Research of Self-disposal Evaluation for Domestic Hard-to-treat Radioactive Waste

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1. Introduction

The volume of domestic radioactive waste which is difficult to treat can be reduced by applying the patented technology of Korea Atomic Energy Research Institute. The support structure which occupies most of the waste volume is separated and subjected to self-disposal. We would like to bury the waste in the landfill by proving that the waste form satisfies regulatory requirement [1,2,3]. We will evaluate the dose of industrial worker and resident farmer scenarios and prove that they satisfy the disposal limit of domestic nuclear safety law (maximum individual dose: 10μSv/y, collective dose: 1man·Sv/y). Therefore, in this study, radiological effect of landfill disposal of support structure from the volume reduction process of domestic industrial radioactive waste will be evaluated using RESRAD 7.2.

2. Evaluation method

RESRAD was developed by Argonne National Laboratory with the support from DOE for the purpose of assessing the radiation dose and risk of residents due to radioactive contaminants. It was approved by DOE for evaluation of radioactive contaminated sites. Also, US NRC approves dose evaluation through RESRAD for nuclear decommissioning licenses [4].

3. Selection of input data

For the purpose of selecting input variable to evaluate landfill scenario using RESRAD, we obtained characteristic data of the landfill and surrounding area. When the local data was not available, domestic survey data and values from literature were selected and applied in a conservative manner. In case appropriate data is unavailable, the default values of RESRAD was used. In this study, we evaluated the industrial workers at the landfill and the general public residence in the upper part of the landfill after closure.

3.1 Disposal capacity and radionuclide concentration

If the volume of the domestic industrial radioactive waste is reduced by 50% using the patented technology of KAERI, the volume of the resultant waste is 710 m^3 and the fraction of mass of each nuclide is shown in Table 1.

Table 1. Landfill capacity & Mass fraction

Classification		Value	Unit
Landfill capacity		710	m^3
Mass Fraction[1)]	U-234	0.001	wt%
	U-235	0.194	wt%
	U-238	99.805	wt%

[1)] Nuclide Concentration ratio: www.wise-uranium.org site, Composition of uranium isotopes in depleted uranium from enrichment of natural uranium

3.2 Evaluation target and period

In case of industrial workers who bury waste for self-disposal, external exposure, inhalation of dust, and inadvertent soil ingestion are considered. For resident farmer scenario, additional pathways are surface water, groundwater, plant food, and fish. Also, evaluation period is chosen as 1000 years which is the default value of RESRAD.

3.3 Other input data

Significant factors among the input variables of the hydrological data of cover, contaminated zone, aquifer and vadose zone, residential and environmental data, inhalation and ingestion, and external exposure are shown in Table 2.

Table 2. Input factors of landfill worker and resident after closure

Parameter		Value	Unit
Nuclide Concentration	U-234	142	mBq/g
	U-235	11	mBq/g
	U-238	847	mBq/g
Area of contaminated zone		355	m^2
Thickness of contaminated zone		2	m
Cover depth[1)]	Worker	0.15	m
	Resident	0.6	
Density of contaminated zone		1.5	g/cc
Wind speed[2)]		2.2	m/s
Precipitation[2)]		1.28	m/yr
Water transport model		MB	-
Well pump rate[3)]		8,288	m^3/yr
Inhalation rate[4)]	Worker	10,519	m^3/yr
	Resident	8,400	m^3/yr
Indoor time fraction	Worker	0.057	m^3/yr
	Resident	0.5	-
Outdoor time fraction	Worker	0.171	-
	Resident	0.25	-
Plant food ingestion[5)] (Resident)		290	kg/yr
Drinking water intake[5)] (Resident)		196.3	liter/yr

[1)] Enforcement Rule of Wastes Control Act asterisk 11 Data
[2)] KMA(Korea Meteorological Administration) Data
[3)] MOLIT(Ministry of Land, Infrastructure, and Transport) Data
[4)] EPA(United States Environmental Protection Agency) Data
[5)] KINS(Korea Institute of Nuclear Safety) Report(KINS/RR-808)

4. Evaluation result

Based on the input data, RESRAD was executed to calculate the dose for industrial worker and resident farmer. The deregulated waste of concentration 1 Bq/g is of volume 710 m^3 and satisfies the annual radiation dose limit of 10 μSv/y according to Nuclear Safety Act Article 70 and Enforcement Rule 94 (Table 3).

Table 3. Targeted Individual dose

Classification	Radioactive nuclide			Total (μSv/yr)
	U-234 (μSv/yr)	U-235 (μSv/yr)	U-238 (μSv/yr)	
Worker	2.438E-4	1.691E-2	7.758E-1	0.793
Resident	0.3876	0.02472	2.05	2.463

In order to evaluate the collective dose, it is assumed that the total number of people in waste treatment is 10. For the number of residents after closure of landfill, Statistics Bureau data is used. City of Ulsan has population density of 1099.6 man/km^2 (2015) and the area of landfill is 0.355 km^2. For population of the contaminated area, 390 people are assumed by multiplying population density and the area of landfill. As a result of the evaluation, it was confirmed that it satisfies the domestic standard of collective dose for self-disposal which is 1 man·Sv/y (Table 4).

Table 4. Targeted Individual dose

Classfication	Individual dose (μSv/yr)	Persons	Collective dose (man·Sv/yr)
Worker	0.793	10	7.93E-06
Resident	2.463	390	9.61E-04

5. Conclusion

The volume of domestic industrial radioactive waste which is difficult to treat is planned to be reduced by applying the patented technology of KAERI. In this study, regulatory compliance of self-disposal of the resulting deregulated waste was evaluated using RESRAD 7.2. As a result, it was confirmed that the disposal limit proposed by the Nuclear Safety Act was satisfied for both the industrial worker scenario and resident farmer scenario. Therefore, it is expected that this paper would be used as evidence that the landfill disposal of deregulated waste resulting from the volume reduction process is safe.

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