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Infiltration processes and flow rates – monitoring environmental & artificial tracers in cave drippings - Mt. Carmel, Israel.

Y. Arbel (1), N. Greenbaum (1), J. Lange (2), M. Inbar (1).

(1) Department of Geography and Environmental Studies, Haifa University, Israel.(2) Hydrology Institute, Freiburg University, Germany.yarbel@geo.haifa.ac.il

The aim of the study was the identification and quantification of different infiltration processes in the carbonate, karst lithology of Mt. Carmel, Israel. Major ions concentration, temperature, EC, pH and water discharge were measured weekly in 14 cave drips at two locations: "Yishach Caves" in the Yagur Dolomite formation and "Oranin cave" in the Muchraka limestone formation. Rainfall and soil moisture profiles above the caves were monitored continuously using tipping buckets and FDR probes. In addition, an artificial tracer experiment was conducted: uranine – a fluorescent dye tracer, was injected into the bottom of nearly saturated soil pockets at the surface above the cave (28m) before a major rainfall event. Caves drips where sampled for chemistry and uranine up to 4 times a day; the amount of dripping was monitored continuously by tipping buckets.

Based on the response characteristics to rainfall we distinguished three different types of cave drips: perennial, seasonal and post-storm drips, which also reflected differences in the relative contribution from the different infiltration processes.

Seasonal drips and post-storm drips emerged only after cumulative seasonal rainfall of more than 180 mm. Fluctuation in water temperature, EC and ions concentrations, following major winter storms, served as indicators for the fraction of preferential flow versus piston flow and wetting front infiltration. For example, a lag time of 12-24 hours between the appearance of uranine and the beginning of storm-dripping, together with the higher salinity and temperature suggested piston flow mechanisms.

The "Post-storm" drips, related to the intensive jointing in the rock above the cave

started 12-48 hours after rainstorms. Discharge built up to its maximum in a few hours, and completely decayed after 2-3 weeks. The tracer breakthrough curve reinforced this hydrograph pattern.

The perennial drips were characterized by stable discharge and higher salinities, nevertheless, post-storms discharge peaks were identified. The total preferential flow component in those drips was calculated using end member mixing analysis at 25-30% of the annual discharge.

The maximum flow rates derived from the time of uranine appearance was 57-78 cm/hr (in all drips). The typical (frequent) flow rates derived from the time to uranine peaks were 15-23 cm/hr in the seasonal and perennial drips and 37-47 cm/hr in the post-storm drips. The difference between the mean flow rates of the various drip types was even larger as estimated from the late-appearance of the uranine peaks in the seasonal and perennial drips.

In general the collected data allows the following analyses: (1) Separation of piston- and preferential flow components in the infiltrating water (2) Calculation of the contribution from different infiltration processes as a response to rainstorms characteristics; (3) Evaluation of the maximum and typical flow rates in the unsaturated zone above the caves.