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The controls of radionuclide mobility in a siliciclastic aquifer in Hungary: Hydrogeological investigations and geochemical modeling

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Groundwater represents a vast majority of the readily accessible fresh water on Earth and satisfies the demand for drinking water for a large portion of the world population. However, groundwater quality can be seriously threatened by geogenic and anthropogenic contamination with elevated concentrations of hydrocarbons, pesticides, metal(loid)s or radionuclides. Understanding the controls of the release and mobility of these contaminants including radionuclides is critical in proper groundwater management. In the southern foreland of a granitic outcrop in Hungary, gross alpha activity exceeding the 0.1 Bq L^{-1} limit was measured in drinking water wells. Nuclide-specific measurements for uranium, radium and radon isotopes were involved. The sampling activities indicate that excess of uranium (3−753 mBq L^{-1}) is mainly responsible for the natural radioactivity measured in drinking water. Radium was measured in low activity concentrations (<5–63 mBq L^{-1}) with the exception of three specific wells (285–695 mBq L^{-1}). Notable radon activity was measured in the spring waters from Velence Hills (101–314 Bq L^{-1}) and in interrelation with the high radium activities. These observations were interpreted in a "groundwater flow system" context. A conceptual model explaining the elevated radioactivity of groundwater was delineated. A geochemical modeling analysis involving redox-controlled kinetic reactions and a surface complexation model was developed to support the conceptual model of uranium mobility. The results suggest that uranium distribution is sensitive to redox changes in the aquifer. Its mobility in groundwater depends on the residence time of water compared to the reaction times controlling the consumption of oxidizing species. The longer the flow route from the recharge point to an observation point where U is measured, the higher the likelihood of finding aquifer reducing conditions and low U concentrations. It is concluded that the joint application of nuclide-specific measurements, hydrogeological approach and geochemical modeling can support safe drinking water management when dealing with the excess of radionuclides in groundwater.

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