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Spatial Variability of Streambed Hydraulic Conductivity of a Lowland River

Uwe Schneidewind (1,2), Steven Thornton (3), Ellen Van De Vijver (2), Ingeborg Joris (1), Piet Seuntjens (1,2,4)

(1) VITO, Environmental Modeling Unit, Mol, Belgium (uwe.schneidewind@vito.be), (2) Ghent University, Department of Soil Management, Gent, Belgium, (3) The University of Sheffield, Groundwater Protection and Restoration Group, Sheffield, UK, (4) University of Antwerp, Department of Bioscience Engineering, Antwerp, Belgium

Streambed hydraulic conductivity K is a key physical parameter, which describes flow processes in the hyporheic zone (HZ), i.e. the dynamic interface between aquifers and streams or rivers. Knowledge of the spatial variability of K is also important for the interpretation of contaminant transport processes in the HZ. Streambed K can vary over several magnitudes at small spatial scales. It depends mostly on streambed sediment characteristics (e.g. effective porosity, grain size, packing), streambed processes (e.g. sedimentation, colmation and erosion) and the development of stream channel geometry and streambed morphology (e.g. dunes, anti-dunes, pool-riffle sequences, etc.). Although heterogeneous in natural streambeds, streambed K is often considered to be a constant parameter due to a lack of information on its spatial distribution.

Here we show the spatial variability of streambed K for a small section of the River Tern, a lowland river in the UK. Streambed K was determined for more than 120 vertically and horizontally distributed locations from grain size analyses using four empirical approaches (Hazen, Beyer, Kozeny and the USBR model). Additionally, streambed K was estimated from falling head tests in 36 piezometers installed into the streambed on a 4 m by 16 m grid, by applying the Springer-Gelhar Model. For both methods streambed K followed a log-normal distribution. Variogram analysis was used to deduce the spatial variability of the streambed K values within several streambed profiles parallel and perpendicular to the main flow direction in the stream.

Hydraulic conductivity Kg estimated from grain size analyses varied between 1 m/d and 155 m/d with standard deviations of 79% to 99% depending on the empirical approach used. Kh estimated from falling head tests varied between 1 m/d and 22 m/d with a standard deviation of about 50%, depending on the degree of anisotropy assumed. After rescaling the data to obtain a common sample support, Pearson correlation coefficients r were calculated between Kg and Kh. Overall, a relatively weak correlation ($r < 0.3$) was found between both parameters. This is most probably a result from soil coring that destroys the original sediment structure and any anisotropy within it.

Analysis of streambed K improved our understanding of the flow behavior in the HZ on a local scale. This will be of importance for the subsequent assessment of nitrate transport and attenuation in the river section.