THE BIODEGRADATION OF ISOSACCHARINIC ACID

Professor Jonathan Lloyd and Dr Nick Bryan, University of Manchester

Synopsis

Microbial metabolism plays a key role in controlling the degradation of organics and the solubility of radionuclides in natural, near-neutral pH subsurface environments. However, there is much less information available on the impact of microbial metabolism on radionuclide speciation at high pH values, representative of intermediate level nuclear waste (ILW) in environments engineered for geological disposal. In the high pH concrete-dominated environment associated with ILW, there is particular concern relating the potential mobilization of radionuclides by the strong chelating agent, isosaccharinic acid (ISA), formed by the abiotic hydrolysis of cellulose. Although a restricted number of studies have suggested that ISA can be degraded aerobically at circumneutral pH by bacteria, the mechanisms underpinning such transformations, and their impact on ISA-radionuclide interactions remain poorly constrained. Furthermore, no published studies have addressed such processes at (1) high pH of relevance to ILW conditions or (2) anoxic conditions, that will dominate with time in a geodisposal facility.

The aim of this NDA-RWMD-funded PhD study, is to develop a deeper understanding of the potential microbial processes that could impact on ISA under GDF-relevant conditions, utilising enrichment and pure cultures to determine the impact of ISA biodegradation on the mobility of key target radionuclides. Comparative data will also be collected from enrichment cultures constructed at neutral pH, under conditions analogous to geosphere conditions surrounding ILW and the associated alkali disturbed zone. This will allow the student to predict the rate and extent of ISA degradation under a range of biogeochemical conditions around a GDF, should the cellulose degradation product travel significant distances from the ILW/ADZ.

Training

The student working on this cross-disciplinary project will gain training in microbiology, molecular biology, geochemistry and radiochemistry and will have access to world-class facilities in the Williamson Research Centre for Molecular Environmental Science, the Centre for Radiochemistry Research and the Research Centre for Geological Disposal at the University of Manchester. The student will also gain additional industrial focus from working in conjunction with the contractors on any related RWMD projects. The final PhD thesis will comprise 3-5 manuscripts formatted for publication in top journals in the field.

References

Brookshaw, D.R., Pattrick, R.A.D, Lloyd, J.R. and Vaughan, D.J. (2012) Microbial effects on mineral-radionuclide interactions and radionuclide solid-phase capture processes. Mineralogical Magazine 76 777–806

Birjkumar, K.H., Bryan, N.D. and Kaltsoyannis, N (2012) Is gluconate a good model for isosaccharinate in uranyl(VI) chemistry? A DFT study. DALTON TRANSACTIONS 41 5542-5552 DOI: 10.1039/c2dt12478e

Lloyd, J.R. and Gadd, G.M. (2011). The geomicrobiology of radionuclides. Geomicrobiol. J. 28:5-6, 383-386

Rizoulis, A., Steele, H.M., Morris, K. and Lloyd, J.R. (2012) The potential impact of anaerobic microbial metabolism during the geological disposal of intermediate-level waste. Mineralogical Magazine 76 397–406

Wilkins, M.J., Livens, F.R., Vaughan, D.J., Beadle, I., Small, J.S. and Lloyd, J.R. (2010) Fe(III) Reduction in the Subsurface at a Low-Level Radioactive Waste Disposal Site. Geomicrobiology Journal 27 231-23

Further details: jon.lloyd@manchester.ac.uk