Geophysical Research Abstracts
Vol. 13, EGU2011-8901-4, 2011
EGU General Assembly 2011

# Integrated field experiments and numerical modelling to evaluate the factors controlling water flow and redox conditions in the hyporheic zone

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The interaction between surface water, the hyporheic zone and the connected alluvial aquifer is an important control for many hydrogeological and biogeochemical processes. The extent and functioning of the hyporheic zone are controlled by a variety of hydraulic and morphological factors. The complex interplay between these factors is still poorly understood; e.g.: upwelling groundwater may delimit the vertical extent of the hyporheic zone and may thus influence hyporheic flow paths and residence times.

The aim of our study is a quantitative description of hydraulic, morphologic and geochemical parameters that control the magnitude and direction of water flow as well as the redox conditions in the hyporheic zone.

We hypothesize that variable hydraulic conditions and bedform morphology are the key controlling factors for flow, solute transport and reactions in the hyporheic zone. The influence of changing hydraulic conditions such as stream flow velocity, water depth and groundwater discharge on the extent and the redox zonation of the hyporheic zone is evaluated. Besides varying hydraulic conditions, different setups of periodic bedform structures, described by their wavelengths, amplitudes and frequencies, are considered.

We collect hydraulic and chemical data at an experimental stream reach of 100 m in length with distinctive pool-riffle sequences. Pressure transducers and electrical conductivity (EC) sensors installed in piezometer nests within the streambed and at different depths in the river bank, measure time series of hydraulic heads and EC. To resolve vertical patterns and variability of dissolved oxygen concentrations (DO) in the streambed, a 2D-optode is developed for in situ measurements. Pore water samples for the analysis of redox-sensitive chemical compounds like nitrate, sulphate, phosphate and dissolved organic carbon (as indicators for the biogeochemical conditions in the hyporheic zone) are taken from multi-level sampling devices, located at the stoss, centre and lee sides of the pool-riffle sequences. To avoid the potential dislocation of installations in the streambed during floods, streambed-adapted sampling and monitoring tools have been developed.

Since streambed water fluxes are difficult to measure directly, magnitude and direction of flow in the hyporheic zone are simulated by coupling numerical surface and subsurface models. The surface water flow is represented by the computational fluid dynamics (CFD) software OpenFOAM. It solves the Navier-Stokes equations, considering turbulence and two phase flow (water and air) by the finite volume method. With the CFD software the pressure distribution on the streambed surface is derived. It serves as the upper boundary condition for a reactive transport model of the hyporheic zone, which will be implemented in the finite difference code Min3P.

Once the basic model has been set up, it can be used in an explorative manner to simulate the influence of various hydraulic conditions on water flow, solute transport and reactions in the hyporheic zone. The numerical experiments will be conducted in close connection with field experiments, which will be carried out to manipulate the hydraulic conditions (e.g. by groundwater pumping to artificially induce losing conditions).