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Tracing peatland geomorphology: sediment and contaminant movements in eroding and restored systems

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Peatlands are an important store of soil carbon, play a vital role in global carbon cycling, and can also act as sinks of atmospherically deposited heavy metals. However, large areas of blanket peat are significantly degraded and actively eroding as a direct result of anthropogenic pressures, which negatively impacts carbon and pollutant storage. The restoration of eroding UK peatlands is a major conservation concern, and over the last decade measures have been taken to control erosion and restore large areas of degraded peat. In severely eroded peatlands, topography is highly variable, and an appreciation of geomorphological form and process is key in understanding the controls on peatland function, and in mitigating the negative impacts of peatland erosion.

The blanket peats of the Peak District, Southern Pennines, UK embody many problems and pressures faced by peatlands globally, and are amongst the most heavily eroded and contaminated in the world. The near-surface layer of the peat is contaminated by high concentrations of anthropogenically derived, atmospherically deposited heavy metals which are released into the fluvial system as a consequence of widespread erosion. Whilst not desirable, this legacy of lead pollution and its release offer a unique opportunity to trace peatland sediment movements and thus investigate the controls on sediment and contaminant mobility.

A suite of established field, analytical and modelling techniques have been modified and adapted for use in peatland environments and these have been successfully employed in combination to address issues of sediment and contaminant release at a range of scales, including: (i) the development of field portable XRF to assess in situ lead concentrations in wet organic sediments; (ii) adaptation of time integrated mass flux samplers to explore spatial and temporal sediment dynamics in peatland streams; and (iii) the application of sediment source fingerprinting and numerical mixing models to investigate suspended sediment composition in contaminated organic rich catchments.

Several mechanisms and controls have been shown to be important influences on sediment dynamics and Pb release across a range of spatial and temporal scales: (i) the presence of vegetation is key in stabilising the peat's surface and trapping mobilised sediment; (ii) sediment preparation influences the timing of POC and Pb release; (iii) antecedent water tables may control the timing and the nature of sediment entering the fluvial system during storm events; and (iv) the degree of degradation influences both Pb storage and release. At the landscape scale, peatland restoration significantly mitigates sediment production in eroding peatlands and substantially reduces carbon and pollutant export. At the catchment scale, sediment preparation and hydrological connectivity are important controls on the magnitude and timing of sediment and lead fluxes from eroding peatland catchments. At the plot scale, complex small scale spatial patterns of contaminant storage in eroding headwater catchments can be explained by interactions between topographic setting and vegetation cover, and the mobilisation of sediment by wind and water.

This deeper understanding of the multi-scalar dynamics of sediment movements in eroding peatlands is important in the context of: (i) the release and reworking of legacy contamination in organic rich systems; (ii) the response of blanket peats to climate change; (iii) informing future restoration strategies that aim to manage peatland sediment and contaminant fluxes.