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Estimation of transit times in a Karst Aquifer system using environmental tracers: Application on the Jeita Aquifer system-Lebanon.

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Estimating transit times is essential for the assessment of aquifer vulnerability to contaminants. Groundwater in karst aquifer is assumed to be relatively young due to fast preferential pathways; slow flow components are present in water stored in the fissured matrix. Furthermore, transit times are site specific as they depend on recharge rates, temperatures, elevation, and flow media; saturated and unsaturated zones. These differences create significant variation in the groundwater age in karst systems as the water sampled will be a mix of different water that has been transported through different flow pathways (fissured matrix and conduits). Several methods can be applied to estimate water transit time of an aquifer such as artificial tracers, which provide an estimate for fast flow velocities. In this study, groundwater residence times in the Jeita spring aquifer (Lebanon) were estimated using several environmental tracers such as Chlorofluorocarbons (CFCs), Sulfur Hexafluoride (SF6), Helium-Tritium (3H, 3H- 3He). Additional stable isotope and major ion analysis was performed to characterize water types. Groundwater samples were collected from six different wells in the Jeita catchment area (Jurassic Kesrouane aquifer) as well as from the spring and cave itself.

The results are reproducible for the Tritium-Helium method, unlike for the CFC/SF6 methods that yielded poor results due to sampling problems. Tritium concentrations in all groundwater samples show nearly the same concentration ($\sim$2.73 TU) except for one sample with relatively lower tritium concentration ($\sim$2.26 TU). Ages ranging from 0.07 $\pm$ 0.07 years to 23.59 $\pm$ 0.00 years were obtained. The youngest age is attributed to the spring/ cave while the oldest ages were obtained in wells tapping the fissured matrix. Neon in these samples showed considerable variations and high delta Ne in some samples indicating high excess air. Four (4) samples showed extreme excess air (Delta-Ne is greater than 70 %) and the remaining 3 samples have Delta-Ne in the expected range between (10-35%). Moreover Tritium-Helium analysis has showed some radiogenic Helium (4He) in one sample along with lower tritium concentrations signifying a mixture of new groundwater with old groundwater (older than 50 yrs). Furthermore, this study is complemented with published analysis of a series of 26 artificial tracer experiments performed in the Jeita karst system (Doummar, 2012). Transit times calculated from tracer experiments ranged between 3 and 300 hours (12 days). The shortest ones were recorded in the Jeita subsurface conduit. While injections in sinkholes yielded moderate transit times, fissured matrix and unsaturated zone resulted in relatively long ones. In Lebanon this type of spatial groundwater age dating using environmental tracers was not applied to date, to the exception of grab sample analysis. A second round of sampling for Tritium-Helium, CFCs and SF6 analysis will be undertaken under different flow periods in February 2016 to validate the obtained results.

References

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