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Environmental tracers and stable isotope fractionation to assess temporal natural degradation of contaminants in groundwater

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Long-term groundwater contamination due to the leaching of toxic substances into an aquifer is difficult to evaluate in cases where degradation and transport of the pollutants are site-specific. An example of such contaminants is highly chlorinated solvents such as tetrachloroethene (PCE), which persists or degrades very slowly under aerobic conditions in an aquifer. The progressive dechlorination leads to carbon isotope fractionation in the degradation products, with subsequent depletion of the heavy isotope ^{13}C along the decomposition path.

Besides tracing decomposition in a contaminant plume we can also trace natural processes in groundwater (flow, mixing and transport) by utilizing conservative and inert tracers such as noble gases (He, Ne, Ar, Kr and Xe) and transient tracers ^{3}H, CFCs (chlorofluorocarbons) and SF_6 (sulfurhexafluoride). The water infiltration temperature can be determined by measuring the concentrations of the dissolved atmospheric noble gases whilst water residence times are determined by the ^{3}H-^{3}He method, CFCs and SF_6.

A combined application of the above methods shall allow a delineation of a contamination plume in time and space, and assess on the degradation and transport of organic contaminants. Preliminary data of a case study in Switzerland is presented for a situation before and during pumping of an open pit (dug for remediation of the site).

We show that a contaminant plume of PCE spilled for approximately 20 years in an unconfined aquifer has undergone negligible degradation in a short water residence time of up to 2.3 years. The absence of the degradation is mostly due to the aerobic conditions in the aquifer. The infiltration temperature of the groundwater was 3-4 ˚C lower than those measured in the field, suggesting a major source of heat input rather than degradation. At the same time the transient tracers CFCs and SF_6 reveal significantly the different water flow directions before and during pumping (underlying the pumping effect changing the hydraulics at the site).