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Assessment of recharge and contamination dynamics of a regional semi-arid carbonate aquifer system

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Karst aquifers are often productive but vulnerable alike. Especially in semi-arid environments with a pronounced seasonality in precipitation, groundwater recharge can be restricted to a few intensive rainfall events per year. Those events can lead to a distinct inflow of contaminants from the surface and lead to high flow velocities within the aquifer including a mobilisation of particles (turbidity). Therefore, short-term adverse effects on groundwater quality especially at springs as the preferred water abstraction points can be observed. Beside and mingled with these very dynamic interferences, long-term effects on groundwater quality may also be observed. The studied regional aquifer system in the West Bank is characterised by a strong urbanisation of the recharge area and is already affected by contamination for several decades. Many springs are approaching or exceeding the drinking water limit for nitrate concentration at 50 mg/L.

In order to assess groundwater recharge processes (e.g. focussed vs. diffuse infiltration and percolation), to quantify the different source water fractions and hence to improve raw water management, we employed multiple monitoring parameters and approaches. Emphasis was put on a high-resolution monitoring of the hydrological system, especially regarding the hydrological trigger precipitation (16 automatic stations) and the response at the karst springs (13 high-resolution monitoring stations). For the latter the main monitoring parameters are: a) stage/discharge, b) electrical conductivity and occasionally c) turbidity and d) nitrate concentration (UV-spectrophotometric). Furthermore, extensive sampling campaigns (up to 45 springs) were conducted during the whole spectrum of hydrological conditions including the system response to large precipitation events. Especially chloride, nitrate, bromide, E.coli, Acesulfame and Carbamazepine were used as proxy parameters, e.g. to quantify wastewater and event water flow fractions.

Chloride was used as environmental tracer for the quantification of the event water fraction. Good correlations between electrical conductivity and chloride concentrations enable that the latter are conveniently estimated in high-resolution by using electrical conductivity monitoring. Associated source vulnerability parameters can be quantified for the springs, i.e. the typical transport time lag until event water/contamination reaches the spring and the duration of the breakthrough. Microbiological and hydrochemical parameters were used to distinguish different classes of springs between various end-members. For example springs with an overall small wastewater impact which is however rapidly conveyed via fast flow pathways in the aquifer require a comprehensive raw water management. Other springs with substantial anthropogenic impacts in the catchments however display comparatively low concentrations of faecal indicator bacteria, i.e. predominantly long residence times in the aquifer. Those water resources often display high and still rising nitrate concentrations. As conclusion, the local water suppliers are recommended to use electrical conductivity as a convenient high-resolution monitoring parameter. These stations can also be equipped with a remote data transfer in order to facilitate raw water management and to optimise the sampling of faecal indicator bacteria.