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Location of the rapid recharge area in karst catchments by the combined analysis of spring responses and artificial tracer tests

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The objective of the study presented is the location of the rapid recharge area in the catchment of a karst spring. For this purpose hydraulic parameters of a karst aquifer are estimated from the discharge hydrograph and physico-chemical responses of a karst spring. The results are compared with hydraulic parameters determined from analyses of artificial tracer tests performed at different distances to the spring. The comparison allows the estimation of the distance between the rapid recharge area and the karst spring.
Spring responses of the Gallusquelle aquifer (Swabian Alb, Germany) were analysed applying the approach proposed by Ashton (1966), i.e. the water discharged between the respective increases in the hydraulic and transport responses allows the quantification of the water filled conduit volume. After recharge events physico-chemical spring responses can be differentiated into summer event or winter event responses. Responses after summer events are mostly the result of heavy rain storms, whereas winter events usually occur after snowmelts. The shape of spring responses differ substantially between summer and winter events, e.g. the effect of superposition of events during extended snowmelt periods. Calculated conduit volumes after snow melts tend to be smaller than calculated conduit volumes after summer events at comparable pre-event discharge. However, the difference is small suggesting that rapid recharge into the conduit system occurs after winter as well as summer events and the applicability of the method for both types of recharge events on the Gallusquelle spring.
Based on thirteen artificial tracer tests conduit volumes between the tracer injection site and the Gallusquelle spring were determined by integrating the volume of water discharged between the time of tracer injection and mean tracer arrival time. Tracer arrival times are calibrated with the non equilibrium approach in the software CXTFIT2. The estimated conduit volumes are translated into equivalent conduit diameters based on linear transport distances. The analyses suggest that conduit diameters decrease slightly with increasing travel distance. The obtained mean diameter of a cylindrical equivalent solution conduit in the catchment area is ca. 5 m, whereas at low discharge the effective conduit diameter decreases. The estimated mean conduit diameter from artificial tests in combination with the conduit volumes obtained from spring responses were used to determine the distance between the rapid recharge area and the Gallusquelle spring. This characteristic length is estimated to be four to five kilometers, which is reasonable considering a length extension of the catchment area of twelve kilometers. It can be assumed that dry valleys in the north-western part of the catchment area are of particular importance for rapid recharge.

Reference

Ashton K (1966) The analysis of flow data from karst drainage systems. Transactions of the Cave Research Group of Great Britain 7(2): 161-203.