Case Study of Soil Characterization Techniques at Decommissioning Nuclear Power Plants

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1. Introduction

Developing the remediation for soil contaminated with radionuclides at decommissioning sites is one of the challenging tasks. Many sites have discovered additional site requiring remediation toward the end of remediation projects and were forced to extend the decommissioning schedules. In order to minimize this maintain decommissioning project schedule, effective characterization of the soil and site of the contamination is needed [1].

In this paper, describes the investigation results for the characterization techniques and overseas cases in order to effectively perform the soil characterization.

2. Soil Characterization Techniques

There are a number of techniques that can be used to collect soil samples. The method chosen is driven by the data needed from the sample and the cost of the sample technique [2].

2.1 Grab Sampling

Grab sampling is the most simple and least costly among the soil sampling techniques and is typically used for surface soil sampling. However, this method is limited for use collecting surface soil samples up to 6 inch [15 cm] in depth. Generally at least 2 liters of sample must be collected per individual sample location to insure adequate material for the subsequent laboratory analyses.

2.2 Split Spoon Sampling

Split spoon sampling is generally limited to fairly loose granular material and to a total sample depth of approximately 0.5 meter. It is a relatively inexpensive method and can be useful in determining if subsurface contamination (i.e. greater than 6 inches [15 cm]) is present in a site.

2.3 Direct Push Sampling

Direct push sampling is generally used when analysis of soil located greater than 0.9 meter below the surface is needed. Samples are generally taken at 1.2 meter increments by adding additional 1.2 meter sections of push rod to the hydraulic drive head. Dividing the sample into shorter lengths would provide a more detailed contamination depth profile but may result in additional laboratory analysis complexity (and cost) due to the limited amount of material from the shorter lengths.

2.4 In situ Gamma Spectroscopy

In conducting the Final Status Survey (FSS) of site at a number of plant decommissioning projects, in-situ gamma spectroscopy equipment such as the In Situ Object Counting Systems (ISOCS) has been used. This method allows relatively large areas to be assessed with one count in place of more time consuming conventional scanning of the decommissioning site. During an FSS, in situ surveys have been used at some sites along with soil sampling to ensure compliance with the site release criteria. In situ gamma spectroscopy could be used during site characterization to determine if significant soil contamination exists in the site or to survey the inside of an excavation otherwise inaccessible from a personnel safety standpoint.

3. Cases of Soil Characterization at Overseas

3.1 Maine Yankee [3]

Maine Yankee site did not have high levels of groundwater contamination. This result would be anticipated based on the soil radionuclide fractions shown in Table 1. The very soluble radionuclide H-3 is present as a low fraction in soil and was measured in relatively low concentrations in groundwater. The somewhat less soluble Sr-90 was not measured in either soil or groundwater. Table 2 shows the summary of the soil characterization results for Maine Yankee. The data in Table 2 are from areas where soil concentrations were above or approaching

the Maine Yankee soil DCGLs. It should be noted that samples were taken in all areas of the site but are not shown here as they were generally below the soil DCGLs.

Table 1. Radionuclide Fraction in Soil at Maine Yankee

Radionuclide	Average Fraction of Total Activity
H-3	0.053
Ni-63	0.048
Co-60	0.009
Cs-137	0.890

Table 2. Summary of Soil Characterization Result at Maine Yankee

	RCA West	RCA East	Roof Drains	RCA Areas	LLW Storage Bd.
# of Samples	58	35	7	8	30
# of Positive for Co-60	23	12	4	3	0
Mean Co-60 (pCi/g)	0.62	0.28	4.09	11,213	N/A
Max Co-60 (pCi/g)	3.29	1.94	11.2	33,600	N/A
# of Positive For Cs-137	55	33	6	7	5
Mean Cs-137 (pCi/g)	10.99	4.88	0.33	0.13	0.1
Max Cs-137 (pCi/g)	156	133	0.53	0.21	0.13

3.2 Rancho Seco [4]

Rancho Seco had not experienced widespread soil contamination during the operation of the plant. The only areas that exhibited significant levels of contamination were the following:

- Spent Fuel Pool(SFP) Cooler Pad
- SFP-Turbine-Diesel Generator Room Gap
- West Tank Farm Area
- South Tank Farm Area
- Effluent Stream(Corridor) & Depression Area

Table 3 shows the results for the soil samples with the highest radionuclide concentrations. The highest samples from the first three areas listed Cs-137 concentrations that were 18, 14, and 2 times higher, respectively, than the Rancho Seco industrial worker DCGL for CS-137. The highest samples from the other two areas were in the range of 40 to 70% of the DCGLs when both Co-60 and Cs-137 results were included.

Table 3. Rancho Seco Soil Characterization Results

Radio-nuclide	Highest 6 samples soil concentration range pCi/g	Rancho Seco industrial worker DCGL pCi/g	Maximum dose contribution from any one sample or percent of soil DCGL
H-3	4.0 ~ 10.2	-	4.6E(-4)
C-14	1.7 ~ 10.0	8.33E(+6)	0.00012 %
Co-60	0.3 ~ 6.5	12.6	52 %
Ni-63	37 ~ 170	1.52E(+7)	0.00011 %
Sr-90	1.3	6,490	0.02 %
Tc-99	4.5 ~ 5	-	8.7 E(-2)
Cs-134	0.21	22.4	0.9 %
Cs-137	8.0 ~ 942	52.8	17.8

4. Conclusion

This paper describes four types of the techniques for characterization of soils. Among these, in situ Gamma Spectroscopy is generally used for decommissioning. In the case of the overseas, the characterization was performed by using the above technologies. The results of this paper, therefore, would be useful information and experiences for their future application at other nuclear power plant decommissioning including Kori-1 in the characterization of soil.

REFERENCES

[1] NUREG-1575/EPA 402-R-97-016, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

[2] EPRI Report 1019228, “Characterization and Dose Modeling of Soil, Sediment and Bedrock during Nuclear Power Plant Decommissioning, 2009.

[3] Maine Yankee License Termination Plan, Revision 3, dated October 15, 2002.

[4] Rancho Seco License Termination Plan, Chapter 6, Revision 0 dated April 2006.