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Understanding the importance of hyporheic processes at the catchment scale

Marc Schwientek, Benny Selle, and Karsten Osenbrück

WESS - Water & Earth System Science, University of Tübingen, Germany (corresponding author: marc.schwientek@uni-tuebingen.de)

Main processes that govern stream water quality are i) the inputs of soluble and particulate matter from diffuse and point sources and ii) in-stream + hyporheic attenuation processes such as dilution, sorption, biotic uptake and degradation. Efficient removal and transformation of solutes in the hyporehic zone has been demonstrated for several sites. Current research aims at further illuminiating the involved reaction pathways and the necessary biogeochemical boundary conditions. Interactions of the aforementioned processes at catchment scales, however, are still poorly understood. The present study quantifies hyporheic source and sink terms for nitrate (NO3-) and evaluates their relative importance at the catchment scale.
To this end, two nested field sampling programs are carried out in a 140 km^2 catchment in SW Germany. For the first program, a reach of the main stem river is investigated to study the interaction of surface water and adjacent groundwater bodies as well as hyporheic degradation processes. A network of piezometers is installed at different depths of the local gravel aquifer, which is bounded by a river meander. Water is regularly sampled from the piezometers, analyzed for redox sensitive parameters, and used for microbiological experiments. Hydrogeologic properties of the aquifer are inferred from slug tests and geoelectric surveys. In addition to reaction mechanisms of particular processes, we focus on the relationship between the fluxes of matter (in particular NO3- and DOC) that are turned over in the subsurface reach and the fluxes transported by the total river discharge. Water flow through the meander aquifer is quantified by tracer experiments and direct discharge measurements of return flow at the downstream end of the meander.
In order to put the results of the local study into a larger scale context, a complementary sampling program is performed. The hyporheic attenuation for the whole stream network as well as for segments is quantified by balancing NO3- loads entering the main stem stream along its course versus loads leaving the catchment at its outlet.
Preliminary results show that hyporheic degradation processes can be intense locally. Mass balances at the catchment scale indicate that a higher fraction of input matter is attenuated in the headwaters of stream networks than in downstream reaches. We demonstrate that this conclusion can be also drawn from theoretical equations describing the changing hydrodynamic conditions along the stream.