Biosorption of Actinides in the WIPP

The Waste Isolation Pilot Plant (WIPP) transuranic repository represents a cornerstone of the U.S. Department of Energy’s (DOE) nuclear waste management effort. Waste disposal operations began at WIPP on March 26, 1999 but a requirement of the repository license is that the WIPP needs to be recertified every five years for its disposal operations. The WIPP is now pursuing its third recertification (submitted in March 2014) and there are many ongoing discussions about the possibility of expanded missions and additional nuclear repository concepts in a salt geology.

Microbial processes have been shown to influence the long-term migration of actinides in a wide variety of subsurface environments [1]. These studies however tend to focus on the near-surface contaminant problems in low ionic-strength groundwater that is present at many DOE sites. The ongoing recertification of the WIPP TRU repository and the broader consideration of salt repository concepts for the permanent disposal of HLW/SF waste has focused attention on the effects of the halophilic microorganisms that are indigenous to salt and high ionic-strength brine systems.

A key and important actinide microbial interaction is the bioassociation of actinide species with microorganisms to form bio colloids. This interaction can potentially contribute to the “mobile” actinide source when physical transport due to intrusion scenarios is the predominant release pathway. If transport pathways are present, bioassociation can lead to reduced mobilization (e.g., if the microbe itself is not mobile) or enhanced mobilization (if the microbe or the degradation “fragments” are mobile). In the self-sealing geology of a salt repository with no interconnected groundwater, only bio colloidal contributions to the source term are considered in Pa.

Herein, we report progress in investigating the bioassociation of actinides toward halophilic microorganisms to extend what has been observed in soil bacteria [2-3] to the microorganisms that are typically found in the high ionic-strength brine systems predicted for the WIPP. A number of isolates have been found and both halophilic archaea and bacteria have been identified [4]. The biosorption of actinides towards these microorganisms is being investigated using redox-invariant analogs (e.g., thorium (IV)) since the biosorption observed is specific to the oxidation state of the actinide and its aqueous speciation. These data are used to define the bio colloidal enhancement factors which are used in WIPP PA.

Actinide Bio colloids in Brine

The biosoluble contribution to dissolved actinide concentrations was re-evaluated using WIPP-indigenous microorganisms as a function of pH. In almost all cases investigated biosorption was observed although these were often coupled with precipitation at high pH. Estimated biosorption effects were used to develop enhancement factors to determine the bio colloidal contribution to the mobile actinide concentration source term.

Biosorption of Nd(III) and Th(IV)

Thoron and neodymium were used as the redox-invariant analog for the Am(IV) and Am(III) oxidation state to avoid surface moderated redox changes in the biosorption experiments.

References:


Acknowledgements

This research was performed by the Actinide Chemistry and Repository Science Team (Los Alamos, Repository Science and Operations Program at the Carlsbad Environmental Monitoring and Research Center (operated by New Mexico State University). Research was funded by the Waste Isolation Pilot Plant, Department of Energy, Carlsbad Field Office (Russ Patterson program manager).