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Geomorphic and substrate controls on spatial variability in river solute transport and biogeochemical cycling

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Nutrient concentrations in surface waters and groundwaters are increasing in many agricultural catchments worldwide as a result of anthropogenic activities. Increasing geomorphological heterogeneity in river channels may help to attenuate nutrient pollution by facilitating water exchange fluxes with the hyporheic zone; a site of intense microbial activity where biogeochemical transformation rates (e.g. denitrification) can be high. However, the controls on spatial variability in biogeochemical cycling, particularly at scales relevant for river managers, are not well understood. Here, we aimed to assess: 1) how differences in geomorphological heterogeneity control river solute transport and rates of biogeochemical cycling at sub-reach scales (10^2 m); and 2) the relative magnitude of these differences versus those relating to reach scale substrate variability (10^3 m). We used the reactive 'smart' tracer resazurin (Raz), a weakly fluorescent dye that transforms to highly fluorescent resorufin (Rru) under mildly reducing conditions, as a proxy to assess rates of biogeochemical cycling in a lowland river in southern England. Solute tracer tests were conducted in two reaches with contrasting substrates: one sand-dominated and the other gravel-dominated. Each reach was divided into sub-reaches that varied in geomorphic complexity (e.g. by the presence of pool-riffle sequences or the abundance of large woody debris). Slug injections of Raz and the conservative tracer fluorescein were conducted in each reach during baseflow conditions ($Q \approx 80$ L/s) and breakthrough curves monitored using in-situ fluorometers. Preliminary results indicate overall Raz:Rru transformation rates in the gravel-dominated reach were more than 50% higher than those in the sand-dominated reach. However, high sub-reach variability in Raz:Rru transformation rates and conservative solute transport parameters suggests small-scale targeted management interventions to alter geomorphic heterogeneity may be effective in creating hotspots of river biogeochemical cycling and nutrient load attenuation.