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Quantifying heterogeneity in stream ecosystems' hyporheic zone: Benefits for representative sampling

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The hyporheic zone is a key habitat for species across many taxa, based on the co-occurrence of different ecological niches. Thus, it attracts high attention among hydrological scientists, but recommendations on appropriate sampling layout to quantify the physico-chemical properties of the hyporheic zone are lacking. Thus, the objective of this study was to develop and validate a framework for sampling strategies to provide an unbiased data collection. Applying geostatistical analysis, we quantified the spatio-temporal variability of parameters which characterize the physico-chemical substratum conditions in the hyporheic zone (specific conductance, pH and dissolved oxygen). We investigated a total number of 14 river sections during three sampling dates, comprising more than one year, in six small, anthropogenically altered lowland rivers that are typical for the majority of temperate areas. In this study, the term spatial variability refers to patch contrast (patch to patch variance) and patch size (spatial expansion of a patch). Patch contrast increased with the macrophyte cover ($r^2 = 0.95$, $p < 0.001$), while their patch size decreased from 6 to 2 m with increasing sinuosity of the stream course ($r^2 = 0.91$, $p < 0.001$), irrespective of the time in the year. The results indicate that a quantification of the spatial variability of a river section is possible before intensive sampling. To this end, easily determinable variables (sinuosity and macrophyte cover), which drive spatial variability are required to deduce recommendations for sampling. Since driver properties and the spatial variability vary between river sections within one river and between rivers, sampling designs have to be adapted to the unique local situation of the spatial variability of each river section.