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Patterns of groundwater discharge to a stream and their influence on the timescales of contaminant release from streambed sediments

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Streambed sediments may act as long-term storage zones for organic contaminants originating from the stream water. The occurrence of contaminants in the streambed results from aqueous-phase transport and particle-facilitated deposition. In temperate climates, groundwater typically discharges into streams and rivers. Groundwater discharge through the sediments may induce remobilization and advective transport of contaminants, so that they are released back from the streambed to the stream water. The focus of this study was to investigate the long-term mass flow rates of chlorinated benzenes (MCB, DCBs) from a streambed to the overlying stream water driven by advection of groundwater. Investigations were conducted at a reach of 220 m in length of small man-made stream in the industrial area of Bitterfeld (Germany), which was used for waste water discharge from the chemical industry nearby until the early 1990s. The spatial patterns and magnitudes of groundwater discharge were quantified at 140 locations using streambed temperatures. Groundwater fluxes through the streambed were found to range from 11.0 to 455.0 $Lm^{-2}d^{-1}$. According to locations with high and low groundwater discharge, time-integrating passive samplers were used to monitor current contaminant concentrations in the streambed. At high groundwater discharge locations, streambed contaminant concentrations were found to be lower than at low discharge locations. Batch experiments were conducted to obtain the kinetic parameters of the mass transfer process as input data for a transport model of the streambed. We ran numerical one-dimensional advective transport models for the observed range of groundwater fluxes to simulate the timescales of contaminant release and their de-

pendence on the magnitude of groundwater flux. The results of the long-term predictive modeling revealed that the time required to reduce the streambed contaminant concentrations and the resulting mass fluxes to the stream water to 10 % of the initial values will be in the scale of decades for high-discharge locations and centuries for low-discharge locations, respectively.