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Unraveling the Drivers of Spatial and Temporal Variability in Biogeochemical Cycling at Aquifer-River Interfaces - The LEVERHULME Hyporheic Zone Research Network

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While there has been substantial improvement of understanding hyporheic exchange flow and residence time controls on biogeochemical turnover rates, there is little knowledge of the actual drivers of the spatial and temporal variability of interlinked biogeochemical cycles. Previous research has mainly focused on bedform controlled hyporheic exchange and the transformation of surface solutes along a hyporheic flow path but failed to explain observations of spatially and temporally variable nutrient turnover in streambeds with higher structural heterogeneity and autochthonous carbon and nitrogen sources.
The “Leverhulme Hyporheic Zone Research Network” has developed an interdisciplinary strategy for investigating the physical controls on hyporheic exchange fluxes and residence time distributions, heat and reactive solute transport along biogeographical and catchment gradients. This strategy combines smart tracer applications with distributed sensor networks in multi-scale nested monitoring schemes and numerical model studies to investigate the interactions between physico-chemical process dynamics and hyporheic microbial, invertebrate and macrophyte ecology. Investigations integrating the process knowledge from mesocosms to artificial channels and stream reaches highlight the impact of small-scale streambed structure on spatial patterns of hyporheic exchange flow, residence time distribution and the development of biogeochemical hotspots. Manipulation studies inhibiting flow through dominant hyporheic exchange flow paths allowed to quantify the functional significance, sensitivity and resilience of biogeochemical, microbial and ecological functioning of identified hyporheic hotspots to environmental change. Further discharge and stage manipulations proved to not only control in-channel macrophyte growth but also temperature patterns and residence time distributions as well as microbial metabolic activity and biogeochemical processing rates, highlighting the potential impacts of flow extremes such as droughts.
As an interdisciplinary project the network is striving to extend its collaborations in particular towards including a wider range of streambed environments and the investigation of biotic feedback functions on biogeochemical cycling.