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Understanding intercatchment flow in a karst aquifer – using the Lurbach system example (Eastern Alps - Austria)

Thomas Wagner (1), Cyril Mayaud (1), Stefan Oswald (1), Thomas Rinder (2), Albrecht Leis (3), Hermann Stadler (4), Ralf Benischke (4), and Steffen Birk (1)

(1) Institute for Earth Sciences, Karl-Franzens University of Graz, Heinrichstraße 26, A-8010 Graz, Austria (thomas.wagner@uni-graz.at), (2) Institute of Applied Geosciences, Graz University of Technology, Rechbauerstraße 12, A-8010 Graz, Austria, (3) Laboratory Centre for Isotope Hydrology and Environmental Analytics, Institute for Water, Energy and Sustainability, Joanneum Research Forschungsgesellschaft mbH., Elisabethstraße 16, A-8010 Graz, Austria, (4) Department of Water Resources Management, Institute for Water, Energy and Sustainability, Joanneum Research Forschungsgesellschaft mbH., Elisabethstraße 16, A-8010 Graz, Austria

A recent tracer experiment with uranine was conducted to further improve the understanding of groundwater flow in the binary Lurbach system, a karst aquifer with significant allogenic recharge via sinkholes and, in particular, the sinking stream Lurbach. The catchment is situated in the Central Styrian Karst, Austria, and is mainly drained by the Hammerbach spring (HB) and the Schmelzbach spring (SB). Spring hydrograph analysis of the HB shows a rather dampened behavior usually characteristic for a poorly developed karst network. In contrast, the recent tracer test results showed clear concentration pulses at the HB with little dispersion. The nearby SB, that drains parts of the same karst system, only showed minor concentration peaks related to the same tracer experiment. However, it is known from a thorough analysis of long-term spring hydographs as well as numerous previous tracer experiments that overflow from the HB to the SB catchment exists if the discharge at the HB exceeds a threshold of approximately 200 l/s. Interestingly, natural tracers (e.g., electrical conductivity, nitrate, chloride and stable isotopes of water) measured contemporaneously with the uranine concentrations indicate that intercatchment flow started already at rather low flow conditions (approximately 140 l/s HB discharge).

These observations allow two main interpretations that are vital for the vulnerability assessment of this karst aquifer: i) a recent change of the overflow threshold increased the intercatchment flow; thus the recharge area of these two springs now overlaps already at rather low flow conditions; ii) the artificial tracer experiment alone would have failed to identify this fact, as the tracer was injected prior to a recharge event (lag time of approximately 40 hrs) and already most of the tracer had likely passed the sections where overflow occurs before the overflow threshold was reached.

The change in intercatchment flow is also evident in the hydrograph of the HB, where discharge peaks decreased since a flood event of August 2005. Interestingly, baseflows increased since that time as well, suggesting that alterations in the karst drainage system rather than climatic changes or changes within the Lurbach catchment are the likely cause for the observed changes. Possible explanations based on speleological knowledge include: (i) the reduced outflow of the HB might be related to collapse material or sediment aggradation in the conduit network, whereas the decrease in the overflow threshold to the SB system might be related to re-excavation of sediment and creation of new flow paths, or (ii) sediment aggradation and therefore reduction in conduit permeability downstream of the overflow sections causes increased hydraulic gradients and thus higher water levels such that overflow starts at lower values of the HB discharge. This new insight into the catchment behavior indicates a time dependence of vulnerability and might be of importance for karst spring catchments in general.