Estimation of Regulatory Clearance for Contaminated Soil Stored in KAERI

Kyungmin Kim [a*], Il-Sik Kang [a], Dae Seong Nam [a], Jong Hwa Pack [a], Sung Jin Han [a], Yun Gun Jung [a], Heung-Ju Cho [a], Dong-Ju Lee [a], Hongrae Jeon [a]
[a] *Korea Atomic Energy Research Institute, Republic of Korea*
[*] *Corresponding author: kkm93@kaeri.re.kr*

1. Introduction

The contaminated soil was generated from decommissioning process of Seoul office in 1988 [1]. A part of the soil was disposed through regulatory clearance in 2007-2008. According to the previous study, the dominant sources of contamination were evaluated as ^{60}Co and ^{137}Cs [2]. In this study, the possibility of self-disposal was evaluated through regulatory clearance levels with radioactivity analysis and dose estimation about some of residual soil. The value of radioactive concentration for regulatory clearance levels are given individually. The criteria for regulatory clearance levels with permissible dose are 10 μSv/y for individuals and 1 man-Sv/y for collective. The results, radioactivity concentrations and dose estimations, were satisfied with the regulatory clearance levels.

2. Methods and Results

In this section, collecting representative sample, radioactivity analysis in soil, and dose estimations of landfill scenario are described.

2.1 Representative Sampling

Contents were checked for drums with a surface radiation dose rate of 0.3 μSv/h or less, and foreign substances were removed by pouring them into a tray. The soil from which foreign substances were removed was flattened, and only background (BKG) level soil was classified. A 10×10 grid was installed on the tray, and the surface contamination was measured, and samples were collected in 1L-Marinelli beaker from 10 points in relatively high places. The sample was satisfied at least 1 kg per 200 kg. The procedure is shown in the Fig. 1.

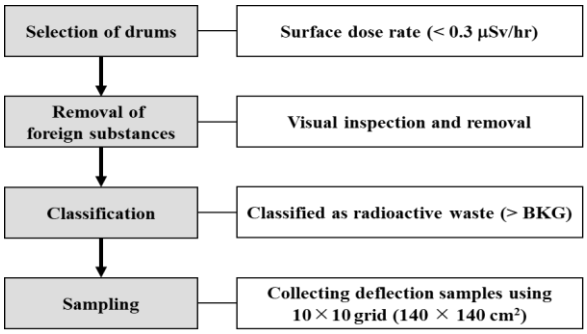

Fig. 1. Procedure of representative sampling methods.

2.2 Radioactivity Analysis

Radioactivity concentrations were analyzed through gamma spectroscopy using HPGe (Canberra-GC3018), and difficult-to-measurement (DTM) radionuclides were analyzed using LSC (Hidex-300SL) and GPC (Canberra-S6LB) for three samples with highest of ^{60}Co and ^{137}Cs concentrations.

a. Analysis of Gamma-emitting Radionuclides

Gamma-ray spectroscopy can be analyzed without chemical pretreatment, which is advantageous for analyzing simultaneous gamma-emitting radionuclides. However, energy interference should be considered by naturally occurring radioactive materials (NORM) in soil. In addition, self-absorption should be corrected when measuring samples with different material from the certificated reference material (CRM).

In some of the samples, ^{54}Mn was identified at 834.85 keV in gamma-ray spectroscopy software (Canberra-GENIE 2000). Considering the storage period of soil and the half-life of ^{54}Mn, it is difficult to exist. According to the analysis results, when the concentration of ^{228}Ac(^{232}Th decay daughter) was 0.044 Bq/g or more, it was misidentified as ^{54}Mn. This error may vary depending on the BKG. Through the fraction of other gamma-ray energies of ^{228}Ac emitted, it was decided that the peak was originated to 835.70 keV of ^{228}Ac. In addition, it can also be verified with GENIE 2000 by adding the energy to the nuclide library. Fig. 2 presents the spectrum around 835.70 keV.

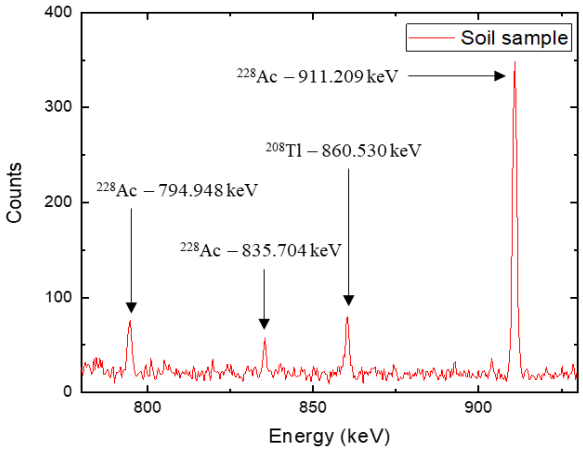

Fig. 2. Gamma-ray spectrum of a sample around 835.70 keV.

Self-absorption correction factors (k_3) were calculated by using MCNP6.2. The absolute efficiency of the CRM experimental results and MCNP6.2 simulation results were compared, and the difference for 13 gamma-ray energies from 59.5 keV to 1,836 keV was 3.7%, averaged relative deviation. The geometry of MCNP6.2 and compared absolute efficiency are shown in Fig. 3. The k_3 was applied for radioactive concentrations analysis of each sample in gamma-emitting radionuclides.

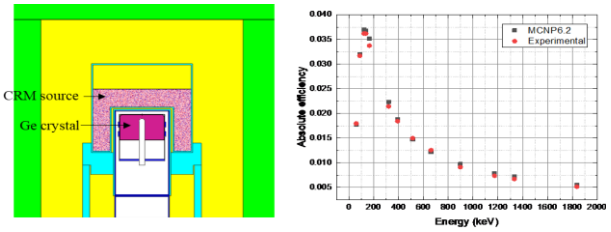

Fig. 3. MCNP6.2 simulation of HPGe (left) and absolute efficiency by comparing MCNP6.2 and experimental (right).

As a result of gamma analysis, there were no artificial radionuclides other than ^{60}Co and ^{137}Cs. Since the distribution of concentration is biased to a low level, the average value is higher than most values. Therefore, the average value was designated as a representative value of the concentration of each radionuclide.

b. Analysis of DTM radionuclides

DTM analysis was performed by samples, which were selected through the highest concentration of ^{60}Co and ^{137}Cs respectively in the results of gamma-emitting nuclide analysis. The selection of nuclides (^{3}H, ^{14}C, ^{90}Sr and ^{99}Tc) was carried out through stream and half-life. The analysis was performed by separating nuclides through physical and chemical pretreatment, and analyzing using LSC and GPC. All DTM radionuclides were below minimum detectable activity (MDA). MDAs were satisfied by 1/10 below of allowable concentration on each radionuclide for regulatory clearance levels.

A summary of the representative radioactivity concentration results for each radionuclide is shown in Table I below.

Table I: Representative radioactivity concentration

Radio-nuclide	Mean radioactivity concentration (Bq/g)	Allowable concentration (Bq/g)
^{137}Cs	0.033	0.1
^{60}Co	0.012	0.1
^{99}Tc	0.017 (< MDA)	1
^{90}Sr	0.049 (< MDA)	1
^{14}C	0.006 (< MDA)	1
^{3}H	0.010 (< MDA)	100

2.3 Dose Estimations

Doses were estimated for landfill scenarios using RESRAD-Onsite 7.2. Parameters were based on the regulatory guidelines of the KINS/RG-N02.02 [5], and calculations were performed through the concentration of representative radionuclides. For conservative estimations, the MDA values of DTM nuclides were also defined as the source-term. Five groups separated with age and worker were estimated, and the highest group in dose was the worker. For workers, dose was evaluated immediately after landfill. The estimation time of residents was conservatively assumed to be after 10 years in consideration of the capacity of the landfill and the residence limit period of regulatory. Table II presents results of dose estimation with the 5 groups.

Table II: Dose estimations through landfill scenario

Group	Individual dose (μSv/y)	Collective dose (man-Sv/y)
Infant	4.14E-01	5.27E-03
5 years	3.23E-01	
15 years	6.32E-01	
Adult	2.81E-01	
Worker	1.75E+00	

The dose contribution fraction of ^{60}Co and ^{137}Cs were 69% and 30%, respectively in the group of workers. The fraction of ^{90}Sr was 97% in the dose assessment results of residents. The source-term of ^{90}Sr is MDA value, and the dose, case that ^{90}Sr is not exist, by the self-disposal is very few for residents.

3. Conclusions

The possibility of self-disposal of contaminated soil generated when the Seoul office was dismantled was evaluated. Representative samples were collected, radioactivity concentration analysis, and exposure dose estimation were performed, and it was confirmed that they were suitable for the deregulation criteria. Through this, it is believed that self-disposal of contaminated soil will be possible.

REFERENCES

[1] Shon, J. S. et al., "Re-evaluation of the Radionuclides and Activity Concentration of Radioactive Contaminated Soils Stored in the Storage Facility.", KAERI/RR-2650/2005, 2006.
[2] Kang, Il Sik, et al. “Treatment of Radioactive Contaminated Soil and Concrete Wastes Using the Regulatory Clearance.”, KAERI/TR-3653/2008, 2008.
[3] Korea Institute of Nuclear Safety (KINS), “Regulation Standard and Guides for Light Water Nuclear Reactors.”, KINS/RG-N02.02 (Rev. 3), 2022.