Investigating the Impact of Heterogeneity in Streambed Sediments on Flow, Transport and Biodegradation Processes in the Hyporheic Zone

Schneidewind, U.[1,2], Joris, I.[1], Seuntjens, P.[1,2,3], Thornton, S.[4]

1 Environmental Modeling Unit, VITO, Boeretang 200, 2400 Mol, Belgium, uwe.schneidewind@vito.be

2 Department of Soil Management, Ghent University, Gent, Belgium

3 Department of Bioscience Engineering, University of Antwerp, Antwerp, Belgium

4 Groundwater Protection and Restoration Group, University of Sheffield, Sheffield, United Kingdom

The hyporheic zone (HZ) is the transition zone between an aquifer and a surface water body and provides various ecosystem services including a habitat for interstitial organisms, a spawning ground for fish and a rooting zone for aquatic plants. Over the last decades this zone has increasingly become the focus of scientific research studying spatial and temporal patterns of groundwater-surface water interaction as well as the exchange of nutrients, oxygen and energy between the aquifer and a surface water body. Consequently, a variety of measurement techniques and analysis tools has been developed to improve the conceptual understanding of these processes (Buss et al. 2009). By comparison, the fate of contaminants in the HZ of streams has received much less attention so far. However, as streams are in many cases the final receptors of groundwater pollution, a delineation of transport and attenuation processes at sediment, reach and catchment scales seems essential for river/aquifer management purposes and for the design of adequate remediation techniques.

Transport and attenuation processes in the HZ are defined by a variety of aspects including groundwater-surface water mixing patterns that define residence time of the contaminated water and biogeochemical activity of the streambed. In turn, mixing patterns are defined by local and regional flow processes, channel properties, climatic conditions or anthropogenic influence. Of major concern however are the characteristics of the streambed sediment that define local parameters such as hydraulic conductivities and exchange fluxes. In this study, we show the influence of heterogeneity in hyporheic sediments on natural attenuation of chlorinated ethenes by conducting a generic modelling study.

A numerical flow and transport model of a synthetic aquifer/streambed is built in HYDRUS/HPx (Simunek 2006) using a TCE contaminant source and considering sequential reductive dechlorination. The model is then used to perform scenario analyses considering different degrees of heterogeneity of the hyporheic zone sediments as well as different spatial distributions of hydraulic conductivity, fluxes and biodegradation rates. These different distributions are based on data obtained from River Zenne and Slootbeek field sites in Belgium and the River Tern field site in the UK with a variety of measurement techniques including soil sampling and grain size analysis, falling head tests, microcosm studies, streambed temperature, exchange flux and hydraulic gradient measurements. Model results show the added value of including heterogeneous hyporheic zone sediments into contaminant transport modelling. However, not all scenarios perform equally well with respect to the attenuation of TCE and its daughter products. Overall, results can be helpful in the development of future management and decision support tools.

Buss, S., Z. Cai, M.B. Cardenas et al, 2009. The Hyporheic Handbook - A handbook on the groundwater-surface water interface and hyporheic zone for environmental managers. Environment Agency Environment Agency Science Report SC050070 280 pp.

Šimůnek, J., M. , T. van Genuchten, and M. Šejna. 2006. The HYDRUS Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media Technical Manual, Version 1.0, PC Progress 241 pp.

Indicate your preference for a platform or poster presentation: Platform presentation