Geophysical Research Abstracts,
Vol. 11, EGU2009-1134, 2009
EGU General Assembly 2009

Determination of small-scale flow directions and velocities in the hyporheic interstitial

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The hyporheic interstitial is a hydraulically dynamic and biogeochemical active interface between surface water and groundwater. Depending on the hydraulic boundary conditions and the connectivity with the adjacent aquifer, infiltrating and exfiltrating water pass through it. In addition to those larger scale flow patterns flow at the centimetre scale is influenced by streambed morphology, such as pool-ripple sequences, boulders and woody debris, and the hydrodynamics in the flowing water resulting in a very heterogeneous pattern of flow in the shallow sediment. Patterns of exchange at this scale control the supply of oxygen and nutrients to the sediments and are in turn crucial for biogeochemical turnover. To investigate flow velocity and flow direction in the hyporheic interstitial in situ, a method employing heat as a tracer was developed. The method was tested in a low gradient stream (mean slope of 1.8 0/00), with sandy streambed in Brandenburg, Germany (river Schlaube). The movement of a heat pulse emitted by a small point source is detected by temperature sensors attached to four rods (four sensors on each rod) that are vertically driven into the sediment in a concentric circle with a radius of 3 to 4.5 cm around the heat source. The resulting breakthrough-curves give evidence of flow velocities and flow directions in three dimensions, accounting for the local heterogeneities of the sediment. Patterns of flow direction were found to be quite heterogeneous even on small scales of a few decimetres. Interestingly at several locations flow in the sediment was directed opposite to surface flow. Measured flow velocities of up to 1.75 cm min-1 are several orders of magnitude larger than values previously reported in the literature. As this method is non-destructive it allows repetition of measurements and long-term investigations to assess the variability in time. Furthermore it is well suited for a combined application with sampling devices such as pore water peepers.