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# Assessing riverbed hydrology and hydrochemistry in the heterogeneous setting of the Lower Coal Measures (South Yorkshire, UK): the interplay of geomorphic and hydrogeologic features at reach and channel-unit scales

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With the recent Water Framework Directive (EC, 2000), interactions between streams and aquifers, and their impact on the stream ecological status have to be assessed. This is particularly difficult in areas of minor aquifers, which tend to be less intensively monitored than more productive formations. Focusing the assessment in the riverbed not only allows to overcome this practical limitation; it also permits to better assess the range of processes occurring at the groundwater/surface water interface and influencing the hydrology, the hydrochemistry and the biology of both streams and aquifers. This understanding is furthermore needed to be able to produce more robust risk assessments, for example in the context of remediation of groundwater contamination (Smith and Lerner, 2008). We carried in 2008 a preliminary hydrological and hydrochemical study of the spatial scales of ground- and surface-water interaction in the hydrogeologically heterogeneous setting of the Coal Measures (Carboniferous deltaic deposits, South Yorkshire, United-Kingdom), based on a network of riverbed mini-piezometers at four reaches, in a 7.6 km river corridor. Our aim was to assess how two scales of geomorphic and hydrogeologic features were interplaying to control the hydrology and the hydrochemistry of the riverbed water: reach scale control on groundwater flowpaths, which infiltrate into the alluvial deposits at the opening of the alluvial valley (unconstrained zone) - where their hydrochemistry evolves in relation to water-rock interactions, biogeochemical processes or mixing with groundwater flow systems - and are forced back to the stream at its narrowing (constrained zone) (Stanford and Ward, 1993); riffle and run/pool sequences, driving localized hyporheic exchange flows between the stream and the riverbed (Harvey and Bencala, 1993; Kasahara and Wondzell, 2003). We measured the Vertical Hydraulic Gradients (VHGs) to discuss the directions and intensities of exchange between the stream and the riverbed. Electrical conductivity (EC), Cl and B were used as conservative tracers to distinguish flow systems and stream and riverbed water mixing; pH, O2, Dissolved Organic Matter (DOC), Alkalinity, NO3, SO4, Fe and Mn to discuss the potential occurrence of biogeochemical processes. Our results show a strong interplay of the reach and channel unit scales of control on the vertical hydraulic gradients and on the hydrochemical signatures in the riverbed. In constrained zone, the hydrochemistry of the riverbed is dominated by the groundwater flowpaths, and the strong upwelling gradients limit the depth of stream water infiltration in riffles; microbiological processes do not seem to be well developed, potentially in relation to low levels of organic matter in the groundwater flowpaths. In unconstrained and asymmetric (bedrock outcropping on one bank) zones, low VHGs favor a vertical differentiation of riverbed hydrochemistry and a much deeper infiltration of stream water; microbiological processes are well-developed, even in areas where organic matter and solutes are not carried into the riverbed by hydrological exchange with the stream. We are now developing a new network of mini-piezometers in order to better characterize the spatial replicability of the hydrological and hydrochemical riverbed patterns observed during our first sampling season, and to discuss their temporal variability, seasonally and in relation to the hydrometeorological conditions.

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