Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.4065

Micro-scale Mapping and Spectroscopic Analysis of Lead and Uranium in Plant Roots Colonised by Arbuscular Mycorrhizal Fungi

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Long-term pollution generated by heavy metal and radionuclide mining has created an expensive and technically-challenging problem worldwide. This legacy of land and water contamination deteriorates otherwise viable agricultural, residential and recreational land, alongside threatening ecosystem health and biodiversity. Bioremediation techniques using plants and micro-organisms have been offered as a cheaper, in-situ alternative for the amelioration of contaminated sites, in contrast to more expensive, destructive options like soil washing and permeable reactive barriers (PRBs). To assess the feasibility of these bioremediation options, and to model food chain transfer risk from contaminants, a better understanding of how plants and microbes interact with heavy metals and radionuclides is essential. One important group of microbes is arbuscular mycorrhizal fungi (AMF), which form a symbiosis with plant roots to supplement plant nutrient absorption and can colonise 80-90% of the world's plant species. Despite AMF prevalence however, very little is known about how AMF influences uptake, speciation and bioaccessibility of radionuclides in plants (Davies et al., 2018)

The influence of AMF on lead (Pb) and uranium (U) uptake and translocation were studied and compared using controlled pot dosing trials (*Plantago lanceolata*) and the model AMF species *Rhizophagus irregularis*. Autoradiography has provided whole-organism scale qualitative comparisons for U activity between pot treatments, whilst scanning electron microscopy coupled with energy dispersive x-ray analysis (SEM-EDX) has unveiled the influence of AMF colonisation on Pb and U distribution within root cross sections. This was further elaborated at a higher resolution via the combined use of secondary ion mass spectrometry (Nano-SIMS) and synchrotron μ-XRF at the Diamond Light Source (Oxfordshire, UK). XANES and EXAFS spectroscopy were used to distinguish the U speciation through establishing oxidation states and relevant ligands that may facilitate U absorption into plant root tissues. Future work will constrain AMF influence on Pb and U absorption within a field-relevant system, soil turfs collected from the abandoned pitchblende mine South Terras (Cornwall, UK), which will be compared against these controlled pot findings.

[1] Davies et al. (2018). Multiple environmental factors influence ^{238}U, ^{232}Th and ^{226}Ra bioaccumulation in arbuscular mycorrhizal-associated plants. *Sci Total Environ*. **640-641**. 921-934.