A Method of Soil Radiological Survey According to Nuclear Power Plant Site Characteristics

Min Seong Kim*, Hyu Chang Choi, Hyung Woo Seo, Young Il Na, and Gang Woo Ryu
Korea Hydro & Nuclear Power (KHNP) Central Research Institute (KHNP-CRI)
**Corresponding author: minseongkim@khnp.co.kr*

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1. Introduction

Radiological survey refers to determining the types, locations, and concentrations of radioactive materials present in nuclear facilities. When decommissioning the nuclear power plant, radiological characteristic survey must be conducted for establishing a decommissioning plan, assessing decommissioning costs, evaluating the amount of decommissioning waste, and checking whether regulatory release criteria for site release are satisfied.

Currently in Korea, radiological surveys in pre-decommissioning stage have been performed.. In the stage of pre-decommissioning, there are three types of surveys: Historical Site Assessment, Scoping Survey, and Characterization Survey. The characterization survey stage derives detailed radioactivity (Bq/g), which forms the basis for future decommissioning plans of nuclear power plant.. Contaminated media include SSCs (Structure, Components, and System), soil, and groundwater. In particular, soil constitutes a significant portion of the decommissioning waste generated from nuclear power plant decommissioning, so radiological survey should be conducted. Therefore, in this study, we developed a methodology for conducting radiological survey of soil according to nuclear power plant site characteristics.

2. Criteria for selecting soil sampling locations

To conduct a radiological survey of soil at a nuclear power plant site, first of all, sampling locations must be determined considering four criteria : ① Areas predicted to contain contamination based on Scoping Survey results, ② Areas exposed to significant gaseous emissions, ③ Areas prone to contamination linked to groundwater wells, ④ Areas influenced by historical or potential pathways of radioactive waste transport.

2.1 Areas predicted to contain contamination based on Scoping Survey results

During nuclear power plant decommissioning, Scoping Survey is performed before soil sampling and analysis. In the Scoping survey stage, workers detect radiation dose rate(μSv/hr) and surface contamination (Bq/cm^2) and classified the contamination level of site as class 1 to class 3. In this stage, workers recognize approximate contamination level. Based on the contamination level data, Candidates of sampling locations can be selected.

2.2 Areas exposed to significant gaseous emissions

Based on the site, the greater the influence of atmospheric diffusion, the higher the likelihood of contaminants being dispersed. Therefore, areas within the nuclear power plant site with low influence of atmospheric diffusion can be designated as areas expected to be contaminated with radioactive material. Fig.1 shows the example of contaminants deposition possibility based on the gaseous radioactive waste emission.

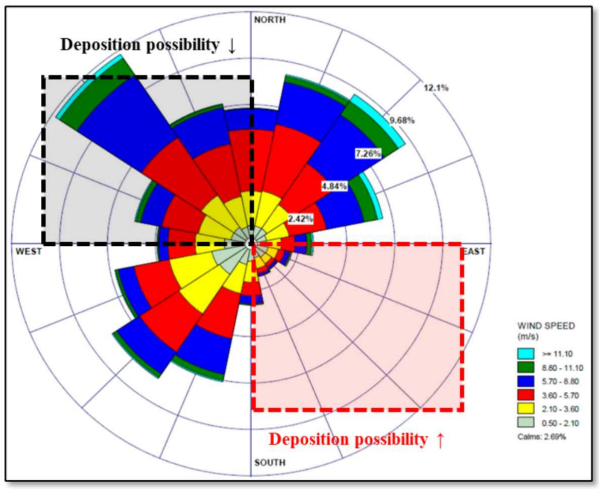

Fig 1. Example of contaminated material deposition possibility based on the gaseous radioactive waste emission

2.3 Areas prone to contamination linked to groundwater wells

Nuclear power plants typically monitor groundwater periodically. H-3, in particular, is a key target for monitoring due to its behavioral characteristics similar to groundwater. Some wells may exhibit elevated radioactivity levels compared to background levels, necessitating analysis of the surrounding soil.

2.4 Areas influenced by historical or potential pathways of radioactive waste transport

Within each nuclear power plant site, major radioactive waste transport routes exist, and these routes

can be contaminated by radioactive waste droppings, spills, and other factors. Furthermore, areas with past radioactive contamination and soil surrounding equipment containing radioactive fluids can be considered sampling sites due to the potential for contamination.

3. Radiological survey process

After selecting a sampling locations, sampling and analysis must be performed. The radiological survey process consists of three steps: ① selecting depth of soil samplings, ② selecting interest radionuclides, and ③ radionuclides analysis according to types.

3.1 Selecting depth of soil samplings

Sampling depth can vary depending on whether the area is paved or unpaved. For paved areas, the depth is typically approximately 15 cm from the surface[1]. Furthermore, if there is a (potential) contaminated device below the surface, sampling of the surrounding soil is required. If significant contamination is identified within 15 cm, additional sampling and analysis are conducted based on the contamination level trend at each depth.

In unpaved areas, there have been cases where contaminants have been found within approximately 50 cm of the surface. Considering sampling conditions, the baseline can be set at 30 to 50 cm. Similarly to paved areas, if contaminants are found or equipment is present, additional sampling and analysis are conducted based on the depth-dependent contamination level trend.

Since some of the older nuclear power plants lack design data and may have contaminated buried pipelines, deep sampling is not performed and detailed radiological surveys will be conducted dering decommissioning.

3.2 Selecting interest radionuclides

Interest radionuclides may include those based on site historical site assessment results, those derived from code-based radioactivity assessments such as ORIGEN/MCNP, disposal limits for low-level radioactive waste, and those specified in the Low- and Intermediate-Level Radioactive Waste Delivery Regulations. And considering the decommissioning period (approximately 15 years), nuclides with short half-lives (e.g., less than 2 years) can be excluded.

3.3 Radionuclide analysis according to types

Radionuclide analysis is broadly categorized into gamma, beta, and alpha. For beta and alpha nuclides, which are difficult to detect, pretreatments are performed using resins and other methods, depending on the nuclide type, rather than simply measuring them. After extracting the target nuclides, beta nuclides are analyzed using a liquid scintillation counter, and alpha nuclides are analyzed using an alpha spectrometer. Figure 2 illustrates an example of a radionuclide analysis method.

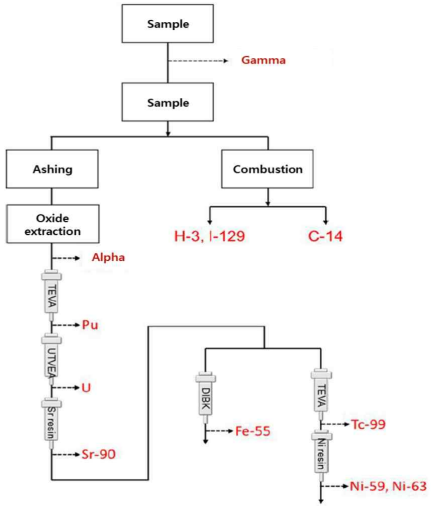

Fig 2. Example of radionuclide analysis method

Volatile radionuclides (H-3, C-14, I-129) require analysis through separate pretreatment. Fig 3 shows example of volatile radionuclide method.

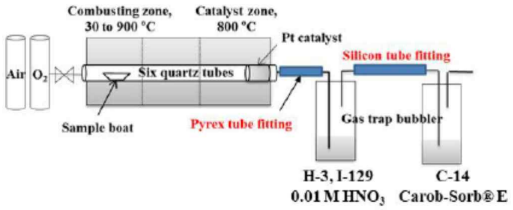

Fig 3. Example of volatile radionuclide analysis method

4. Conclusion

In this study, we developed a methodology for conducting radiological survey of soil according to nuclear power plant site characteristics: ① Criteria for selecting soil sampling locations, ② Radiological survey process. Sampling locations can be established based on past contamination history, on-site atmospheric diffusion, groundwater wells, and waste transport routes. When conducting a characterization assessment, sampling depth and the nuclide of interest are selected, and analysis methods based on nuclide type are applied to derive the radioactivity concentration (Bq/g). The results of this study can be useful in the future for the application of radiological survey method in domestic nuclear power plant decommissioning.

REFERENCES

[1] U.S.NRC, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, Rev. 1 2000.