Statistical Approach of the Geochemical Mobility of Geogenic Uranium in Groundwater of KURT

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1. Introduction

For the high-level radioactive waste disposal facilities, it is important to evaluate the mobility of radionuclides in groundwater and the geochemical factors that control its behavior in case of unplanned leakage of radionuclides to groundwater. So far, a number of studies have been conducted to investigate hydrochemical and biogeochemical properties of the groundwater in the KAERI Underground Research Tunnel (KURT) [1]–[4], but statistical approach of mobility and transport of natural nuclides in the groundwater have not been carried out. The purpose of this study is to evaluate geochemical characteristics of groundwater in DB-1 (500m in depth) within KURT and to statistically identify factors that affect uranium mobility in the KURT groundwater.

2. Results and Discussions

2.1 Hydrochemical characteristics of KURT groundwater

Analytical results of the samples acquired on a quarterly in 2015 and 2016 in the KURT DB-1 borehole have been used for evaluation of hydrochemical characteristics. The interval of the borehole is divided into six sections (i2, i3, i4, i5, i6 and i7) with the depth. The groundwater chemistry with depth in DB-1 shows the changes from Ca-HCO_3 to Na-HCO_3 (exclude i5 section) which is common trend in granitic aquifers.

2.2 Hydrochemical type with depth

The i3 section (91.7 ~ 114.7 m) shows relatively high Eh, DO and PCO_2 values. Moreover the uranium concentration is the highest in the section (mean value: 720.34 μg/L).

The i5 section (199.7 ~ 228 m) shows considerably higher pH, K, SO_4, and CO_3 values. This section may have the potential for a grouting effect, and the water quality in the section is classified as an anthropogenic (not natural) interval.

The i7 section (246.7 ~ 299.7 m) shows a Na-HCO_3 water type due to a relatively long residence time. Therefore, this section shows high pH, EC, F, Na and HCO_3 values while Eh and DO are low.

2.3 Geochemical mobility of uranium

The uranium concentration in each section showed a statistical difference through the analyses of Variance (ANOVA) test was performed ($p<0.05$). The uranium concentration in the KURT groundwater is the highest in the i3 section under oxidized condition. Uranium mobility shows the increases in the groundwater with higher oxic-alkaline condition and PCO_2. The main factors affecting uranium mobility in groundwater are pH, DO (ORP) and partial pressure of carbon dioxide (PCO_2) [5]. The statistical result confirmed that uranium mobility is higher under the pH 8.0 - 9.5, DO>0.5 and high PCO_2 conditions. The Eh-pH diagram for uranium species in the KURT groundwater showed that major specie of uranium existed as $UO_2(CO_3)_3^{4-}$ which is a high mobile one in a solution.

3. Conclusions

The water quality of DB-1 groundwater in KURT is evolving from Ca-HCO_3 to Na-HCO_3 with depth. The concentration of uranium is the highest in the i3 section (around 100 m), and the DO, Eh, and PCO_2 values are also high in the section. The i5 section (around 200 m) is likely to have a grouting effect. The i7 section (around 300 m) is characterized the Na-HCO_3 type with relatively high EC, pH, F, and Na values because of long residence time. Geogenic Uranium in the KURT groundwater within granite bedrock demonstrated statistically different existence and mobility in each section (depth). Uranium mobility in groundwater generally depends on the pH, DO (Redox), and PCO_2, and its mobility in the KURT groundwater is increased under oxic-alkaline and high PCO_2 conditions.

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References

[1] J.-H. Ryu, J.-S. Kwon, G.-Y. Kim, and Y.-K. Koh, "Geochemical Characterization of Rock-Water Interaction in Groundwater at the KURT Site," *J. Nucl. Fuel Cycle Waste Technol.*, vol. 10, no. 3, pp. 189–197 (2012).

[2] N.-Y. Ko, K. W. Park, K. S. Kim, and J. W. Choi, "Groundwater Flow Modeling in the KURT site for a Case Study about a Hypothetical Geological Disposal Facility of Radioactive Wastes," *J. Nucl. Fuel Cycle Waste Technol.*, vol. 10, no. 3, pp. 143–149 (2012).

[3] J.-H. Lee, H. Jung, E. Lee, and S. Kim, "Estimation of groundwater level fluctuation of the crystalline site using time series analyses in south Korea," *J. Nucl. Fuel Cycle Waste Technol.*, vol. 11, no. 3, pp. 179–192 (2013).

[4] S. Y. Lee, Y. Roh, and J. T. Jeong, "Changes of the Oxidation/Reduction Potential of Groundwater by the Biogeochemical Activity of Indigenous Bacteria," *Econ. Environ. Geol.*, vol. 47, no. 1, pp. 61–69 (2014).

[5] P. L. Smedley, B. Smith, C. Abesser, and D. Lapworth, "Uranium occurrence and behaviour in British groundwater", 2006.