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Estimation of groundwater flow velocities in a landfill leachate plume using ^{85}Kr measurements

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Pollution of groundwater has been observed world-wide at many old landfills constructed before the eighties as most lack leachate collection systems or liners preventing the migration of leachate to underlying aquifers. As conventional remediation techniques are not cost-effective, much research has been performed in the last decade to the performance of natural degradation processes leading to natural attenuation of pollution. The key parameter for estimation degradation rates and kinetics is the groundwater age or flow velocity

Since 1998 research to natural attenuation processes has been going on at the Banisveld landfill site, Boxtel, the Netherlands. Decomposition of organic waste in the landfill body produces large amounts of CO_2 and CH_4 . Furthermore, inside the plume, like in other and similar cases, degradation of DOC and apparently BTEX adds additional CO_2 and CH_4 . This leads to an oversaturation of gas relative to the hydrostatic pressure and potential for degassing. Gas stripping would reduce the concentrations of all dissolved gases and affect all gas based dating techniques including CFCs, $^3\text{H}/^3\text{He}$ and SF_6 . Additionally local contamination with ^3H and CFC impedes the application of these methods further. Because the ^{85}Kr is based on an isotope ratio ($^{85}\text{Kr}/\text{Kr}$) it is much less sensitive to degassing than the other dating methods for young groundwaters. 6 samples from monitoring filters in the plume from different depths and flow distances were analyzed for ^{85}Kr , $^3\text{H}/^3\text{He}$, SF_6 and CFC. The results demonstrate the applicability of the ^{85}Kr method whereas the other methods lead to an overestimation of the groundwater flow velocity. ^{85}Kr ages range up to 30 years and increase with depth and distance from the landfill.

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Application of uranium series disequilibria as a tracer for radionuclide migration in an aquifer

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Uranium is a naturally and anthropogenically occurring element in surface and subsurface environments. U-decay chains contain several isotopes of U, Th, Ra with different half-lives, allowing to study a large range of processes. We have studied uranium-series disequilibria in a chalk aquifer in order to characterise the time scales of radionuclide migration from the water recharge zone of the aquifer to the nearby river. We have collected both carbonate rocks and groundwater samples from boreholes and spring and river water from an aquifer located in Eastern France.

U, Th and Ra isotopes were measured in carbonates samples, collected at different depths in the aquifer by TIMS and MC ICP-MS. The fractionation of U and Th isotopes is distinctive in the various parts of the aquifer. Rock samples are characterised by variable ($^{234}\text{U}/^{238}\text{U}$) activity ratios, suggesting U leaching in the unsaturated part of the aquifer and U reprecipitation where seasonal water table variations take place, possibly due to a redox front. Although rock samples display equilibrium for $^{226}\text{Ra} - ^{234}\text{U}$, ^{226}Ra is depleted relative to ^{230}Th with ($^{226}\text{Ra}/^{230}\text{Th}$) activity ratio inferior to unity due to preferential leaching of Ra after alpha-decay of Th. Moreover large excess of ^{222}Rn over ^{226}Ra in water shows a release of radon from the solid phase indicating a large source of radium at the interface between rock and water. Water samples show oxidising characteristics and speciation calculation present U-carbonate complexes ($\text{UO}_2(\text{CO}_3)_2[2-]$ and $\text{UO}_2(\text{CO}_3)_3[4-]$) whereas Th is retained in the water phase by colloids.

We have developed a 1-D model to constrain radionuclide transport. This model is based on mass balance calculation, considering sources and sinks of each nuclides in the different phases of the aquifer. We consider a water and two solid phases (rock and a surface coatings) using measurement on natural samples in order to determine transport parameters and adsorption/desorption rate of the radionuclides in the substratum, taking recoil effect into account, and apply it to contaminated site. We consider that rock and water phases are not at steady state. With this model we can predict necessarily length scale and time scale of radionuclide migration within this chalk aquifer.