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Temporal variability in water flux and nitrogen biogeochemistry in hyporheic zone sediments

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We examine the influence of river stage on mixing depth and spatial variation in biogeochemistry in the hyporheic zone of a groundwater-fed river. A 250m reach of the River Eden, Cumbria, UK, is instrumented with a dense network of 88 piezometers at depths from 10cm to 100cm providing detailed data on subsurface water fluxes and pore water biogeochemistry. Our monitoring data suggests increases in river stage during high flow events cause predominant upwelling hydraulic flow paths (vertical) in our study reach to weaken or reverse at some locations. Here, we test whether these disturbances to hydraulic exchange can affect the depth of surface water-groundwater mixing and biogeochemical gradients in the hyporheic zone. The impact of river stage fluctuation is investigated for distinct geomorphological environments (riffle and pool).

Our results reveal significant differences in the magnitude of vertical hydraulic exchange and direction of biogeochemical gradients between geomorphological environments and between low and high stage levels. Chloride is used here as a conservative tracer from which to base interpretations of reactive species. Chloride pore water concentrations at low stage indicate shallow (up to 20cm) surface water-groundwater mixing at riffle sites and no mixing at pool sites. At high stage, shallow mixing is observed at pool sites and continuous subsurface head measurements indicate vertical hydraulic gradients have weakened at pool sites relative to low stage. For riffle sites, high stage coincides with higher ground and river water nitrate concentrations than at low stage. Interestingly, manganese concentrations in surface water and groundwater increase significantly at high stage at both riffle and pool locations, although the magnitude of the increase is greatest in the riffle. This may be evidence of reducing conditions developing at some depths in the riffle during high stage . Dissolved organic carbon concentrations show a similar trend to manganese. Multivariate statistical analysis of the hydrological and biogeochemical datasets reveals a significant environmental gradient related to geomorphological setting and stage level. Two principal components summarised 81% of the variance in the data. Distinct biogeochemical zones are identifiable in the data, which are characterised most strongly by high nitrate / low manganese or low nitrate / high manganese.