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Dynamic boundary conditions control the spatial and temporal variations of nutrient turnover in human impacted surface waters

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The temporal dynamics of nutrient cycles and the remineralization of micropollutants in given stream or river sections are driven by a complex interplay of hydraulic, climatic and ecological processes which are difficult to quantify and to predict. Typically, we use either e.g. water levels or velocity, radiation input, oxygen availability, water and air temperatures, hyporheic exchange or the activity of auto- and heterotroph organisms alone or in combination to explain observed rates of substance cycling. To improve the predictability of occurring nutrient cycles and biomass growth we selected seven river reaches (1.5 -3.3 km) throughout the Mosel-region in western Germany which are located down stream of sewage water treatment plant effluents. Over a time span of four months we carried out about 10 longitudinal snapshot sampling campaigns at each of the river sections. We sampled for nutrients (C, N, P) and selected pharmaceutical products as well as the hydraulic and climatic and boundary conditions. Additionally, at one of the river sites we observed along the river reach weekly microbial biofilm growth rates, microbial biodiversity (DNA), macrozoobenthos biodiversity in the dominating streambed substrates as well as weekly samples of C, N, P in the sediment.

The results show clearly how the interplay between hydraulic and climatic boundary conditions controls ongoing nutrient cycles and process rates; e. g. the spatial (downstream) extent of measurable surplus C, N, and P varies clearly over time as well as between the substances (P > C > N). Restricted by hydraulic boundary conditions, biomass production and a reduced (function specific) biodiversity of microbial biofilms coincide either with high nutrient surplus or with exposition to solar radiation. Favorable ambient conditions (lower water levels and higher energy availabilty) are dominant drivers for observable removal of pharmaceutical products rather than nutrient availability. Overall, our results demonstrate the importance of the local settings (cross section, shading) in combination with season and hydraulic loadings at given river sections for occurring process rates in nutrient cycles and biomass growth.