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Organic compounds as indicators for transport in an urban characterized complex karst system

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In northern Hesse (Germany), sediments of the Upper Permian (Zechstein-Formations) are outcropping in a coastal facies along the western rim of the Rhenish Massif. The geologic section is characterized by a sequence of carbonate rocks (carbonates of the Werra-, Staßfurt- and Leine-Formations) and predominantly fine clastic sediments. The carbonate aquifers of the Werra-Formation and the Leine-Formation are used for drinking water abstraction of a provincial town and surrounding communities. Concurrently, the urban area is characterized by industrial and commercial uses.

The groundwater flow system is composed of three potential karst aquifers, aquitards and aquicludes within a complex tectonically faulted area. The study area is divided into three spring catchment areas. However, the locations of the subsurface water divides are unknown. Traditional methods to determine the catchment areas (e.g. artificial tracer tests) are difficult to apply, due to a lack of adequate injection points.

The presented work deals with the use of organic compounds as indicators for subsurface flow paths. Medical drugs, pesticides, corrosion inhibitors and such typical waste water compounds as caffeine (NÖDLER ET AL. 2010) are observed in approximately fifty groundwater observation points by regular sampling.

The seasonal variability of the distribution pattern of organic compounds is low. The most common compounds are atrazine and its metabolites desethylatrazine and desisopropylatrazine, as well as the corrosion inhibitor 1H-benzotriazole. Since these substances are applied in different regions different input functions can be assumed. However, the highest concentrations are detected along a North-orientated axis, which also exhibits the greatest compound variety. This distribution pattern indicates preferential flow and transport pathways in the subsurface. The absence of organic compounds in other parts of the investigation area implies the existence of a water divide between these areas. The occurence of atrazine in groundwater samples denotes the existence of a water component with a transit time of more than 20 years because the use of atrazine as a pesticide has been banned in Germany since 1991.
Furthermore, since atrazine and 1H-benzotriazole are found in all investigated aquifers, the presence of hydraulic connections between the aquifers (e.g. associated to faults) is likely.

In addition to the long-term flow component, the periodic detection of such antibiotics as erythromycine, after strong recharge events (for example snow-melt events), suggests also the presence of a short-term flow component in the aquifer system.

Consequently, the observation of organic compounds is an appropriate method to determine subsurface flow paths within complex aquifer systems. Furthermore, such a method can also be employed in the subsurface to approximate transit times and to identify mixing zones.

Lecture

NÖDLER, K., LICHA, T., BESTER, B., K. SAUTER, M. (2010): Development of a multi-residue analytical method, based on liquid chromatography–tandem mass spectrometry, for the simultaneous determination of 46 micro-contaminants in aqueous samples.- Journal of Chromatography A, 1217 (2010) 6511–6521.