How can flow system approach help to understand the natural radionuclide content of the drinking water originated from groundwater sources? Case study in the vicinity of a granitic complex

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In groundwater, the soluble members of the uranium decay chain such as uranium, radium, and radon can be found in significant concentration. Their distribution is affected by physicochemical properties such as pH, redox potential and chemical composition of the groundwater. Uranium can be mobilised under oxidising conditions especially in the water where the pH is near neutral and has high alkalinity. In contrast, radium is mobile in reducing environment, enhanced by the presence of carbonate, sulphate, chloride. These parameters vary along the groundwater flow paths and with regard to the change of regime characteristics. Areas with recharge regime and discharge points of local flow systems are characterised by oxidising environment while discharge areas of higher-order systems tend to be reducing. The natural radioactivity of groundwater, as a possible threat for human health, has been investigated for a few decades as groundwater is a very common drinking water source. In Hungary, 96% of the water supply relies upon groundwater. Following the Euratom Drinking Water Directive the radioactivity of drinking water is screened in Hungary by gross alpha and gross beta activity measurements. Whenever the measured concentrations surpass the limit values the long-term consumption of the water can lead to health issues. High values of gross alpha activity can be found in the foreland of Lake Velence. Previous studies have already shown high uranium concentration values (compared to average crust values) related to the Velence Granite Formation in Velence Hills and to the carbonatic and organic-rich beds of the Ujfalu Formation in the foreland of Lake Velence. Until recently no observations and measurements were made regarding the radioactivity of the groundwater. Therefore, uranium, radium, and radon concentration measurements were carried out in the adjacent area and interpreted in flow system context. A total of 53 samples were taken from surface water as well as from groundwater. Alpha spectrometry applied on Nucfilm discs was used to measure the uranium (U-234, U-238) and radium (Ra-226) activity while radon (Rn-222) activity was determined by TriCarb 1000 TR liquid scintillation detection. Pressure-elevation
profiles, hydraulic cross-sections, tomographic potential maps were compiled to understand the groundwater flow directions and regime characteristics in the wider area. The areal distribution of the activity concentration values was interpreted regarding the groundwater flow system, physicochemical parameters measured onsite and in the laboratory. Those areas can be delineated where according to the flow conditions and the related geochemical environment the mobility of the uranium or radium and thus elevated activity concentration can be expected in groundwater. The results of the study have proved that the areal variability of the natural radioactivity of the groundwater is strongly affected by the groundwater flow conditions along with geological features. This flow system approach and its methodology may facilitate the safe water management of drinking water supply systems.

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