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# Sensitivity Analysis of Primary Contaminated Zone Parameters after Landfilling By-product Generated from Coal-fired Power Plants

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## 1. Introduction

Coal is the representative NORM, which is used as a primary fuel in coal-fired power plants and generates ashes when burned. According to a number of international organizations such as IAEA, ICRP, EU, etc, fossil fuel industries are included in the list of major NORM industries to consider for radiological safety management [1]. In Korea, there are several coal-fired power plants, and the ashes generated by them are buried at a separate landfill site within the power plant.

After landfilling ashes, which are the by-products of coal-fired power plants, radiation exposure can occur through multiple pathways such as surface water and groundwater leaching, and several exposure parameters are entailed as well. To accurately evaluate radiation exposure, it is necessary to select the significant parameters that affect a radiation dose the most and to consider domestic site-specific data. Particularly, primary contaminated zone parameter should be considered as a priority because it tends to have a greater impact on radiation dose than other parameters do.

Therefore, the objective of this study is to perform a sensitivity analysis of primary contaminated zone parameters, considering domestic site-specific data that reflects the characteristics of Korean coal-fired power plants for reliable radiological assessment.

## 2. Material and Methods

Sensitivity analysis was carried out utilizing RESRAD-OFFSITE computer code. To perform sensitivity analysis, we divided a research process into 3 parts, which are the selection of source term, exposure scenario, and methodology of sensitivity analysis.

### *2.1 Source term*

In this study, source was selected as fly ashes, which are representative NORM by-products from coal-fired power plant. Radioactive concentration for each nuclide was selected based on a prior study of foreign coal-fired power plants [2].

Table I: Selection of nuclide and radioactive concentration

| Classification | Nuclide | Radioactive* concentration (Bg/kg) |
|---|---|---|
| U series | Ra-226 | 16.6 |
| | Po-210 | 16.6 |
| | Pb-210 | 16.6 |
| Th series | Th-232 | 14.9 |
| | Th-228 | 14.9 |
| | Ra-228 | 14.9 |
| - | K-40 | 26.4 |

* Radioactive equilibrium is applied to nuclide of each series

### *2.2 Exposure scenario*

The exposure scenario is characterized by several pathways such as external exposure, soil and food intake, inhalation, etc. Considering those pathways, we chose the resident farmer scenario because it is one of the representative scenarios presented in NUREG/CR-7268 [3]. This scenario is conservative since it includes all the pathways. Table II shows pathways considered in the resident farmer scenario.

Table II: Exposure pathways considered in resident farmer scenario

| Exposure scenario | Exposure pathway | |
|---|---|---|
| Resident farmer scenario | External exposure by soil | |
| | Inhalation | Dust |
| | | Radon |
| | Ingestion | Soil |
| | | Plant |
| | | Meat |
| | | Milk |
| | | Fish |
| | | Water |

### *2.3 Methodology of sensitivity analysis*

We performed sensitivity analysis for primary contaminated zone parameters that are directly related to soil. In order to consider the characteristics of domestic coal-fired power plants, the actual area of landfill and amount of by-product were used. Parameters related to atmospheric transport, intake, and indoor occupancy fraction were based on domestic data [4].

Finally, NDD (Normalized Dose Difference) was utilized as an indicator of the magnitude of the effect of the primary contaminated zone parameter on the dose. if

NDD of the parameter is equal to or greater than 10, the parameter is identified as a sensitive one [5]. The equation for deriving NDD is shown in equation 1 below.

$$(1)\ \text{NDD} = \frac{D_{high} - D_{low}}{D_{base}} \times 100\%$$

$D_{high}$, $D_{base}$ and $D_{low}$ represent dose derived by using 95, 50, 5 percentile value of probability distribution built in RESRAD-OFFSITE computer code respectively.

## 3. Results and Discussion

Table III shows the NDD value for each parameter. Five sensitive parameters, which are slope-length-steepness factor, cover and management factor, rainfall and runoff factor, soil erodibility factor of the contaminated zone, and support practice factor were derived. These are the parameters that are used to calculate erosion rate. Among them, slope-length-steepness factor is found to be the most sensitive, having a NDD value of 2,801. Moreover, it is found that the value of its NDD is about 9.84 times larger than the second largest factor which is cover and management factor. Its biggest difference between 95 percentile value and 5 percentile value among the five sensitive parameters might contribute to the one of the factors of the highest NDD. The values for the rest of the three parameters were derived as 228, 112, and 43, respectively and the other 7 parameters were discovered to be insensitive.

Table III: NDD value for each parameter

| Rank | Parameter | NDD |
|---|---|---|
| 1 | Slope-length-steepness factor | 2,801 |
| 2 | Cover and management factor | 285 |
| 3 | Rainfall and runoff factor | 228 |
| 4 | Soil erodibility factor | 112 |
| 5 | Support practice factor | 43 |
| 6 | Dry bulk density | 2 |
| 7 | Runoff coefficient | 2 |
| 8 | Depth of soil mixing layer | -* |
| 9 | Total porosity | -* |
| 10 | Effective porosity | -* |
| 11 | Hydraulic conductivity | -* |
| 12 | b parameter | -* |

* NDD was found to be negligible

Fig.1 shows that dose distribution varies with sensitive parameter. Slope-length-steepness factor was found to have the largest dose distribution and it varies by about a factor of 741.5, depending on percentile. Rest of the four sensitive parameters varies by about a factor of 133, 17, 4, 2, respectively.

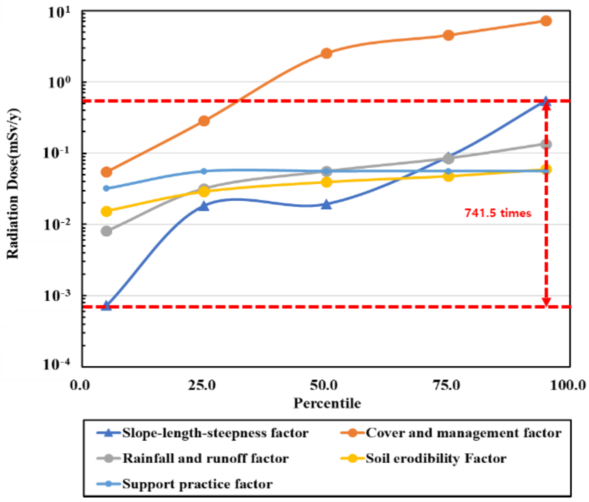


Fig. 1. Dose distribution of sensitive parameter by percentile

## 4. Conclusions

In this study, we performed a deterministic sensitivity analysis for the primary contaminated zone parameter, considering domestic site-specific data. Slope-length-steepness factor was found to have a significant impact on radiation dose among the multiples of primary contaminated zone parameters due to its largest value of NDD. Since five sensitive parameters are used to calculate erosion rate, it is clear that these parameters have an influence on erosion rate. These results provide wider support for the background data when developing a standard assessment model for radiological impacts in the disposal NORM waste.

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## REFERENCES

[1] ICRP, Radiological Protection from Naturally Occurring Radioactive Material (NORM) in Industrial Process, ICRP 142, 2020.
[2] A Basic Study on the Radiological Characteristics and Disposal Methods of NORM Wastes, Jongtae Jeong, 2014.
[3] ANL, Default Parameter Values and Distribution in RESRAD-ONSITE V7.2, RESRAD-BUILD V3.4, and RESRAD-OFFSITE V4.0 Computer Codes, NUREG/CR-7267, 2020
[4] KINS, KINS Regulatory Guide 2.2, KINS/RG-N02.02, 2016.
[5] Deterministic vs. Probabilistic Analyses to Identify Sensitive Parameters in Dose Assessment Using RESRAD, Sunita Kamboj, 2005.