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Examining Hyporheic Dynamics Under Fluctuating Stream Stage Conditions

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Gaining river systems that are connected to groundwaters with increasing nitrate levels are at risk from increased nitrate loading. The consequences of greater nitrate transfer to surface waters are uncertain, but attenuation of nitrate waters at the groundwater –surface water interface may help to reduce the ecological impact on receiving surface waters.
The majority of studies of groundwater-surface water interactions have focussed on low flow conditions. Some studies have revealed evidence of biogeochemical reactions occurring at a greater depth in the subsurface than could be supported by mixing between surface water and groundwater under low flow conditions. We believe that, under particular geomorphological settings, short-lived changes in groundwater flow pathways may lead to transformations of the extent of hyporheic flow, and thus potentially impact on biogeochemical cycling at this interface.
Here we focus on the influence of changes in stream stage, during storm events, on the extent of the hyporheic zone. It is hypothesised that when there is a large sudden change in surface water level, ambient groundwater gradients can undergo a transient reversal, leading to temporary downwelling of surface water which alters the physical and biogeochemical conditions in the subsurface. Physically, downwelling surface water increases the residence time of water within the subsurface by impeding the movement of upwelling groundwater. Biogeochemically, downwelling surface water supplies, for example, dissolved organic carbon to the subsurface, potentially supporting favourable redox conditions for nutrient transformations.
To evaluate this concept, the dynamics of groundwater-surface water interactions are being examined at an instrumented gaining reach of the River Leith, Cumbria, UK. Experimental evidence is being gathered by continuously logged hydraulic head data, electrical geophysics and temperature profiles. These data are supported by repeat spot sampling during events for Radon-222 and stable isotopes from multi-level porewater samples. Radon-222 and stable isotopes have been used as tracers for mixing at the groundwater-surface water interface as there is a clear contrast between surface water and shallow groundwater compositions. Water level hydrographs have revealed localised hydraulic head reversals lasting for 36 hours during the peak of an event. Modelling of these responses has shown surface water infiltration into the streambed up to 10-20cm depth. Surface water downwelling is seen up to 20cm depth in electrical geophysics time series and the time delay between evidence of surface water infiltration between 10cm and 20cm depths is consistent with preliminary analysis of temperature-derived vertical fluxes. Riverbank hydrographs also display a reversal in shallow groundwater flow direction during the peak of an event.
This work will provide a field based assessment of hyporheic flow processes, help interpret hydrochemical data obtained along the study reach, contribute to a greater understanding of complexities within the hyporheic zone and consequently help to inform future management strategies.