



Reactive multi-tracer test in a karst system

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Parameter identification in karst aquifers is complicated by the dualistic nature of the flow system consisting of a fractured matrix and conduits. The conduit system acts as the main hydraulic component because of its dominant draining function. Because of its low volume fraction compared to the total aquifer, parameters are rather difficult to obtain.

The aim of the presented work is to assess hydraulic and geometric parameters of the conduit system. For this purpose a multi-tracer test was conducted in a well characterised karstic system (Gallusquelle, Swabian Alb, Germany). The three tracers uranine, sulforhodamine G and tinopal CBS-X were simultaneously and directly injected into the conduit system via a sinkhole. Before and after the experiment, the system was extensively flushed to ascertain nearly saturated conditions and to reduce the influence of the vadose zone on tracer breakthrough. The breakthrough curves were monitored by online fluorescence spectroscopy. In addition, samples were taken and analysed later with HPLC-FLD to avoid possible cross interferences and to verify results.

The tracers separated well along the flow path in less than two days travel time according to their acid strengths. This separation can be explained by ion exchange on metal oxihydroxides with a point of zero charge of ca. 8 on the conduit surface. Uranine breakthrough occurred first followed by sulforhodamine G 25 minutes later and after another 20 minutes tinopal CBS-X appeared. While the curves of uranine and sulforhodamine G are nearly symmetrical the tinopal CBS-X displays a distinct tail-

ing. The breakthrough curves were fitted by the process-based non-equilibrium model CXTFIT. The model provides among other parameters the volume and the exchange coefficient of mobile and immobile phases. Conservative transport parameters were obtained from the non-retarded tracer uranine and further used to fit the two other tracers by reactive transport modelling taking into account exchange processes between mobile and immobile water and retardation. This procedure largely reduces the uncertainty of the reactive transport model. The results can be explained process-oriented by the physico-chemical properties of the tracers and the interaction with the metal oxihydroxides of the conduit surfaces.