Impacts of Major Input Parameters on the Safety of Landfill Disposal of Decommissioning Wastes

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1. Introduction

Among various kinds of decommissioning wastes, very low level waste (VLLW) comprises about 43% of total decommissioning wastes [1]. For the safe management of these very low level decommissioning waste, the appropriate disposal method have to be established and the safety have to be secured. Many input data are required for the safety assessment of a landfill disposal site. Especially, the impacts of input data on the safety of a landfill disposal site may affect the conceptual and detail design stages of a landfill disposal site. Therefore, we made sensitivity analyses of major input parameters of a landfill disposal site on the safety using the RESRAD code [2].

2. Methods and Results

2.1. Landfill disposal facility

According to the KORAD's implementation plan for low- and intermediate-level radioactive waste management, facilities for the disposal of VLLW including decommissioning wastes will be a landfill site as shown in Fig. 1[3]. They will be located to adjacent to the surface land burial facilities, and will compose of disposal trench, trench shelter, subsidiary facility, and spoil earth area. Total 5 trenches will be constructed successively, and will start the operation 2027. Total 260,000 waste drums based on a 200 L drum will be disposed.

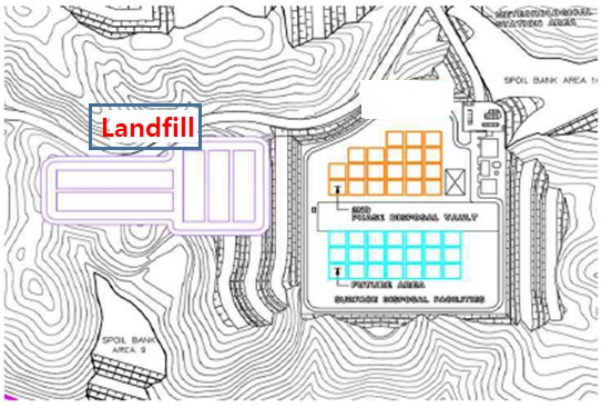

Fig.1. Construction plan for the landfill disposal facility.

2.2. RESRAD code for the estimation of exposure dose

We use the RESRAD code for the estimation of exposure doses and sensitivity analyses of major input parameters for the landfill disposal of very low level wastes including decommissioning wastes. The RESRAD code is a computer model developed as a multifunctional tool to assist in developing cleanup criteria and assessing the dose or risk associated with residual radioactive material [2]. It has been used widely by the many government agencies, research institutes, and industries. It is also used in many research institutes and industries in Korea [4, 5].

The exposure pathways considered in the RESRAD code shown in Fig. 2 are 1) direct exposure to external radiation from the contaminated soil material; 2) internal dose from inhalation of airborne radionuclides including radon progeny; 3) internal dose from ingestion of plant foods grown in the contaminated soil and irrigated with contaminated water, meat and milk from livestock fed with contaminated fodder and water, drinking water from a contaminated well or pond, fish from a contaminated pond, and contaminated soil.

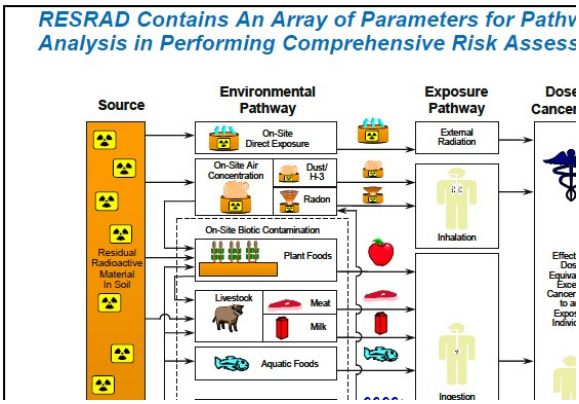

Fig.2. Illustration of exposure pathways in RESRAD code.

2.3. Sensitivity analyses of major input parameters

We consider two kinds of very low level decommissioning waste, i.e., wastes containing Co-60 and Cs-137. We assume that they are disposed into a conceptual landfill site. The input data for the base case are summarized in Table 1. The exposure doses for the base case are shown in Figs. 3 and 4. As shown in Figs. 3 and 4, the most important pathway is internal dose from ingestion of plant foods grown in the contaminated soil and irrigated with contaminated water. The total exposure doses are below 1 mSv/yr although the cover

depth considered in this study is 1 m. The typical cover depth for landfill disposal is 4 ~ 5 m.

Table 1: Input data for the base case

Input variable	Value
Activity (Bq/g)	100
Cover depth (m)	1.0
Density of cover material (g/cm^3)	1.6
Depth of contaminated zone (m)	4.0
Erosion rate of contaminated zone (g/cm^3)	0.001
Distance to aquifer (m)	600
Hydraulic conductivity in saturated zone (m/yr)	1,000
Hydraulic conductivity in unsaturated zone (m/yr)	100

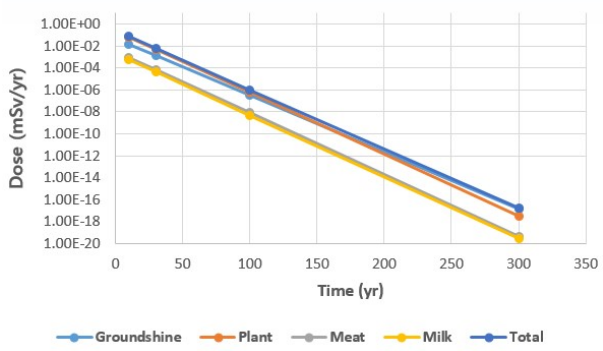

Fig.3. Exposure doses for each pathway for Co-60 containing waste

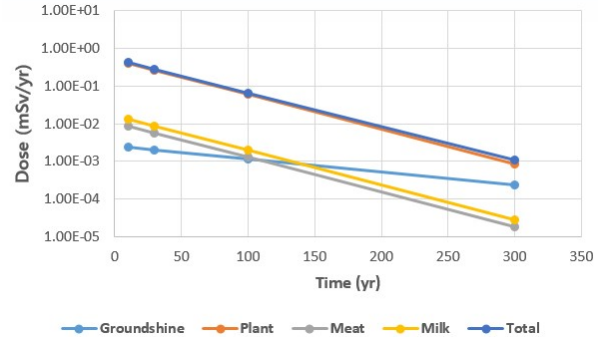

Fig.4. Exposure doses for each pathway for Cs-137 containing waste

Major input parameters considered in this study for the investigation of impacts on the exposure doses are a cover depth, an erosion rate of cover material, a density of cover material, a rainfall rate, a distance to aquifer, and hydraulic conductivities of saturated and unsaturated zone.

The change of exposure doses as a function of cover depth for the landfill disposal of decommissioning wastes containing Co-60 and Cs-137 are summarized in Tables 2 and 3. The change of cover depth impacts much on exposure doses for the landfill disposal of decommissioning waste. The major exposure pathway is the direct exposure to external radiation from the contaminated soil material, and the internal dose from inhalation of airborne radionuclides occurs only when the cover depth is 0.1 m or less. If the cover depth is 1.0 m or more, only the direct exposure to external radiation from the contaminated soil material occurs.

And if the cover depth is 1 m or more, the exposure doses are six or more orders of magnitude lower than 1 mSv/yr which is the safety goal to the general public.

Table 2: Change of exposure doses as a function of cover depth (Co-60 waste) (mSv/yr)

Cover depth Pathway	0.1 m	0.5 m	1 m
Groundshine	1.85E-01	1.26E-03	2.45E-06
Inhalation	1.97E-07	-	-
Plant	9.64E-03	5.00E-03	-
Meat	2.01E-04	7.17E-05	-
Milk	8.82E-05	4.21E-05	-
Total	1.95E-01	6.36E-03	2.45E-06

Table 3: Change of exposure doses as a function of cover depth (Cs-137 waste) (mSv/yr)

Cover depth Pathway	0.1 m	0.5 m	1 m
Groundshine	8.82E-01	2.02E-03	1.01E-06
Inhalation	6.72E-05	-	-
Plant	5.02E-02	2.60E-01	-
Meat	2.06E-02	5.60E-03	-
Milk	1.98E-02	8.77E-03	-
Total	1.42E-01	2.77E-01	1.01E-06

The change of exposure doses as a function of erosion rate of cover material for the landfill disposal of decommissioning wastes containing Co-60 and Cs-137 are summarized in Tables 4 and 5. According to results summarized in Tables 4 and 5, the total exposure doses increase as the erosion rate of cover material increase. The increase of exposure doses is mostly due to the increase of groundshine exposure dose. As the erosion rate of cover material increases, the amount of radioactive material exposed to ground surface increases and the groundshine exposure dose increases.

We also made sensitivity analyses of other input parameters such as a density of cover material, a rainfall rate, a distance to aquifer, hydraulic conductivities of saturated and unsaturated zone. According to sensitivity analyses results for these input parameters, the changes of exposure doses are negligible.

Table 4: Change of exposure doses as a function of erosion rate of cover material (Co-60 waste) (mSv/yr)

Erosion rate Pathway	0.0001 m/yr	0.001 m/yr	0.01 m/yr
Groundshine	8.91E-04	1.26E-03	3.86E-02
Inhalation	-	-	-
Plant	4.68E-03	5.00E-03	8.18E-03
Meat	6.71E-05	7.17E-05	1.17E-04

Milk	3.94E-05	4.21E-05	6.88E-05
Total	5.67E-03	6.36E-03	4.69E-02

Table 5: Change of exposure doses as a function of erosion rate of cover material (Cs-137 waste) (mSv/yr)

Erosion rate Pathway	0.0001 m/yr	0.001 m/yr	0.01 m/yr
Groundshine	1.33E-03	2.02E-03	1.31E-01
Inhalation	-	-	-
Plant	2.44E-01	2.60E-01	4.26E-01
Meat	5.25E-03	5.60E-03	9.15E-03
Milk	8.22E-03	8.77E-03	1.43E-02
Total	2.58E-01	2.77E-01	5.80E-01

3. Summary and Conclusions

We investigated the impacts of major input parameters on the safety of landfill disposal of decommissioning wastes containing Co-60 and Cs-137 using the RESRAD code. The most important pathway is internal dose from ingestion of plant foods grown in the contaminated soil and irrigated with contaminated water. The important input parameters are the cover depth and the erosion rate of cover material. However, other input parameters such as a density of cover material, a rainfall rate, a distance to aquifer, hydraulic conductivities of saturated and unsaturated zone have negligible impacts on the exposure dose.

Acknowledgement

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