Lanthanides and uranium in groundwater under influence of distinct aquifers

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The composition of groundwater extracted from four tubular wells was investigated to find associations between the dissolved trace elements and the lithological units of the respective aquifers. The four wells are used for potable water supply. They are in an area of ca. 1 km^2 within a complex geological setting. The water of two wells is mostly extracted from fractured aquifers, formed by granite, gneiss and also diabase, while the other two wells are mostly from porous aquifers, dominated by sandstones. The groundwaters are slightly alkaline (pH = 7.3-8.1) and calcium bicarbonate type.

The rare earth elements La-Lu were determined in 0.2 μm pore size membrane filtered samples after preconcentration. The quality of the results was assessed using field and laboratory blanks, duplicate sampling and analysis of reference materials. The ΣETR in the four wells ranged between 1.76 and 9.50 ng/L. The PAAS normalized REE patterns of the samples showed distinct shapes and features. They showed similarities with the REE patterns of the different lithotypes that host the aquifers, despite some fractionation. In three wells, the heavy REE are enriched against the light REE, with $(La/Yb)_N$ values ranging from 0.26 to 0.92. One well presented a $(La/Yb)_N$ of 2.9. This light REE enrichment suggests an influence from the crystalline aquifer. On the other side, this same well exhibited a small positive anomaly of Gd, attributed to percolation of surface water contaminated with anthropogenic Gd chelates. Excess of Gd in water also previously found in a nearby stream, probably is related to two hospitals in the surroundings. All samples produced negative calculated Ce anomalies, attributed to the sorption of tetravalent Ce to solid phases.

Former analysis of the groundwater systematically resulted in uranium values higher than the recommended limit for drinking water (30 μg/L) in one of the wells of the sedimentary aquifer. The U in water probably originates from the oxidative dissolution of U-bearing phases. Results of uranium speciation calculations done with PHREEQC and introducing additional stability constants showed that the main dissolved uranium species are $Ca_2UO_2(CO_3)_3$ and $CaUO_2(CO_3)_2^{2-}$, which are considered nontoxic and nonbioavailable.