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A Study on the Effects of Key Parameters using A Post-closure Safety Assessment Model for the LILW Disposal Facilities

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1. Introduction

Geological disposal facilities for LILW (Low- and Intermediate-Level Waste) at Gyeongju have various disposal concepts in one site. Permanent disposal of waste drum has already been conducted at a silo-type facility of phase I since 2015 [1]. Now a construction plan of a vault-type disposal facility of phase II is in progress under the supervision of NSSC (Nuclear Safety and Security Commission) [1]. The location of the 2nd phase facility is scheduled to be the current repository site just next to the silo-type facility for the purpose of disposing of future LLW (Low-Level Waste).

The most favorable option internationally for the disposal of radioactive waste is a geological disposal. Therefore many types of disposal facilities of LILW are designed to provide a long-term isolation by means of EBS (Engineered Barrier System) and NBS (Natural Barrier System). For assessing a dominant data which has lots of uncertainty, we need to verify which input parameter is crucial by checking out an effect of the key inputs.

In this paper, the effects of the key parameters (e.g. a sorption coefficient, a solubility) by nuclide transport were studied to evaluate a post-closure safety assessment model.

2. Methods and Results

2.1 Model Concept

The evaluation of the influences of the key parameters is simulated using the model developed by GoldSim software with Contaminant Transport Module [2]. The GoldSim module allows users to identify and understand the factors which control the system or to predict the future behavior of the system.

Fig. 1 shows the screen shot on a scheme of the GoldSim model for both a silo- and a vault-type facility similar to the repository at Gyeongju. Surrounding environment near the repository site is contaminated as a result of radionuclide mass transfer by diffusion and advection from waste drums to its surroundings.

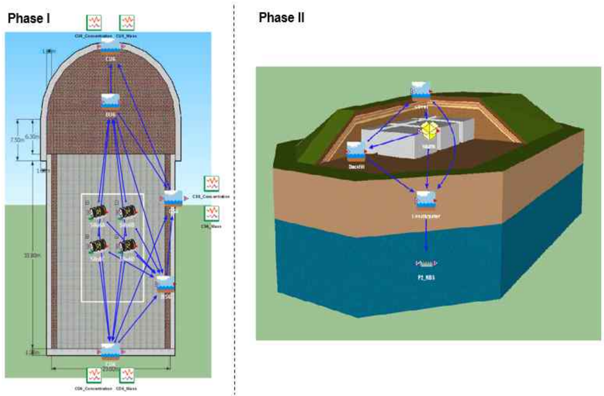

Fig. 1. The simulation model for the post-closure safety assessment of LILW repository based on GoldSim [3]
(Left: Silo-type facility, Right: Vault-type facility)

2.2 Safety Assessment Methods

The model was assumed to be simulated for one million years. The institutional control period of operation was set as a 100 years [3] and a degradation time of concrete was also assumed to be a 1,400 years [3].

Regarding a waste inventory for the simulation model, a radioactive source term was assumed to be an arbitrary fixed value (e.g. 1 g for one source term) only to assess the effects of the key parameters on the hypothetic repository model.

For evaluating the effects of the inputs on the safety assessment model, waste packaging degradation, repository conditions, and radiation dose to the representative person through a variety of exposure pathways [4] should be taken into account.

Among the main parameters, a sorption coefficient and a solubility, from the repository environment were selected to assess some influences caused by the input factors. The sorption coefficient (K_d) is the degree of sorption of a particular species in groundwater [5]. The solubility is a property which a substance dissolves in a solvent to solution [6]. The reason for selecting these two factors is that the sorption coefficient and the solubility are one of the most important parameters for estimating contaminant migration potential in groundwater.

A media for the nuclide transport was chosen as a host rock at the silo-type repository and an aquifer at vault-type facility. That is because the host rock and the saturated zone of NBS would constitute the largest domain for each facility. For verifying influences of the input parameters at the media, the range of K_d is presumed from 1.00E-03 to 1.00E+01 m^3/kg and that of solubility is presumed from 1.00E-02 to 1.00E-02 g/m^3.

The result data would be represented as a form of mass rate to the receptor from the GoldSim-based hypothetic repository model. The mass rate is defined as the mass of a substance which passes per unit of time. Unit of time on this research is set as a year value. Then the simulated results are plotted to find out the effects of parameter values at the subsurface solid media also known as NBS.

2.3 Results

The maximum mass rate of the radionuclide transport results from the two parameters of each disposal facility model mentioned above is depicted in Fig. 2 and 3 below.

2.3.1 Result of Phase I Facility

In case of the silo-type facility, the maximum mass rate by radionuclide transport as shown in Fig. 2 is consistently decreasing as the sorption coefficient of host rock increases. However it seems that it is hard to find the influences from the solubility in host rock. That is because the mass rate graphs turn out to be the similar trend values which are negligible effects by solubility variations as shown in Fig. 2. In other words, the number of the mass value results do not vary at all in regard to the solubility values, but only vary with the changing of K_d parameter values.

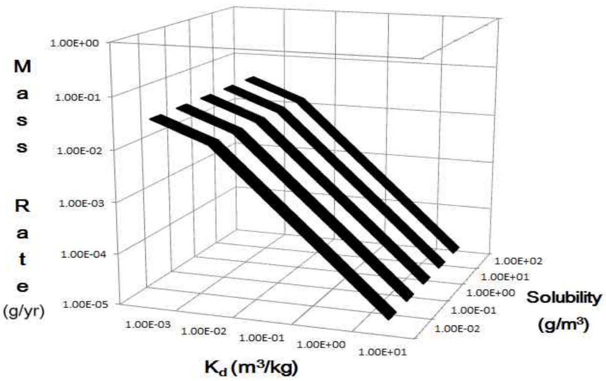

Fig. 2. A distribution of the maximum mass rate [g/yr] between "Kd" and "Solubility" at host rock for the silo-type facility of phase I

For these reasons, we could guess a few things as follows. First, the effects of solubility from the nuclide transport are relatively smaller than those of sorption coefficient. But it has to be approached differently depending on a nuclide name. That is because some radionuclides (e.g. cesium, iodine) have a high solubility [7]. Therefore it can be sensitive to solubility change depending on the radionuclide inventory from the source term model. Second, it could be also largely subject to the solubility when the amounts of specific nuclide are plenty. If an abundance of nuclide inventory are dissolved individually, it is likely to be restricted by its solubility. Judging from these features, this is the reason why Fig. 2 above has no difference by the solubility value change.

2.3.2 Result of Phase II Facility

Similar to the above results as shown in Fig. 2, the maximum mass rate of the vault-type facility has almost the same tendency by the variation of K_d parameter values alone as shown in Fig. 3 below. Even though the media on the 2nd phase facility is the aquifer rather than the host rock, it is hard to find the conspicuous difference from the previous result.

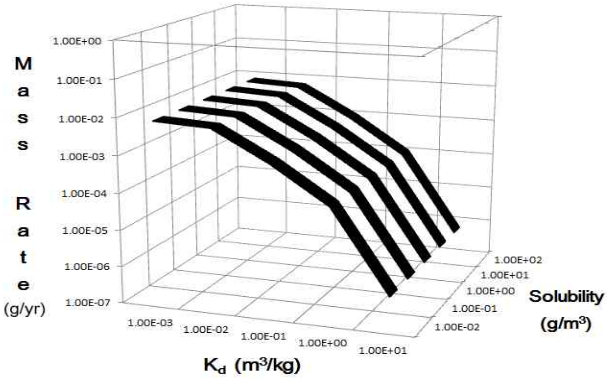

Fig. 3. A distribution of the maximum mass rate [g/yr] between "Kd" and "Solubility" at aquifer (saturated zone) for the vault-type facility of phase II

2.3.3 Time Result

Time to reach the maximum mass rate tends to show the similar result depending on the sorption coefficients value. Thus the time to the peak values of the mass rate has no direct effect on this model by solubility variables unlike the K_d parameter. Fig. 4 below is an example of the simulated result.

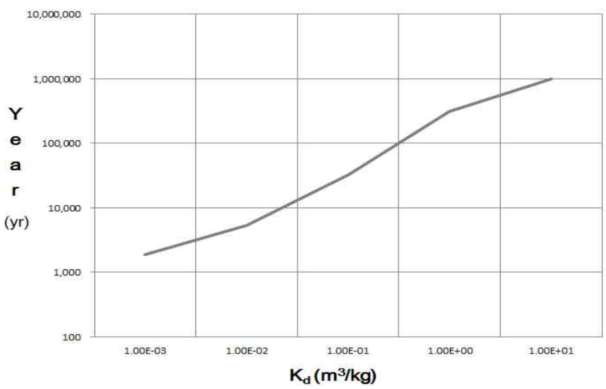

Fig. 4. An example on time [yr] to reach the maximum mass rate result

3. Conclusions

The effects analysis of the key parameters for the post-closure safety assessment model was developed for both the silo-type disposal facility of phase I and the vault-type facility of phase II.

On this hypothetic safety assessment model, the sorption coefficient (K_d) had a huge impact on the mass rate on underground circumstances. On the other hand, the solubility variable change resulted in relatively negligible effects. And the impacts of the sorption coefficients to the mass rate at solid media (e.g. host rock, aquifer) showed the analogical tendency in results based on the data of host rock at phase I facility as shown in Fig. 2 and aquifer at phase II in Fig. 3.

This research would be meaningful for a preliminary assessment of effects and sensitivity analysis for the input parameters of repository. Furthermore, the interaction analysis of the parameters for the complex repository performance that has various types of disposal facilities in one site will be necessary in the near future.

Acknowledgement

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