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Investigation of natural and anthropogenic sulfur origin in groundwater of granite area using multi-isotope and radon data

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Sulfur can be derived by natural process and anthropogenic activities, and commonly exists in nature through both paths. The importance of research on sulfur has emerged due to the water contamination by sulfur as human activities increased. Also, a certain type of rock matrix such as granite can restrict the use of drinking water by enrichment of geochemical characteristics in bedrock groundwater resource. The objective of this study is to investigate hydrogeochemical properties in granite bedrock groundwater based on multi-isotope ($\delta^{18}O$, δD, $\delta^{34}S$-SO_4 and $\delta^{18}O$-SO_4), and radon data using fuzzy C-means clustering (FCM) technique. In clustering result, which was conducted based on the principal component analysis, showed that sulfur sources were classified into 4 groups: 1) granite bedrock; 2) surface water; 3) water-rock interaction; and 4) anthropogenic source. Group 1 showed the impact of granite bedrock through high fluoride concentration with radon and also had high correlation between pH. Most of the samples containing high sulfate (32~40 mg/L) concentration belonged in Group 1 and Group 3 indicating the dominant source in this area. On the other hand, sulfate concentration of samples in Group 2 were distributed at lower range (0~16 mg/L), which can be attributed to dilution by the summer precipitation. Samples in Group 3 had high positive loadings of HCO_3^-, Mg^{2+}, TH (Total hardness), Ca^{2+} and SO_4^{2-}, which can be explained by water-rock interaction. Group 4 had SO4+Cl water type unlike with the other groups showing higher impact of anthropogenic activities according to the piper diagram result. This study presents that hydrogeochemical process in granite bedrock groundwater including anthropogenic source can be revealed through applying FCM using multi-isotope and radon data. The results can give contribution to improve drinking water quality management in granite area by identifying the natural and anthropogenic sources of sulfur. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government(MSIT) (No. 2022R1A5A1085103).