The Dose Assessment in the Vault Test Case of Near-Surface Disposal Facility for Drinking Water Scenario

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1. Introduction

It is generally accepted that the radionuclides contained in the radioactive wastes will be eventually released and these will be transported to the accessible environment (near-field, far-field, biosphere). Therefore, the long-term safety assessment of near-surface radioactive waste disposal should be required by modeling the expected release of radionuclides from the repository, far-field area, and biosphere. Finally, the effective dose rate should be estimated through the released radionuclides.

In this study, the radiological dose was evaluated for the reference near-surface radioactive waste disposal facility in Vaalputs, South Africa, which has been selected as a part of IAEA coordinated research program on improvement of safety assessment methodologies(ISAM).[1] The assessment of radiological dose was performed for drinking water scenario from a well. The release and transport of radionuclides in disposal system were simulated by GoldSim. This approach suggested the time variation of effective dose over long-term period. And the results from this approach were compared with another approach method for the same facility and scenario.[2]

2. Methods

2.1 safety assessment tool

To obtain the radiological dose rate, this study was conducted by using GoldSim tool developed by GoldSim Technology Group in Issaquah, USA, which is one of the safety assessment tools, and this tool is worked by a compartment modeling approach. The GoldSim has been used to evaluate radioactive waste disposal facilities such as Yucca mountain disposal facility.

2.2 system description

The conceptual model for leachate release in the valut test case consists of three main parts, as shown in Fig 1. The near-field part has the repository stored radioactive wastes and engineering barriers such as cap layer, and outer well of the repository. The far-field part consists of the other four unsaturated zone, and saturated zone. The biosphere has included information about the path of the radiation exposure.

In order to design the vaults test case, which is used in this study, The parameters for the modeling of the near-field(source term, engineering barriers), far-field (medium, groundwater) and biosphere are mainly obtained from the site specific data in IAEA publications.[1]

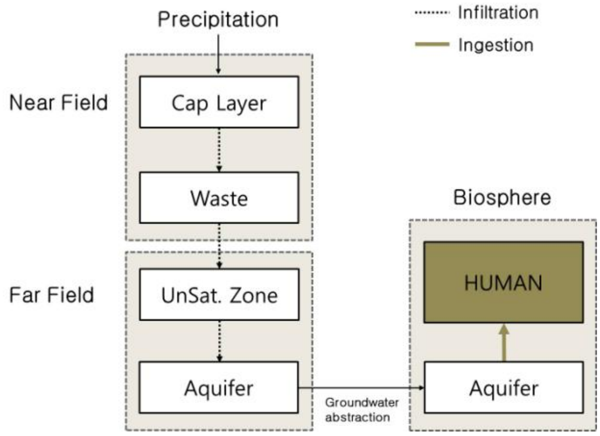

Fig. 1. Simplified representation of the conceptual model.

2.3 Assessment method

This study was considered about the drinking water scenario caused the released radionuclides. These radionuclides are transported in unsaturated ground-water flow from the repository to the unsaturated zone and then to the saturated zone. The saturated zone includes a well from which water is ingested by human. In determining the transfer rate of radionuclides between the mediums, the precipitation rate and the performance of engineering barriers play an important role. Fig. 2 illustrates the time frame in safety assessment to represent the precipitation, and the physical and chemical degradation of engineering barriers as condition changes.

Finally, for radionuclides with a human health endpoint of committed effective dose, in Sv, radiological dose, D is given by

$$D = C_{Wat}\ Ing_{Wat}\ DCF_{Ing} \qquad (1)$$

$$C_{wat} = \frac{Amount_W}{\theta_W\ V_W\ R_W} \qquad (2)$$

Where

C_{wat} : Groundwater concentration for each radionuclides (Bq/m^3)
Ing_{wat} : Water ingestion rate (m^3/yr)
DCF_{ing} : Ingestion dose conversion factor for each radionuclides (Sv/Bq)
$Amount_W$: Amount of radionuclides from the well
θ_W : Effective porosity in saturated zone
V_w : Volume of saturated zone
R_w : Retardation factor in saturated zone

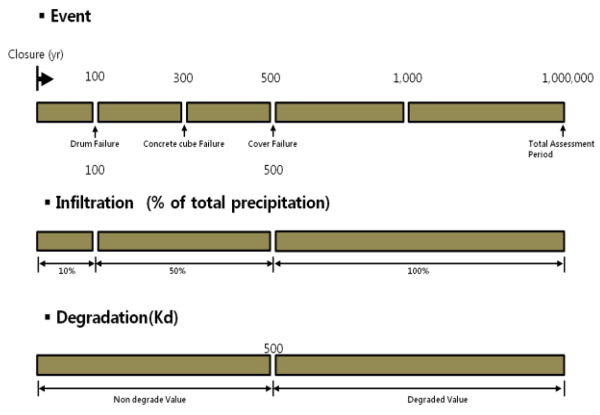

Fig. 2. The time frame to represent the precipitation and the degradation of near-field as condition changes.

3. Results and Discussion

The annual dose rate from drinking well water using GoldSim can be seen Fig.3. It is found that the annual effective doses are dominated by the radionuclides such as ^{99}Tc, ^{129}I, ^{234}U, ^{238}U, ^{230}Th, ^{226}Ra, ^{210}Pb, ^{210}Po, which can be characterized by the half-life and mobility of parents and daughters. The contribution of ^{129}I to total effective dose is dominant among these radionuclides. Dose from the ^{129}I has a peak dose at 5800 yr, and this dose value is 15 μSv/yr.

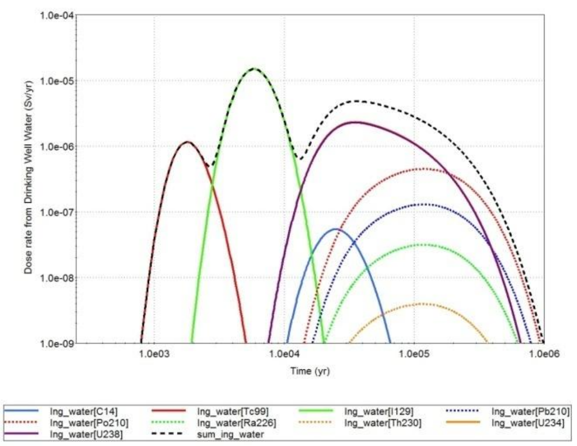

Fig. 3. Annual dose rate from drinking well water using GoldSim.

Comparison of the results of GoldSim and MASCOT for timing and magnitude of peak individual dose from drinking water is reported in Table. 1. As can be seen, the peak dose from drinking water of the majority of radionuclides are similar to each other. However, the emergence of peak timing of radionuclides is different. It seems that two researches have used another approach modeling method.

Table. 1. Comparison of the results of GoldSim and MASCOT for timing and magnitude of peak individual dose from drinking water.

Radio-nuclide	GoldSim [This]		MASCOT [IAEA]	
	Time (yr)	Peak Dose from drinking water (Sv/yr)	Time (yr)	Peak Dose from drinking water (Sv/yr)
^{14}C	25,000	5.4e-8	31,000	3.1e-8
^{99}Tc	1,800	1.2e-6	2.400	1.9e-6
^{129}I	5,800	1.5e-5	7,000	2.3e-5
^{234}U	35,200	2.3e-6	73,000	4.2e-6
^{238}U	35,100	2.3e-6	59,000	4.1e-6
^{230}Th	116.500	3.9e-9	120,000	2.7e-8
^{226}Ra	118,900	3.1e-8	120,000	6.4e-7
^{210}Pb	118,900	1.3e-7	120,000	5.2e-6
^{210}Po	118,900	4.5e-7	120,000	3.9e-5
Total	5.800	1.5e-5	7,000	2.4e-5

4. Conclusions

In this study, the radiological dose for drinking water scenario was evaluated for the reference near-surface radioactive waste disposal facility, and then this result was compared with another research.

Although this study is only conducted for drinking water scenario, it is concluded that total effective dose(15 μSv/yr) caused by drinking water would be far below the general regulatory limit 0.1 mSv/yr for radioactive waste disposal facility. Comparison result also shows there is a good agreement in the peak dose values between our simulation and another simulation conducted with MASCOT.

REFERENCES

[1] IAEA, Safety Assessment Methodologies for Near Surface Disposal Facilities, IAEA publication, Vol. 1-2, 2004

[2] J.W. Park, K.M. Chang, C.L. Kim, A Case Study on the Safety Assessment for Groundwater Pathway in a Near-Surface Radioactive Waste Disposal Facility, J. Korean Nuclear Society, Vol.34, No.3, pp.232-241, 2002