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Understanding in-stream temporal coupling of macronutrients based on high-frequency monitoring in groundwater dominated rivers

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Developments in high-frequency water quality measurements enable capturing of fine structure of temporal variations in river biogeochemistry. Understanding of the temporal variation in the nutrient source and in-stream processes is critical in restoration of the good ecological and chemical status of river ecosystems. However, to date the in-stream temporal variability of macronutrients captured by high-frequency sampling is poorly understood (Scholefield et al., 2005; Milne et al., 2009; Harris and Heathwaite, 2011). Typically, river water quality monitoring is based on coarse sampling or storm event targeting strategies that miss the low flow water quality dynamics when in-stream processes and chemical-biological interactions may be of the greatest importance.
This paper investigates the temporal dynamics and interdependencies between multiple high-frequency (hourly) nutrient and water quality time series collated for the River Leith, a tributary of the River Eden (Cumbria, UK). In-stream nutrients (total phosphorus TP, soluble reactive phosphorus SRP, nitrate nitrogen NO_3N) and water quality parameters (turbidity, specific conductivity, pH, temperature, dissolved oxygen, redox potential) were measured by an automated remote mobile lab. A 54 km2 catchment of the River Leith is of mixed geology with Carboniferous limestone overlain by Penrith Sandstone and glacial till deposits. Permeable riverbed deposits create an active groundwater-surface water interface with hyporheic processes potentially exerting control over nutrient cycling.
The temporal variation in in-stream nutrients and water quality variables was analysed. Diurnal patterns were observed during low flow conditions for both nutrients and water quality time series. Possible physical and biogeochemical controls on nutrients short-term dynamics were discussed. Antecedent and contemporaneous interdependencies between nutrients, water quality and hydrometric time series were explored in more detail using time series analysis methods to provide insights into how temporal patterns of nutrient signatures might be related to hydrological and biochemical processes.
This study recognises the importance of high-frequency sampling schemes in providing the understanding of complexities of patterns and processes controlling the nutrient cycling in river ecosystems. This knowledge is essential to deliver adequate programmes of measures focusing on restoration of good ecological health of the rivers and to model the in-stream responses to the changing environment.

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