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Assessment of chelate effect on a repository based on EDTA analysis data

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1. Introduction

According to the determination of the Kyungju repository for low-level radioactive wastes, a reception criterion of the radioactive wastes for a disposal was prepared. As the criterion focused on the integrity of radioactive wastes, it contained several quantitative numerical values. Among them, chelates were expected to have effects on the repository system. In this study, the chelate effect on the repository system is assessed using the MASCOT[1,2] and AMBER[3] codes based on the EDTA(ethylenediaminetetraacetic acid) analysis data of radioactive wastes.

2. Methods and Results

For the study, the basic input data such as the nuclide inventories, sorption coefficient at each barrier and velocity and path length of each underground flow which were adopted for the preliminary assessment of the Kyungju repository are used[4]. Also, to establish the chelate effects, a method to compare an assessment of a chelate condition with an assessment of a no chelate condition is used.

2.1 Concept of the assessment for the chelate effects

As a basic concept, normal characteristics of chelate should be investigated. Chelating agents form stable coordination compounds by a coordinate bonding with a metal ion. The ring type complex containing nuclide is not expected to adsorb in the artificial and natural barriers during its travel time. When chelating agents react with metal ions, they usually collect the same number of metal ions. Also, the amount of EDTA in radioactive wastes was investigated in 2005 by a sample survey. Table 1 is a summary of the survey. As EDTA is the most popular chelating agent in the nuclear field, the amount of EDTA may be considered as the amount of chelating agent, roughly speaking.

Table 1. EDTA amount in sample radioactive wastes

Waste Form	Paraffin waste	Solid waste
No. of sample drums	28	35
No. of drums containing EDTA	28	23
Total amount of EDTA (mg)	3407	2365.8

The characteristics of chelating compounds and the result of the sample survey make it possible to establish an assessment model.

2.2 Establishment of an assessment model

To establish the chelate effects, it is best to compare a chelate condition with a no chelate condition. Assessment models adopting the basic concepts need to be established for this comparison. In the modeling, it is important to know that the amount of chelating compounds containing nuclides. The amount of chelates in the radioactive wastes to be disposed can be derived from table 1. Also, chelates in the radioactive wastes are considered to be chelating compounds. Therefore, three models are established in consideration of the following four principles.

First, nuclide inventories should be classified by the possibility of a direct contact with ground water. According to the possibility, nuclides not in contact directly with a ground water are considered to leak by a solubility limited source term. Nuclides in contact directly with a ground water are considered to leak by a simple leaching.

Second, with regard to the sample survey, data were investigated from the radioactive wastes of power plants. Therefore, nuclide inventories of power plants should be distinguished from those of other organizations.

Third, the amount of chelates in the radioactive wastes to be disposed should be converted to a unit of mole. For the conversion, the molecular weight of a chelating compound is considered to be 360.

Fourth, in case that the amount of chelates from table 1 is more than the amount of the nuclide inventory, excess chelates will be in the form of chelating agents. The excess chelates can react with nuclides from neighboring radioactive waste, with minerals from a ground water or with elements from others (container, materials of waste package, etc). Two models should be developed to distinguish whether there are additional reactions between the excess chelating agents and the neighboring nuclides or not. Actually, the amount of chelates(EDTA) is estimated to be total 7.53 moles from table 1 and the total amount of nuclides is 6.46 moles from the nuclide inventory. It means the excess is 1.07 moles in about 20,000 drums.

Based on the four principles, three models are developed as shown in Figures 1, 2 and 3.

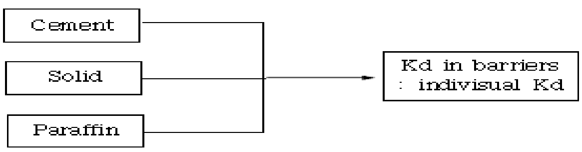

Fig. 1 Reference model

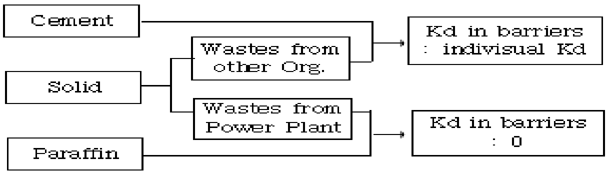

Fig. 2 Chelate assessment model 1

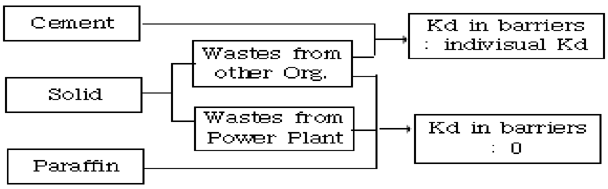

Fig. 3 Chelate assessment model 2

Figures 1, 2 and 3 show that all assessment models are established based on the Kds (distribution coefficients) of nuclides. Reference model means that there are no chelates in the radioactive wastes. Also there are some differences between model 1 and model 2 in view of the treatment of excess chelating agents, as mentioned. Especially, Kd=0 means the nuclides are not adsorbed in the barriers.

2.3 Results of assessments

Three assessment results can be obtained as follows;

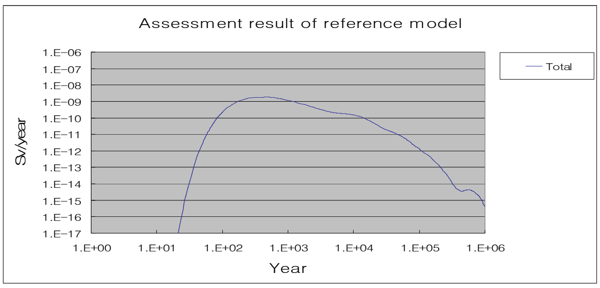

Fig. 4 Assessment result of reference model

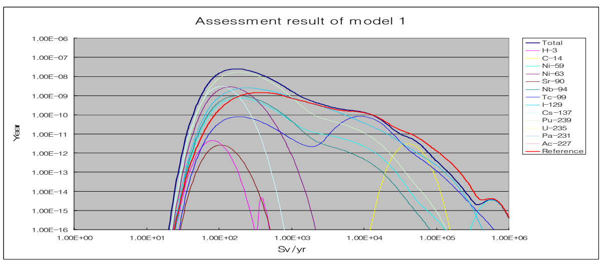

Fig. 5 Assessment result of model 1

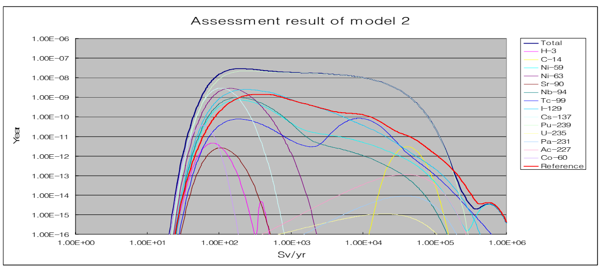

Fig. 6 Assessment result of model 2

Comparison of Figures 4, 5 and 6 shows that chelates have effects on the repository. The maximum fluxes in models 2 & 3 are almost 10 times as much as the flux of the reference model. Maximum fluxes of models 2 & 3 are arrived at earlier than the maximum flux of the reference model. Also, almost the maximum level of a nuclide flux is maintained continuously in model 2. Actually, the chelate effect from each element is not so important because the selectivity of a chelating agent is not considered.

3. Conclusions

Based on a sample survey, chelate effects were assessed by three models using MASCOT and AMBER. Graphs obtained from the simulations reveal the following.

First, chelates in radioactive wastes to be disposed have effects on the repository obviously. Second, total flux based on the amount of chelates from a sample survey is almost 10 times as much as the flux of the reference model. Third, with a dependency on an excess reaction between the chelating agents and the nuclides of the neighboring radioactive wastes, the chelate effects will be brought out in the shape of graph between the result of model 1 and the result of model 2.

To obtain a better assessment result, an amplification of the sample survey and a selectivity study of the chelating agents will be needed..

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