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Assessment of transport parameters in a karst system under various flow periods through extensive analysis of artificial tracer tests

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It is primordial to understand the sensibility of a catchment or a spring against contamination to secure a sustainable water resource management in karst aquifers. Artificial tracer tests have proven to be excellent tools for the simulation of contaminant transport within an aquifer before its arrival at a karst spring as they provide information about transit times, dispersivities and therefore insights into the vulnerability of a water body against contamination (Geyer et al. 2007). For this purpose, extensive analysis of artificial tracer tests was undertaken in the following work, in order to acquire conservative transport parameters along fast and slow pathways in a mature karst system under various flow conditions. In the framework of the project "Protection of Jeita Spring" (BGR), about 30 tracer tests were conducted on the catchment area of the Jeita spring in Lebanon (Q= 1 to 20 m^3/s) under various flow conditions and with different injection points (dolines, sinkholes, subsurface, and underground channel). Tracer breakthrough curves (TBC) observed at karst springs and in the conduit system were analyzed using the two-region non-equilibrium approach (2NREM) (Toride & van Genuchten 1999). The approach accounts for the skewness in the TBCs long tailings, which cannot be described with one dimensional advective-dispersive transport models (Geyer et al. 2007). Relationships between the modeling parameters estimated from the TBC were established under various flow periods. Rating curves for velocity and discharge show that the flow velocity increases with spring discharge. The calibrated portion of the immobile region in the conduit system is relatively low. Estimated longitudinal dispersivities in the conduit system range between 7 and 10 m in high flow periods and decreases linearly with increasing flow. In low flow periods, this relationship doesn't hold true as longitudinal dispersivities range randomly between 4 and 7 m. The longitudinal dispersivity decreases with increasing flow rates because of the increase of advection control over dispersion and increasing dilution. Therefore variance of the TBC is controlled on the hand by dispersivity during high flow periods and on the other hand by increasing mobile phase in low flow periods due to an increase of the portion of immobile zones (pools and ripples) as water level decreases. For tracer tests with injection points at the surface, longitudinal dispersivities are found to be of higher ranges (8–27 m) and highly reflective of the compartments in which the tracer is flowing (unsaturated rock matrix, conduits or channel). The comparison of tracer tests with different injection points shows clearly that the tailing observed in some of the breakthrough curves is mainly generated in the unsaturated zone before the tracer arrives to the main channel draining the system and decreases gradually within the channel.

Geyer, T. , Birk S., Licha T., Liedl R., Sauter M. (2007): Multitracer Approach to Characterize Reactive Transport in Karst Aquifers. Groundwater, Vol. 35, No 1. 35-45.

Toride, N., Leij, F.J., van Genuchten, M.T., 1999. The CXTFIT code (version 2.1) for estimating transport parameters from laboratory or field tracer experiments. U.S. Salinity Laboratory Agricultural Research Service, U.S. Department of Agriculture Riverside, California. Research Report 137.