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Hydrogeochemical Monitoring Parameters for Characterizing Disposal Site at National, Regional, Local and Site Scales

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1. Introduction

Hydrogeochemical monitoring of radioactive waste disposal sites is conducted to generate baseline data before the construction of the disposal facility and to characterize changes that occur during the construction and operation stages. The monitoring process can provide insight into the long-term safety of natural barriers and provide input data for radionuclide transport modeling [1]. In addition, monitoring data can be used to understand the interaction between the geological/hydrogeological elements of the site and to predict the geochemical behavior of the site. Therefore, this study aimed to identify the types and characteristics of hydrogeochemical parameters that should be observed at different scales and regions in future disposal site in South Korea through a review of previous studies. Additionally, the current status of the nationwide hydrogeochemical monitoring system in South Korea was confirmed and additional considerations for disposal-related monitoring were identified.

2. Hydrogeochemical monitoring by disposal stage

2.1. Pre-construction stage

Pre-construction monitoring aims to identify naturally occurring hydrogeochemical processes before the construction of the disposal facility. This monitoring data can provide the reference baseline for assessing disturbances [2].

2.2. Construction/Operation stage

The groundwater flow and dissolved chemical components move toward the facility due to excavation and groundwater pumping during construction. In this stage, hydrogeochemical changes at the surface and underground due to the infiltration of oxygen into deeper subsurface areas. Therefore, the purpose of this stage is to monitor the environmental changes induced by the construction of the facility [2].

2.3. Post-closure stage

After the facility is closed, groundwater will naturally infiltrate and the site will reach a saturated state. However, unlike the pre-construction stage, various hydrogeochemical changes occur within the natural barriers. Therefore, the monitoring should be performed to generate input data for future prediction modeling that takes into account various changes.

3. Hydrogeochemical monitoring by region

Chemical and isotopic monitoring for site characterization is conducted on surface water (precipitation, lakes, streams, sea), groundwater in regolith, and groundwater in bedrock (Fig.1) [3].

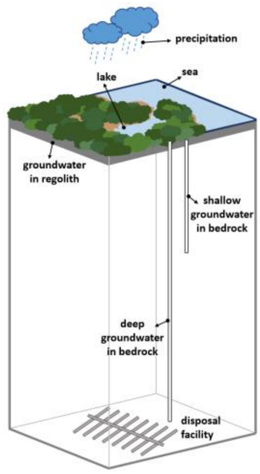

Fig. 1. Schematic diagram of the hydrogeochemical monitoring locations

3.1. Surface water

Surface water from precipitation, lakes, streams, and the sea is monitored to characterize seasonal and long-term changes. These data are used as input for site models that form the basis for long-term safety assessments. Monitoring includes field measurement parameters such as pH, DO (Dissolved Oxygen), and EC (Electrical Conductivity), as well as major cations (Na, K, Ca, Mg, Li, Sr, Si-tot) and major anions (Cl, F, SO4, Br, I). Additionally, trace elements, nutrients, carbon, and isotopes that can trace the origin or age of the water are also monitored.

3.2. Regolith groundwater

Groundwater in regolith is monitored to understand the radionuclide transport process at the boundary between the geosphere and biosphere and to assess the impacts and evolution of surface and subsurface environments due to disposal activities. The same parameters as surface water are monitored, but eutrophication indicators such as TN (Total Nitrogen) and TP (Total Phosphorus), which are typically not monitored in groundwater, are excluded. HS (Hydrogen Sulfide) is monitored as a redox indicator to identify redox transition zone.

3.3. Bedrock groundwater

Groundwater in bedrock is monitored to understand the hydrogeochemical evolution and to provide information on groundwater mixing and residence time in the bedrock where the facility is located. In addition, the monitoring data are used to define model boundary conditions necessary for impact assessment and disturbance analysis due to facility construction and operation. The same parameters as the regolith groundwater are monitored, with the addition of Fe_{tot} and Fe(II) as redox indicators.

4. Hydrogeochemical monitoring by scale

Site-scale monitoring is conducted to identify changes occurring in the overall stages of disposal activities. At the local scale, monitoring provides reference data that are not disturbed during the construction and operation stages of the facility. Monitoring at the regional and national scales is conducted to predict long-term trends that cannot be observed in site- and local-scale or short-time series data. Therefore, the monitoring cycle is relatively long, about once every 5 to 6 years, compared to site- and local-scales and nationwide network data can be utilized. Since hydrogeochemical monitoring parameters are used for comparative analysis across all scales, there are no differences in the monitoring parameters according to scale [3].

5. Hydrogeochemical monitoring network

In South Korea, surface water monitoring is conducted through the river, lake, and stream monitoring system (water.nier.go.kr) and the seawater monitoring system (meis.go.kr). The monitoring cycle varies depending on the monitoring points and parameters, but monitoring is conducted for all parameters at least once a year. Groundwater is also periodically monitored through monitoring networks nationwide (gims.go.kr), and field measurement parameters, major cations/anions, groundwater and domestic water quality are analyzed (Fig. 2).

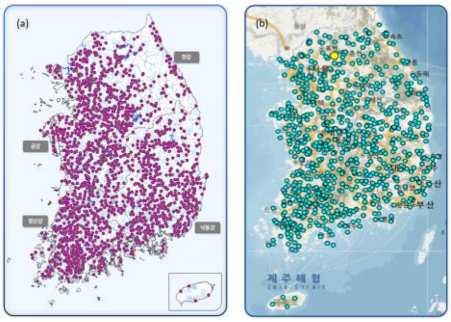

Fig. 2. (a) surface water monitoring network [4] and (b) groundwater monitoring network [5] in South Korea

6. Conclusions

Hydrogeochemical monitoring data from disposal activities provide information on the safety of the facility and are used as input data for modeling related to radionuclide transport. From the pre-construction stage to post-closure stage, field measurement parameters, major ions, trace elements, and isotopes in surface water and groundwater are monitored periodically. There is no difference in the types of monitoring parameters by scale, and local/regional/national data are used as a reference for comparing changes that occur at the site scale. In South Korea, chemical components in surface water and groundwater are periodically monitored. However, parameters monitored in surface water and groundwater lack uniformity in assessing geochemical changes occurring from the underground to the surface caused by disposal activities. In particular, parameters monitored in surface water at the national scale are mainly focused on human health risks, making it difficult to describe geochemical processes. Therefore, uniformity of parameters across regions and scales will be needed to evaluate and compare hydrogeochemical changes and radionuclide behavior during the entire disposal stages.

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