WASTE DISPOSAL & RESEARCH

Tackling disposal of radioactive waste in the UK

The international consensus for the ultimate disposal of radioactive wastes, embodied in current UK Government policy, involves emplacement of waste packages in an engineered facility within a deep, stable, geological formation. In general, the disposal facility incorporates multiple safety barriers, which work in concert to retard radionuclide release from the disposal facility and migration to the biosphere. A key component of this multi-barrier concept is the back fill material placed around the waste containers – providing both physical protection and isolation from the geological environment.

In the UK context, deployment of a cementitious backfill is under consideration with the aim of providing an additional chemical barrier to radionuclide release (particularly actinides) by imposing hyperalkaline conditions in the vicinity of waste packages. 99Tc (Technetium-99) is abundant in radioactive wastes due to its high fission yield of ca. 6% for thermal fission of 235U. As a consequence of the long half-life of 99Tc (2.1 x 10^14 years) and high solubility of the pertechnetate species (TcVIIIO4-), this radionuclide is a key contributor to the potential radiological risk to future populations in post closure safety assessments.

Hence, the research (lead by Professor Neil Hyatt at Sheffield University, and funded by the Academy’s Research Chairs Scheme and the Nuclear Decommissioning Authority) has focused on understanding the transport of 99Tc through porous cementitious media through development of a novel gamma camera imaging technique.

The methodology involves the use of purpose-designed flow-through cells containing the cement material or sand (as a reference material) in the form of 1-2 mm grains (Figure 1). Peristaltic pumps maintain a constant flow rate of water through the cell. A known activity of 99mTc, a γ-emitting metastable-isomer of Tc with a half life of 6h, is injected at the top of the flow cell, in the form of the pertechnetate species. Transport through the porous medium is imaged using a hospital γ-camera, taking snapshots every 30 seconds over a period of several hours. In this way, the passage of 99mTc through the porous media can be directly imaged. Moreover, pertechnetate transport through porous media can be reliably quantified by application of spatial moment’s analysis to the digital γ-camera image data. Key to this analysis is correction for the decay of 99mTc during the course of the experiment by reference to a calibration cell.

Examples of calibrated concentration contour maps of 99mTc in sand and a cement backfill material are shown in Figure 2. In both materials, 99mTc is seen to be transported conservatively, that is the materials do not impose a significant physical or chemical impediment to 99mTc transport. However, the transport of 99mTc through the cement backfill material is approximately three times slower, and the plume considerably more dispersed along the vertical direction of flow, in comparison to sand. We can therefore conclude that whilst the high internal porosity of the cement material provides a more tortuous path to pertechnetate transport, it does not function as a significant chemical barrier for this species.

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