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Evaluating physico-chemical spring responses to identify flow components in a karst system with allogenic recharge (Lurbach, Austria)

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Storm responses of karst springs provide integral information about the spring catchments. However, the analysis is often limited by lack of information about the spatial and temporal distribution of the input (recharge) and its physico-chemical properties. Thus, the data interpretation usually relies on simplifying conceptual models that involve various assumptions about the contributing flow components. For instance, it is frequently assumed that the electrical conductivity of the spring water changes because the spring discharge represents a mixture of pre-event groundwater and lower mineralised rainwater or higher mineralised subcutaneous (epikarst) water.
In this work, we combine artificial tracer testing with the analysis of multiple natural tracers in the Lurbach Karst System (Semriach-Peggau, Styria, Austria) to improve our knowledge about the flow components of two karst springs (Hammerbach, Schmelzbach). In addition, we characterise the quantity and quality of one allogenic recharge component (Lurbach), which further helps to constrain the conceptual model of the karst flow system. The results demonstrate that the aforementioned assumptions can be misleading. For instance, the Schmelzbach spring shows an increase of the water temperature concurrently with the increase of electrical conductivity after a rainfall and snow-melt event. This suggests that the water discharged during this time period is mobilized from the aquifer storage ("old" water) rather than from the epikarst, thus contradicting the aforementioned conceptual model. As opposed to the Schmelzbach, the Hammerbach spring shows a continuous decrease of the water temperature over a period of several days suggesting ongoing infiltration of cold water, e.g., from snow melt. At the same time the electrical conductivity of the Hammerbach exhibits variations resembling those observed in the allogenic Lurbach component. The tracer test further shows that under the prevailing hydro-meteorologic conditions the Lurbach contributes to the Hammerbach but only to a minor extent to the Schmelzbach.
In conclusion, our results suggest that the karst system under investigation is significantly more complex than the common conceptual models used for the separation of flow components. The discharge at each of the two springs is composed of several flow components including input from an allogenic stream, autogenic recharge due to rainfall and snow melt, aquifer storage, and epikarst, all of which are mixed with the pre-event groundwater in varying proportions. The identification of these flow components and the quantification of their time-variant contribution to the spring discharge can only be accomplished by a combined evaluation of multiple natural and artificial tracers.