Case Study on the Soil Remediation Experience in the U.S.

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1. Introduction

Kori-1 was permanently shutdown and the other domestic commercial nuclear power plant to be decommissioning near future. Preliminary work of Kori-1 is ongoing to prepare for D&D after the decision of permanent shutdown, June 2017 and site restoration work is scheduled on 2031 after the removal of all structures as a final phase of D&D. Korea doesn't have experience in soil remediation in commercial NPP site so it is important to develop effective remediation strategy reflecting domestic site characteristics and conditions from other cases. This paper would like to review the advanced experience about contaminated soil assessment, remediation technique in the U.S. and suggest some considerations based on site specific condition in Korea.

2. Case Study

2.1 Soil Type

Two types of soil is defined that one is 'Surface soil' which is 0 to 30 cm depth and 'Subsurface soil' represent below 30 cm until aqufier. It is important to distinguish the soil type that they have unique pre-assumtions such as; surface soil is important to the exposure pathway simulation as it is possiblely excavated in the future by the activity of residence (such as resident farmer) and cause a expose to them. The other hand, subsurface soil has rare chance to be contaminated due to the depth but if subsurface soil is contaminated then it is regarded as contamination of groundwater which required comprehensive assessment and long-term monitoring.

2.2 Case Study NPP in the U.S.

Total five NPP sites in the U.S. were selected in this paper that four decommissioned sites and one delayed D&D site (*see Table 1*)

Table 1. Case Study NPP in the U.S.

NPP	Type	Capa. (MWt)	Op./ Shut.	Status	Site use
Big Rock Point (BRP)	BWR	240	1964/ 1997	DECON Completed	ISFSI
Dresden-1	BWR	700	1959/ 1978	SAFSTOR	-
Haddam Neck (HNP)	PWR	1,825	1974/ 1996	DECON Completed	ISFSI
Maine Yankee (MY)	PWR	2,700	1973/ 1996	DECON Completed	ISFSI
Rancho Seco (RSNGS)	PWR	2,772	1974/ 1989	DECON Completed	ISFSI

2.3 Cause and Measures of Soil Contamination

The cause and measure of contaminated soil in each site was found based on historic site sssessment result (*see Table 2*) which is performed to identify the contamination situation in the site for the development of remediation plan.

Table 2. Soil Contamination and Measures

NPP	Area	Main radionuclide and Max. Con. (pCi/g)	Reme. measures	Note
BRP	TRN and CB[1] base soil	Cs-137 (5.29) Co-60 (0.17) H-3 (32,000 pCi/l)	Total 1,776m^2 area excavated in 4m	10.7m of substructure excavated and removal water leads remediation of H-3 in groundwater
HNP	PAB and Reserve Tank Area subsurface soil	Co-60 (202.4) Cs-137 (97.14)	About 11,700m^2 area excavated in Max. 12.2m	Groundwater contamination found then perform soil remediaiton before long-term monitioring
Dresden	Unit 2,3 CST buried pipe	H-3 (3,200,000 pCi/L)	61m of corroded pipe was replaced and adiacent soil excavated	Groundwater contamination assessment for total 9~10 million pCi/L result shows no remediation required (only monitoring)
MY	RRA[2]	-	Total 3 reserve tank area excavated in Max. 1m	Comprehensive remediation performed to the all RRA area(13 survey unit)
RSNGS	SF pool cooler	Cs-137 (941) Co-60 (6.41)	Buried pipe removal with soil excavation in 2.5m	Soil remediation performed to the several reserve tank area

1) CB : Containment Building
2) RRA : Radiological Restricted Area

Result shows that the major contamination area in this case study is concentrated in the reservoir area and buried pipeline routes in the RCA area and major radionuclides were identified as Co-60, Cs-137 and H-3.

Even though immediate remediation measures were performed to the contaminated soil, repetitive leakages in this area lead to increasing of residual activity and those high concentrate of contaminants in surface soil has been move into the subsurface soil

and groundwater (BRP, HNP and Dresden-1) as well by infiltration and leaching. [1]

In this case, the U.S. regulatory body required long-term monitoring of groundwater after soil remediation and the case of long-term monitoring of groundwater in Dresden site until permanent shutdown of Unit 2,3 shall be considered when site remediation strategy for Kori-1 is established in case of wide range of groundwater contamination is found along the Kori site.

2.4 Contaminated Soil Remediation

Excavation is commonly used in soil remediation work as it is very simple and effective remediation technology in both surface and subsurface soil. It is assumed that extensive excavation was performed to the wide area of every NPP site in this paper so that residual activity can be reduced by removal of contaminants along with the special excavation techniques for specific areas on a case-by-case basis (*see Table 3*);

Table 3. Special Excavation Techniques [2,3]

NPP	Contaminated Media	Depth	Applied Technology
BRP	Substructure (CB)	10.7 m	1) Slurry wall (side collapse and groundwater penetration) 2) Pump (stagnant water) 3) Storage basin (water treatment and discharge)
HNP	Bedrock (PAB)	12.2m	- Hydraulic Hammer (Hoe-Ram) - Explosive - High flow rate vacuum truck

Both cases were produced the huge amount of excavated soil but the U.S. regulatory body allowed on-site disposal of excavated soil to the very low level contaminated soil with certain procedure so that licensee can use less contaminated soil as a backfill for their site restoraion work.

Not all the contaminated soil were exempted but some of highly conmaninated soil is disposed as radioactive waste based on regulatory guideline and licensee's technical justification (*see Table 4*) which provides effective method for the effecient management of radioactive waste in response to the occurrence of large amounts of contaminated soil in US.

Table 4. Licensee's Justification in Dresden Site

Regulatory Body	Licensee (Exelon, Inc)
On-site disposal approval request to the U.S. NRC for the contaminated soil (6,000m^2) that only have 20% of DCGL (U.S. NRC requests environmental effect analysis)	Establish on-site disposal procedure and perform environmental effect analysis(by minimize leakage and groundwater monitoring)
Discharged contaminated liquid containing radioactive material (H-3) to the unauthorized place rather than designated discharge route (U.S. EPA issues violation letter)	Groundwater generated during excavation of soil is discharged after treatment through waste management system, and groundwater is not subject to unauthorized discharge management such as river, stream and lake

Consideration should be given for the establishment of regulatory standard about on-site disposal of excavated soil in compliance with the domestic waste management system and considering safety impact review result from the residual activity in soil.

3. Conclusion

In this study, soil remediation experience of the five NPP were reviewed in order to suggest some considerations take into account for the site specific condition in Korea. Application of lon-term monitoring strategy of groundwater and establishment of on-site disposal guideline of very low level contaminated soil are suggested along with the status about major contaminated area and radionuclides in soil.

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