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The influence of cave stream sediments on the transport behavior of karst springs

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Spring response to recharge in karst systems is influenced by the complex distribution of the rock mass hydraulic properties, fracture systems, and the presence of conduits. In addition the exchange of karst water with unconsolidated sediments in conduits may also further influence spring responses. To evaluate the effects of cave streams and sediments on solute transport in karst systems a small scale tracer experiment using fluorescein as an artificial tracer and water temperature as a natural tracer was conducted within the hyporheic zone of the active cave stream Schmelzbach. This interior stream drains parts of the Lurbach Karst System (Semriach-Peggau, Styria, Austria). The main goal of the experiment was to investigate if measurable cave stream hyporheic exchange (with the stream bottom sediments) occurs and the degree to which this process alters the transport of conservative tracers. One hundred meters downstream of the tracer injection point three cross sections of monitoring wells (9 in total along a distance of approximately 25 m) were constructed and fitted with two vertically isolated activated charcoal bags, 10 cm and 30 cm below the streambed surface. PVC monitoring wells were installed along the three cross sections using hand driven steel pipes as a temporary casing. In two of these wells temperature sensors were placed at different depths within the saturated bed sediment to investigate how post tracer test stream flood events impacted the timing and rate of stream water penetration into the bed sediments. The tracer breakthrough curve was measured with a fluorimeter located 100 m from the injection point. The results show a sharp peak and a modest tailing of the breakthrough. A one-dimensional advection dispersion model that accounts for mass transfer and storage of tracer in immobile fluid zones such as pools or sediments provides a good fit to the measured breakthrough curve. The model results suggest that immobile fluid zones amount to 40% of the total water volume. Nevertheless, the stream tracer recovery was about 95% after approximately one hour. Thus, the tracer remained in the pools along the stream and the sediments only during a short time period. The tracer was detected in all charcoal bags (except two that were installed in a dry section of a sand bar). This documents that tracer did penetrate the bed sediments moving vertically downward. The potential for hyporheic exchange of cave stream water was also clearly evidenced by the detected vertically downward hydraulic gradients in the bed sediments and the response of the temperature sensors in the bed sediment during several flood events. The return of the bed sediment temperature to pre-event values occurred over a short period of time, which suggests a short residence time of the event water in the sediments and thus confirms the findings from the artificial tracer test. These preliminary results suggest that in this active cave stream the bed sediments may not be a significant reservoir for active cave stream waters in this setting.