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Mass fluxes of organic pollutants between groundwater, streambed sediments and surface water

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Rivers and groundwater are commonly hydraulically connected and thus also pollutants migrate between one and the other. Particularly in small lowland streams, pollutant transport by discharging groundwater can deteriorate the surface water quality. Moreover, in urban and industrial areas streambed sediments are often polluted with a variety of organic and inorganic substances. For planning measures to improve surface water quality or to mitigate pollutant migration, it is an essential prerequisite to understand pollutant pathways and mass fluxes between the stream, the streambed sediment and the connected aquifer.

We present methodological approaches and results of a study conducted at a small man-made stream located in the industrial area of Bitterfeld-Wolfen, Germany. This site is characterized by a diffuse groundwater contamination with a variety of aliphatic and aromatic organic substances. The underlying approach of this study was to quantify the mass fluxes between the aquifer, the streambed and the stream by combining high-resolution with integral monitoring approaches. Magnitudes and pattern of water fluxes were obtained by mapping streambed temperatures. The method was applied to a reach of 280 m in length. The mass fluxes from the aquifer towards the stream were estimated by combining the water fluxes with representative, average pollutant concentrations. The concentrations were obtained from an integral pumping test with four simultaneously pumped wells operated for the period of five days. For monochlorobenzene (MCB), the main groundwater pollutant at the site, the resulting average mass flux from the aquifer towards the stream was estimated to 724 μg/m^2/d. Mass flux calculations with average aqueous concentrations of MCB in the streambed were found to be higher than those originating from the aquifer. Consequently, the streambed sediments represent a secondary pollutant source for the surface water. Pollutant concentrations in the streambed were lower at locations with high groundwater discharge and vice versa. Hence, the spatial heterogeneity of water fluxes must be considered when mass fluxes between surface water and streambed sediments are assessed.

River restoration could improve the structural state of rivers and may thus result in an enhanced biodegradation of organic pollutants in the streambed. However, before any physical measure is applied a profound knowledge of pollutant concentration and pathways is required in order to avoid mobilization of sediment-bound pollutants.