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The value of automated high-frequency nutrient monitoring in inference of biogeochemical processes, temporal variability and trends

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Stream water quality signals integrate catchment-scale processes responsible for delivery and biogeochemical transformation of the key biotic macronutrients (N, C, P). This spatial and temporal integration is particularly pronounced in the groundwater-dominated streams, as in-stream nutrient dynamics are mediated by the processes occurring within riparian and hyporheic ecotones.
In this paper we show long-term high-frequency in-stream macronutrient dynamics from a small agricultural catchment located in the North West England. Hourly in-situ measurements of total and reactive phosphorus (Systea, IT), nitrate (Hach Lange, DE) and physical water quality parameters (turbidity, specific conductivity, dissolved oxygen, temperature, pH; WaterWatch, UK) were carried out on the lowland, gaining reach of the River Leith. High-frequency data show complex non-linear nutrient concentration-discharge relationships. The dominance of hysteresis effects suggests the presence of a temporally varying apportionment of allochthonous and autochthonous nutrient sources. Varying direction, magnitude and dynamics of the hysteretic responses between storm events is driven by the variation in the contributing source areas and shows the importance of the coupling of catchment-scale, in-stream, riparian and hyporheic biogeochemical cycles. The synergistic effect of physical (temperature-driven, the hyporheic exchange controlled by diffusion) and biogeochemical drivers (stream and hyporheic metabolism) on in-stream nutrient concentrations manifests itself in observed diurnal patterns. As inferred from the high-frequency nutrient monitoring, the diurnal dynamics are of the greatest importance under baseflow conditions.
Understanding the role and relative importance of these processes can be difficult due to spatial and temporal heterogeneity of the key mechanisms involved. This study shows the importance of in-situ, fine temporal resolution, automated monitoring approaches in providing evidence and understanding reach-scale in-stream biogeochemical processes. In this paper we discuss the advantages and limitations of the in-situ high-frequency nutrient monitoring, the challenges related to data analysis and process inference and the integration of the short-term biogeochemical behaviour with the long-term trends. Finally the potential for integration of the long-term high-temporal resolution datasets with the predictions of reach- and catchment-scale biogeochemical models and observations from coarse-sampling monitoring strategies has been discussed.