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Prediction of Groundwater Flow and Transport Processes in an Urban Area: A Combined Approach of Field Testing and Numerical Modeling

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Drinking water supply in urban areas is challenging due to different kinds of water use and potential groundwater contamination. We investigate an area where drinking water production is close to different contaminated sites. The study site is characterized by a high complexity of the tectonic and geological setting with a gravel and a karstic aquifer. The two aquifers are partly connected, partly disconnected by an aquitard. To avoid drinking water contamination, artificial groundwater recharge with surface water into the gravel aquifer is used to create a hydraulic barrier between the contaminated sites and the water abstraction wells. Trace compounds, that were found in former times in the surface water but not nowadays, are still detected in the extracted drinking water. Different studies have been performed such as numerical modeling, intensive groundwater monitoring and investigation of drilling cores to get a differentiated overview of the distribution of the contaminants. Back-diffusion from the matrix due to changing hydraulic boundary was stated to be the reason for the actual distribution of the contaminants. In a first approach due to the lack of experimental data or evidence from field measurements, the permeabilities of the karstic aquifer were assumed as homogeneous.

In our study, we seek to identify the flow and transport processes within the system including the fracture network in a combined approach of field work and 3D modeling with FEFLOW. During a field campaign we acquired water samples for the analysis of stable water isotopes as well as organic and inorganic compounds. Furthermore, tritium and helium samples were taken to estimate water ages and to determine the flow through the fracture networks. A combination of existing and recently obtained data was used to build and validate a 3D flow and transport model. The simulation of different scenarios such as the water flow for varying injection and extraction rates as well as particle transport from different sources is carried out. To investigate the effect of subsurface heterogeneity, PEST, an independent parameter estimation and uncertainty analysis software, was used.

With the calibrated model we will be able to optimize the operational conditions of artificial recharge and drinking water production especially at the boundaries of the production field. Hence, we can provide guidelines for an improved water resource management.