Estimation of groundwater mean residence times in a near-surface aquifer using different natural tracers (Radon-222, Sulfur-35, Tritium, and $\delta^{18}$O)

Axel Schmidt, Michael Engel, Simon Mischel, and Dirk Radny
Federal Institute of Hydrology, Koblenz, Germany (axel.schmidt@bafg.de)

The residence time of groundwater is an essential parameter for water resource management. In the presented study, environmental tracers (Rn-222, S-35, H-3, $\delta^{18}$O) and hydrogeochemical groundwater components are used for assessing groundwater mean residence times in a near surface aquifer.

At a barrage station at the River Moselle, four groundwater monitoring wells and two surface water spots were sampled at a 4-week interval over an 18-month period. At each sampling event, isotopes as well as other hydrogeochemical parameters (e.g. water level, water temperature, oxygen, pH value and electrical conductivity) were measured and evaluated.

All tracers showed different concentrations and signatures in ground- and surface water samples. As expected, Radon showed high concentrations in groundwater (up to 25 Bq/L) and low concentrations (about 0.2 Bq/L) in surface water. The tritium content of groundwater (13 Bq/L; ~110 TU) was similar to the long-term average concentration measured in surface water (~14 Bq/L); these comparatively high concentrations are way above the natural background concentration of about 1 Bq/L and result from the release of tritium from the French nuclear power plant Cattenom (situated about 250 km upstream of the sampling site). S-35, produced in the atmosphere and entering the hydrological cycle via precipitation, could be determined only once (January 2021) due to technical obstacles. The S-35 concentration measured in surface water (0.035 Bq/L) was about 4 times higher than the concentration in groundwater (0.0093 Bq/L). Finally, the median $\delta^{18}$O signature in surface water (-8.13 ‰) was similar to the signature found in groundwater (-7.78 ‰).

The selected isotopes and water parameters indicate that (i) the aquifer is predominantly recharged by surface water and (ii) the groundwater mean residence times varies between 5 and 6 months based on S-35 and $\delta^{18}$O.

Hence, it can be concluded that the selected isotopes are suitable as tracers for estimating groundwater mean residence times. However, further studies are needed, especially to minimize the time gap between the established tracers Radon (useful for up to 40 days) and tritium (useful from about one year). The novel tracer S-35 seems promising, but long-term data series of S-35 in surface and precipitation water are still missing to establish the necessary input functions.