Collaborative project of JAEA/AIST on hydrochemical study at MIU construction site Part 2: Biogeochemical study

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For geological disposal of high-level radioactive wastes, it is essential to evaluate the baseline redox state, because many of radionuclides are immobile under reducing conditions. However, it is becoming aware that the baseline redox state of the deep subsurface is one of the most difficult parameters to evaluate due to disturbance caused by drilling and shaft construction as well as air contamination during sampling and measurements. As it is known that microorganisms that mediate energetically favorable redox reactions can thrive in the deep subsurface, integrated characterizations of hydrogeochemistry and microbiology might provide reliable information about the redox state.

In this research, groundwater samples were collected from the MIZ-1 borehole located in the Mizunami Underground Laboratory (MIU) site. A Hybrid Stand Pipe Multi-Packer System (Solexperts AG, Switzerland) was used to pump the deep groundwater samples to the surface without being exposed to air, and the groundwater samples contained less than 1% of loading tracer concentration. The chemical and isotopic compositions and microbial communities of the groundwater samples were analyzed. In addition, microbial metabolic activities were measured using cell suspensions ~20-fold concentrated from the original groundwater samples.

The Eh values of groundwater samples measured under flow-through conditions were approximately 0 mV, and reducing compounds such as S^{2-} and Fe^{2+} were poor (less than 0.05 mg/L) in the groundwater samples. Results from gas analyses showed that one of groundwater samples contained a detectable amount of H_2 (33 nM). Measurements of metabolic activities of nitrate-reducing bacteria revealed that organic acids and H_2 were metabolized as reducing compounds coupled to reduction of nitrate. The results from microbial community analysis suggested that the groundwater sample were mainly colonized by bacteria that utilize O_2 and $NO_3{}^-$ as oxidizing compounds. In our future investigations, the effects of contamination during drilling and groundwater sampling on microbial community structure and activity will be carefully evaluated, as well as the possibility of short groundwater flow paths from the surface around the MIZ-1 borehole.

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