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The use of groundwater dating for the characterisation of Swiss groundwater monitoring sites

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Within the framework of a pilot study, mean residence times of more than 30 sites of the Swiss National Groundwater Monitoring NAQUA were estimated by the tritium-helium (3H/3He) method. These sites are part of the basic module, which monitors groundwater quality and aims at understanding the main groundwater systems in Switzerland and its hydrogeological and hydrochemical processes. Therefore, the sites are equipped with data loggers for the continuous record of water level, discharge, temperature and electrical conductivity. A large range of chemical data, such as basic hydrochemical parameters, nutrients, various plant protection products, volatile organic compounds and wastewater tracers have been collected from these sites for more than 10 years. In addition stable isotopes (deuterium and oxygen-18) are being analysed since 2006.
The purpose of the groundwater dating in the presented study is to (i) further consolidate the conceptual models of the monitoring sites and to (ii) verify the applicability of the method.
The tritium-helium method provided reasonable results with mean groundwater residence time estimates of between 4 months and 20 years. The emphasis was between 2 and 10 years. This is consistent with shallow groundwater in small-scale alluvial aquifers typical for conditions encountered in Switzerland. Groundwater collected from springs situated in fractured aquifers predominantly showed low 3H/3He-ages of less than 2 years. Seasonal variations were mostly observed at sites situated adjacent to rivers where bank filtration is observed. This indicates that mean residence times in a well catchment area can change within a short period of time due to groundwater – surface water mixing effects, even in groundwater systems with a relatively high 3H/3He-age.
A more detailed view on selected site compared 3H/3He results with time series of continuous measurements as well as discrete [U+F064]18O, [U+F064]2H and groundwater quality data. The main findings are:
• The 3H/3He-method is a powerful tool to identify older components in mixed groundwater systems, which can hardly be captured by means of classical standard methods,
• Recent infiltration from either a river or precipitation resulted in lower residence times. The existence of this young groundwater component was confirmed by stable isotopes and electrical conductivity values, and
• 3H/3He-ages may potentially contribute to the interpretation of detected contaminant concentrations at the sites, although a better knowledge of the temporal and spatial input of the contaminant sources would be necessary.
In conclusion, the estimation of groundwater residence times by the tritium-helium method allowed a consolidation of the hydrogeological conceptual models. The data could also be used as an additional parameter for the calibration of numerical flow and transport models, which in turn would provide a better understanding of contaminant transport mechanisms at the sites.