Impact of earthworms on metal mobility and availability

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It has been suggested that earthworms may be of use in enhancing phytoremediation or alternatively that earthworms may enhance metal mobility at contaminated sites thereby increasing risk of exposure for receptors. In this study earthworms were cultivated for 28 days in two different metal contaminated soils at differing earthworm number to soil mass ratios. Swaledale soil contained 16 ppm Cd, 28 ppm Cu, 5164 ppm Pb, 3433 ppm Zn, 6 % organic matter, had a pH of 6 and a sandy texture. Wisley soil contained 5 ppm Cd, 110 ppm Cu, 910 ppm Pb, 260 ppm Zn,10 % organic matter, had a pH of 5.4 and was a loamy sand. Earthworm number to soil mass ratios ranged from 1 :200 to 1 :5. After 28 days earthworms were depurated on filter paper and metal body burden was determined. Soil solution was extracted from soils using rhizon soil solution samplers and analysed for metals and dissolved organic carbon. Cold and hot water extractable carbon were measured on the soils. Soils were extracted with K_2SO_4 to estimate microbial numbers. The European 3-stage sequential extraction was applied to the soils.

Earthworm metal body burden and BCR Step 1 extractable metal decreased with increasing earthworm density. Metal and organic carbon soil solution concentrations and cold and hot water extractable soil C increased with increasing earthworm density. There were no signficant changes in microbial activity with earthworm density.

The data are consistent with earthworm-derived organic compounds complexing metals and bringing them into solution off soil particle sorption sites. Thus metal concentration in soil solution and therefore metal mobility increases with earthworm density. However, the metals present as organo-metal complexes are not available for uptake by the earthworms so that metal body burden is unaffected or decreases, i.e. metal bioavailability decreases.

Corroded Magnox sludge and plutonium waste cementation

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Corroded Magnox sludge waste

Corrosion of spent Magnox fuel rods in water filled storage ponds has produced magnesium-rich sludges contaminated with fuel and fission products. We have experimentally investigated the composition and evolution of an inactive corroded Magnox sludge (CMS) simulant.

Our characterisation of the sludge using infrared spectroscopy, X-ray diffraction, and environmental scanning electron microscopy (ESEM) has determined that CMS is mainly composed of brucite, $Mg(OH)_2$, and additionally artinite, $Mg_2CO_3(OH)_2.3H2O$.

Plutonium association with CMS

It has been suggested that Pu adsorption onto CMS colloids may provide a mechanism to enhance Pu mobility. Therefore, we have determined the associative behaviour of plutonium in solution with CMS in a model storage pond/ effluent treatment system. Using a full-factorial design, we have quantitatively determined the effects of CMS, and other components of the storage pond and effluent treatment system, on Pu solubility. This provides an important first approximation to true Pu solubility.

The addition of carbonate in solution had the largest influence over Pu solubility, allowing >90% of the Pu to pass through a filter membrane. The presence of CMS, and polyelectrolyte increased Pu filter hold-up. Silica at 1 ppm produced no observable effect. Solution pH was also found to have a significant influence over Pu filterability. Over the pH 7 to 11.5 range examined, more Pu was held up on the filter at higher pH.

Cementation of Pu contaminated CMS

For long-term storage it is intended that the CMS waste be immobilised in a cementitious wasteform. Our current research is intended to extend our understanding of the structure and behaviour of these cemented wasteforms. Our investigation of CMS evolution is continuing, and additionally we have begun to examine the microstructure of ordinary Portland cement (OPC) based samples. Our cement samples doped with CMS, Zr, U (and later Pu) have been analysed using SEM to establish the hydrated calcium silicate (CSH) phases present and with which phases the Zr and actinide elements associate. Further work will determine the evolution of these phases and co-ordination chemistry of the actinides. Eventually this data will be included with those from actinide leaching experiments to relate the cement microstructure with immobilisation performance.