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# Evaluation of hydraulic characteristics in a pilot-scale constructed wetland using a multi-tracer experiment

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In recent years, constructed wetland systems have become into focus as means for organic contaminant removal. The use of constructed wetlands as part of water treatment offers great opportunities to realize significant savings in future wastewater treatment costs for small communities and the adaptation of large wastewater treatment plants. Wetland systems provide a highly reactive environment in which several elimination pathways of organic chemicals may be present at the same time; however, these elimination processes and hydraulic conditions are usually poorly understood. Previously, in our study site monochlorobenzene removal was observed in a pilot-scale wetland system which treats contaminated groundwater from the regional aquifer in Bitterfeld. The degradation was linked to either aerobic or anaerobic, iron- or sulfate- reduction or multiple processes, in parallel. However, it was unclear how the groundwater flows through this system, precluding a more founded understanding of the flow and transport processes.

Therefore, we investigated the flow system in this three dimensional pilot-scale constructed wetland applying a multi tracer test combined with a mathematical model to evaluate the hydraulic characteristics. The pilot system consisted of a 6 m length x 1 m wide x 0.5 m depth gravel filter with a triple inflow distributed evenly approx. 5 cm from the bottom at the inflow. Three conservative tracers (uranine, bromide and deuterium) were injected as a pulse at the inflow and analyzed at 4 meters distance from the inflow at three different depths to obtain residence time distributions of groundwater flow in the gravel bed of the wetland. A mathematical multi-flow dispersion model was used to model the tracer breakthrough curves of the different sampling levels, which assumes parallel combinations of the one-dimensional advection-dispersion equation.

The model was successfully applied to fit the experimental tracer breakthrough curves by assuming three flow paths. For each flow path, the groundwater volume, water-saturated porosity, mean groundwater retention time, longitudinal dispersivity and flow velocity in the wetland were derived from the model parameters. The results indicate the existence of a multiple flow system with two distinct flow paths through the gravel bed and a preferential flow at the bottom resulting from the inflow design of the model wetland system. The used model was calibrated with high accuracy for the bottom level. Differences between simulated and measured concentrations in the upper levels indicate possible influence of diffusion processes with stagnant water zones. The tracer study demonstrated the complexity of flow and transport processes in the constructed wetlands which need to be taken into account during interpretation of the determining attenuation processes.