Storage of Uranium, and its Radioactive Decay Products, in Fine Floodplain Sediments: River Fal, SW England

Geoffrey Millward[1] and William Blake[2]

[1]Marine Institute, Plymouth University, Drake Circus, Plymouth, UK
Phone: +44-(0)-1752-584788
[2]School of Geography, Earth and Environmental Sciences, Plymouth University, Drake Circus, Plymouth, UK
E-mail: gmillward@plymouth.ac.uk

Introduction: River floodplains are important reservoirs for the storage of contaminants from historic industrial land use in their catchments [1]. Spate conditions in rivers augment the spread of contaminants during overbank inundation of fertile river floodplains [2]. .Management of legacy contaminants requires an understanding of the time-dependent sequestration of contaminants associated with fine sediments. As a consequence of historical uranium mining in mainland Europe there are many abandoned mines[3] impacting river systems [e.g. 4].

The abandoned uranium mine at South Terras, SW England, had deposits containing up to 30% uranium. Waste heaps of inefficiently processed minerals, are on the banks of the River Fal, where U concentrations ~10,800 µg g^{-1} have been detected [5]. Here we test the null hypothesis that inputs of radionuclides from the mine had no impact on the river's floodplain.

Methods: Cores were collected from sites in the Fal floodplain, including a core above the mine and reference cores (REF) at an undisturbed site. Cores were sectioned at 1 cm intervals, dried, sieved to <2 mm, packed in sealed containers, incubated for ~5 months and gamma counted for key radionuclides (^{137}Cs, ^{241}Am, ^{234}Th, ^{214}Pb, ^{210}Pb). Particle size and loss on ignition were determined in each section.

The gamma spectrometer was an HPGe detector (ORTEC, UK), with a relative efficiency of 25%. It was calibrated using a natural soil spiked with a radioactive traceable standard solution (Eckert & Ziegler Analytics, USA) and managed using GammaVision software. Samples were counted for at least 80,000 s and activity concentrations determined with a 2-sigma counting error. Quality control involved determinations of the radionuclide content of moss soil (IAEA-CU-2009-03) and synthetic sand from the NPL, UK .

Results: Peak ^{137}Cs activity concentrations occurred at ~25 cm depth at all sites, except above the mine (Fig. 1a). ^{238}U activity concentrations above the mine were relatively low and uniform throughout the core, whereas below the mine they were higher and they increased with depth. At 24 km, the activity concentrations were constant and generally elevated over those from upstream but at 32 cm there was a significant peak (Fig. 1b). The depth profiles of ^{226}Ra (using ^{214}Pb as a surrogate) and total ^{210}Pb below the mine all indicated inputs below the 1963 ^{137}Cs peak.

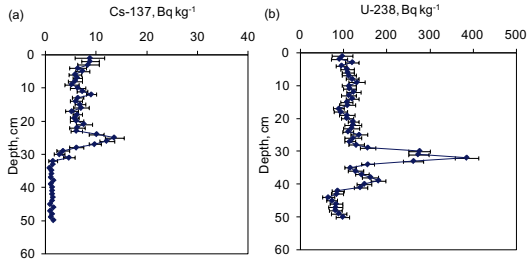

Fig. 1: Depth profiles at 24 km (a) ^{137}Cs; (b) ^{238}U.

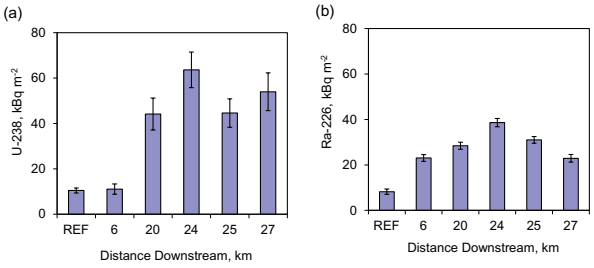

Fig. 2: Floodplain inventories, kBq m^{-2}, at the REF and along the River Fal (a) ^{238}U; (b) ^{226}Ra.

Discussion: Inventories, Bq m^{-2}, of radionuclides were estimated by integrating over the depth of each core. ^{238}U inventories (Fig. 2a) show elevated values downstream of the mine which are 7-fold higher than the REF site. Accumulation, and storage, of ^{238}U was most evident at 24 km. Similarly, the ^{226}Ra, inventory (Fig. 2b) had higher values in the floodplain than the REF. The elevated radionuclide inventories in the mid-river indicate the extent to which the underlying uranium geology of the catchment, and the mine waste, pollutes a fertile floodplain. If contamination of floodplains is replicated by redundant uranium mine sites across the EU then an international effort in clean-up is urgently required.

References: [1] Owens & Xu (2011) *J. Soils Sediments* **11** : 875-885 ; [2] Walling et al.. (2003) *Appl. Geochem.* **18** :195-220 ; [3] EU (2011) Commission Staff Working Paper SEC (2011) 340, 12 pp ; [4] Hudcová et al., (2013) J. Environ. Radioact. 116: 159-165. [5] Read et al. (1991) *Radiochim. Acta* **52/53**: 349-356.