and organic phases, e.g., macromolecular natural organic matter (NOM). Strong binding to NOM can occur by chelation or chemical reactions. Despite many years of research, relatively little is known about the NOM pathway for many radionuclides. For radionuclide incorporation into NOM to become significant, this often requires microbial activities, either directly through absorption into cells, or indirectly through exo-cellular enzymatic activities.

In this presentation, microbially mediated chelation and chemical reaction controls are discussed, using plutonium (Pu) and iodine (I) isotopes, respectively, as examples. In both cases, the presence of NOM in contaminated soils complicates conventional remediation techniques that often add base to either increase the cation exchange capacity of soils or to promote direct precipitation of the radionuclide in the waste stream. This addition then has the consequence that both isotopes become more mobile in organic matter-enriched sediment.

Iodine, which has multiple radioisotopes, occurs in multiple oxidation states in aquatic systems in the form of organic species ((organo-I, where I is covalently bound by aromatic moieties) and inorganic species (iodide (I^-) and iodate (IO_3^-). This fact leads to complex biogeochemical cycling of iodine and its long-lived isotope, ^{129}I, a major by-product of nuclear fission. Plutonium has been demonstrated to be strongly chelated by hydroxamate siderophores in the laboratory and the field. I and Pu speciation and interaction with NOM from vastly different field studies will be discussed: Fukushima (Japan), Savannah River Site (South Carolina), Rocky Flats (Colorado), and Hanford (Washington).