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Impact of fluvial flooding on potentially toxic element mobility in floodplain soils

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Climate projections suggest that rainfall events will become more frequent and intense, which may lead to more widespread flooding. Floodplains can be used to help reduce the magnitude of floods downstream by storing excess flood water, thus making them useful for flood risk management. This means that floodplains are subjected to repeated drying and rewetting, which has implications for biogeochemical cycling of chemical elements in floodplain soils.

Floodplains have been considered a sink for contaminants in urban catchments, where high river flows transport contaminated sediments downstream and deposit them onto the floodplain topsoil. With increasing flooding frequency and duration, floodplains may become sources of legacy pollution through desorption of contaminants into soil porewater or resuspension of particulate matter into the overlying floodwater. Therefore, flooding could re-mobilise potentially toxic elements (PTEs) such as Cadmium (Cd), Copper (Cu), Chromium (Cr), Nickel (Ni), and Lead (Pb) that are present in the floodplain soil as a result of historic deposition. Mobilising PTEs in floodplain soils may cause adverse ecological impacts for soil microorganisms, plants, and both terrestrial and aquatic fauna.

The mobility of PTEs from the floodplain soil can increase or decrease due to the net effect of five key processes that influence dispersion and accumulation; 1) soil redox potential for which decreases can directly alter the speciation, and hence mobility, of redox sensitive PTEs (e.g. As and Cr), 2) soil pH for which an increase usually reduces the mobility of metal cations (e.g. Cd^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}), 3) dissolved organic matter which can mobilise PTEs were strongly bound to soil particles, 4) iron (Fe) and manganese (Mn) hydroxides undergo reductive dissolution, releasing adsorbed and co-precipitated PTEs, and 5) reduction of sulphate which immobilises PTEs due to precipitation of metal sulphides.

We took a field-based approach; extracting soil pore waters from a floodplain downstream of a typical urban catchment in southeast England before, during and after a flooding event. During the flood, there was increased mobility of Cd and Pb, and decreased mobility for Cu and Cr, compared to the mobility before flooding. After the flood, Ni mobility increased, whereas the other PTEs had lower mobility than they had prior to the flood. We also measured explanatory variables (e.g. pH, redox, Fe and Mn) that might explain the changes in mobility of PTEs that we found. Reductive dissolution of Mn is a possible mechanism for the increased mobility of Cd and Pb and redox likely played a role in the reduced Cr mobility.

Flooding did not influence the mobility of all PTEs in the same way. The duration of flooding is thought to influence the mobilisation due to the length of time for key processes to take place. It is therefore difficult to predict what PTEs might be mobilised into the environment with any given flooding event, further work is required to identify which soil properties should be measured in order to improve our capability to predict how a flooding event will influence the mobility of individual PTEs in geochemically contrasting floodplain soils.