Investigation of the biodegradation of isosaccharinic acid and its degradation products in the far field of geological disposal

G. KUIPPERS[1*], N. BRYAN[2] AND J. R. LLOYD[1]

[1]Research Centre for Radwaste and Decommissioning & Williamson Research Centre for Molecular Environmental Science, SEAES, The University of Manchester, Oxford Road ([*]gina.kuippers@manchester.ac.uk jon.lloyd@manchester.ac.uk)

[2]National Nuclear Laboratory, Chadwick House, Birchwood, Warrington WA3 6AE, UK (nick.bryan@manchester.ac.uk)

It is UK Government policy to dispose of higher activity radioactive waste through geological disposal into an engineered deep underground geological disposal facility (GDF). Low-level (LLW) and intermediate-level (ILW) radioactive wastes are very heterogeneous, containing significant amounts of cellulosic material. After closure of the GDF, eventual resaturation with groundwater will result in the development of a hyperalkaline environment within the cementitious backfill. Under these high pH conditions, cellulose is unstable and will be degraded chemically, forming water-soluble isosaccharinic acid (ISA). As ISA is known to form stable, soluble complexes with a range of radionuclides, the impact of microbial metabolism on this organic substrate was investigated, to help determine the role of microorganisms in moderating the transport of radionuclides from a cementitious GDF.

In this study we focused on circumneutral conditions representative of the geosphere surrounding a GDF. Here we report the fate of ISA in circumneutral microcosms poised under aerobic and anaerobic conditions; the latter with nitrate, Fe(III) or sulfate added as electron acceptors. Data are presented confirming the metabolism of ISA under these conditions, including the direct oxidation of ISA under aerobic and nitrate-reducing conditions and the fermentation of ISA to acetate, propionate and butyrate prior to utilization of these acids during Fe(III) and sulfate reduction. The microbial communities associated with these processes were characterized using 16S rRNA gene pyrosequencing. Mineralogical degradation products were identified using XRD, Mossbauer, TEM and microscopic techniques. Methane production was also quantified in these experiments, and the added electron acceptors were shown to play a significant role in minimizing methanogenesis from ISA and its breakdown products.