Process controls on microplastic recontamination in fluvial sediments due to flooding

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Microplastic burden in aquatic environments is now recognised as one of the largest threats to human and environmental health of the 21st century. However, although microplastic transfers to the ocean from the terrestrial river network contributes between 64 and 90% of the plastics in the oceans (Mehlart and Blepp, 2012) the pathways and mechanisms of transfers are largely unconstrained. Within river channels it is the sediment bed that plays a vital role in mediating transfers since microplastics are buried and stored within the sediments on the river bed. During flood events erosion of the bed surface means microplastics buried within the bed are exchanged with the surface across the active layer and are potentially re-mobilised. However, we have very little grasp on the magnitudes of floods required to mobilise the sediment bed such as to re-mobilise the microplastics and hence very little understanding of microplastic recontamination risk.

In order to quantify the effect of flood events on microplastic remobilisation a series of experiments were run within a glass-sided, flow-recirculating flume (8.2m x 0.6m x 0.5m). During experiments, a sediment bed of unimodal distribution (σ_g = 1.3 and D_{50} of 9mm) was seeded with high density PVC microplastic nurdles (between 3-5mm) at a 1% concentration. The sediment bed was exposed to a period of steady flow for five hours to water-work the surface (initial $\tau^* \approx 0.041$). After this beds were exposed to a flood wave with a 2 hour rising limb and either a 3 or 8 hour falling limb during which discharge was changed in discrete steps (τ^* ranged between 0.033 and 0.049). High resolution laser scans were taken of the bed surface prior to the application of the flood wave, after the rising limb and at the end of the experiment. Surface grain size distributions together with the bed load and microplastic transport rates were measured every half an hour during the steady flow period and at every step of the flood wave. Microplastic contaminant profiles were measured using 3D CT scanning of cores buried within the bed and removed at the same time the bed was scanned.

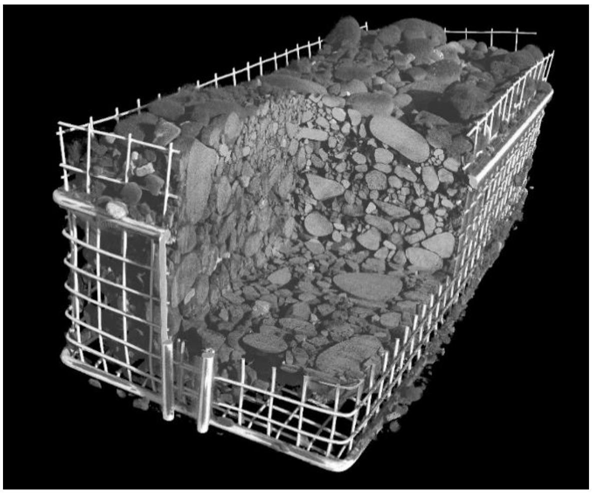

Figure 1- *Example of a cut through 3D CT scan captured of a sediment core taken post flood event. Voxel resolution is 3mm and microplastic nurdles are identified in the scans from the differential density and hence the intensity of the return signal*

Discussion concentrates on linking the changes in bed surface topography to the character of the bedload and microplastic flux in response to differing flood wave characteristics. Data shows that as the bed surface develops during the passage of a flood wave a significant hysteretic response develops in both the bedload and microplastic flux but that the degree of microplastic hysteresis is much greater. The outcome of this research is pertinent to developing understanding surrounding the sensitivity of fluvial systems to microplastic recontamination during flood events.