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Characterizing saltwater contamination of subsurface water around the underground storage cavern with hydrochemical analysis

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Underground storage caverns have built in Korea to stock up oil and gas in reserve since 1980s. A principal of storage cavern is to suppress oil and gas by injecting water in rock fractures around the cavern, and this system causes changes to the natural hydraulic system of the region and also the hydrochemistry as well. Thus, the hydaluic head and quality of both the groundwater and seepage water from caverns have been periodically monitored for stable management of the storage cavern since its construction. Chemical analysis of groundwater and cavern seepage water samples suggested a possibility of saltwater intrusion into the caverns built near coastline. Salinization of groundwater and saltwater intrusion into the caverns could be a critical problem in operating storage cavern threatening stability of the hydraulic pressure supressing caverns.
Therfore, this study focuses on the hydrochemistry of the storage cavern area located near coastline to identify the origins of salinity in cavern seepage water and to quantify its influence to the caverns. The concentration of major cations and anions were collected from curtain wells located in front of caverns facing coastline showed little influence of saline water (0.32-51.95 mg/l Cl), while, in cavern seepage water, high concentration of Na, Cl (max. 2845.56 mg/l Cl and max. 2740.00 mg/l Na) and high electrical conductivity (max. 10581 μS/cm) were observed. Na, and Cl concentration of groundwater showed that seawater might have intruded through the major fault not from the coastal line, which can explain the result of curtain well investigation result. Principal component analysis(PCA), which is one of multivariate analysis, was used to investigate the characters of saline water from cavern seepage. The result of PCA suggested that the seepage water from the cavern was mainly affected by seawater. To quantify the extent of seawater mixing in the cavern seepage water, mixing ratio of Cl and Br ions were calculated with the concentration of Cl and Br of seawater and groundwater as two end members. δ18O-Cl relationship was also analyzed to cross validate the seawater mixing ratio calculated based on Cl, Br ion concentrations. The hydrochemical analysis of water samples from the storage cavern area near coastline suggested that there was little influence of seawater invading from the coastal line toward the frontal face of caverns in the area at large. However, local intrusion of seawater along the major fracture of the region was suspected and the seawater mixing ratio in the cavern seepage water was estimated to be 14% at maximum.