Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 12-13, 2016

Development of subsurface characterization method for decommissioning site remediation

Sang Bum Hong , Jong Soo Nam, Yong Suk Choi, Bum Kyoung Seo, Jei Kwon Moon, Jong Won Choi*
Decontamination and Decommissioning Technology Development Div., Korea Atomic Energy Research Institute
1045 Daedeok-daero, Yusong-gu, Daejeon, 305-353
**Corresponding author: sbhong@kaeri.re.kr*

1. Introduction

The release of the site and building from regulatory control is the final stage of the decommissioning process. A characterization survey, sufficient time, and a proper budget are required. The possibility of the presence of subsurface contamination below a building or in the soil of the site should be clarified in order to prepare site remediation and release. Assuming the dose associated with subsurface contamination is significant compared to the release criteria, 3D characterization and transport modeling may be necessary to evaluate the contaminant status and remediation of hot spot areas [1]. In situ gamma spectrometry and spatial analysis have been used several situations and environments which were proven to be a powerful tool in demining the residual radioactivity in the environment [2,3].

In this study, In situ measurement of peak to valley method based on the ratio of counting rate between the full energy peak and Compton region was applied to identify the depth distribution of ^{137}Cs. The In situ measurement and sampling results were applied to evaluate a residual radioactivity before and after remediation in decommissioning KRR site. Spatial analysis based on the Geostatistics method provides a reliable estimating the volume of contaminated soil with a graphical analysis, which was applied to the site characterization in the decommissioning KRR site. The in situ measurement and spatial analysis results for characterization of subsurface contamination are presented.

2. Experiment and Results

2.1 In situ measurement for subsurface characterization

The peak to valley method based on the ratio of counting rate between the full energy peak and Compton region was applied to identify the depth distribution of ^{137}Cs in KRR site. The typical depth profiles of radioactive cesium can be fitted with an exponential function, indicating that the cesium concentration exponentially decreases with mass depth [9]. The specific activity distribution with depth A(ξ) is obtained from the following equation.

$$A(\xi) = A_0 \times e^{-(\frac{\xi}{\beta})} \quad (1)$$

The procedure relies on a spectrally derived coefficient Q with depth activity distribution. The extend of the forward scattering of gamma rays is related to the interaction probability associated with the photon trajectory between sources and detector providing a measurement of source burial. The soil depth profiles collected and analyzed by conventional gamma spectrometry, we determined relaxation coefficient (β = ρ/α) by fitting expression to the activity concentrations found in each layer as a function of the depth mass (ρz).

$$Q = \frac{A}{B_T} \quad (2)$$

Where Q is spectrally derived coefficient, A is the area of the full energy peak, and B_T is difference between the integrals of the immediately preceding and following regions. The concentration of Cs in a soil was directly measured and analyzed using ISOCS(Canberra, USA).

The observed results has a good correlation, relative error between in situ measurement with sampling result is around 7% for depth distribution in KRR site before remediation.

2.2 Spatial analysis for site characterization

To provide reliable costs and schedule for site remediation, optimization methods and appropriate data processing techniques are needed. Geostatistics extend the statistical framework by providing methods that integrate the spatial structure of the contamination. The most probable estimates of the surface and subsurface radioactivity can be derived using Kriging techniques. Variants of these techniques also provide access to estimates of the uncertainty associated with the spatial prediction or to the probability to exceed a given threshold [3].

The Gostatistics method was applied for estimating the volume of contaminated soil with a graphical analysis. The KARTOTRAK software(Geovariance, France) provides a reliable Gostatistics method for estimating the volume of contaminated soil with a graphical analysis. A spatial analysis of the measured data by using Kriging and simulation can generate continuous data [4]. The depth distribution of the decommissioning site was calculated through a Kriging calculation process. The evaluation results of the subsurface contamination distribution is shown in figure 1. The waste volume of the contaminated soil, the contamination levels higher than a pre-calculated release criteria (DCGL>0.25 Bq/g for ^{137}Cs) are evaluated and presented in figure 2.

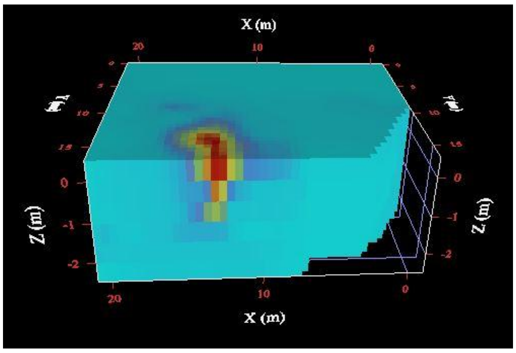

Figure 1. The subsurface characterization results of the decommissioning KRR site.

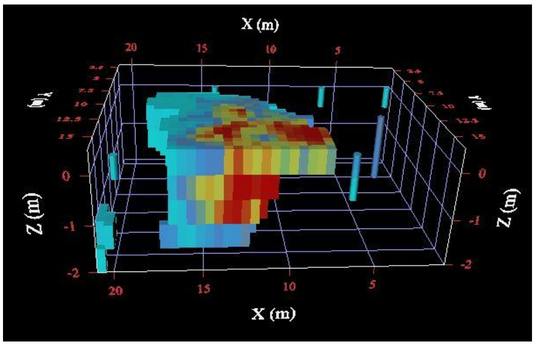

Figure 2.The evaluated remediation volume of blocks where the probability to exceed the release criteria.

3. Conclusion

The objective of a remedial action is to reduce risks to human health to acceptable levels by removing the source of contamination. Site characterization of the subsurface contamination is an important factor for planning and implementation of site remediation. Radiological survey and evaluation technology are required to ensure the reliability of the results, and the process must be easily applied during field measurements. In situ gamma-ray spectrometry is a powerful method for site characterization that can be used to identify the depth distribution and quantify radionuclides directly at the measurement site. The in situ measurement and Geostatistics method was applied to the site characterization for remediation and final status survey in decommissioning KRR site. The integrated analysis method using in situ measurement and spatial structure of the contamination using Geostatistics analysis be useful way to the site characterization in decommissioning projects.

REFERENCES

[1] International Atomic Energy Agency, Release of Sites from Regulatory Control on Termination of Practices, IAEA Safety Guide No. WS-G-5.1, IAEA, 2006.

[2] International Commissioning on Radiation Units and Measurements, Gamma-ray spectrometry in the environment. ICRU Report 53, 1994.

[3] Andrew N. Tyler. Monitoring anthropogenic radioactivity in salt marsh environments through in situ gamma ray spectrometry. Journal of Environmental Radioactivity, vol. 45 235-252, 1999.

[4]] Y. Desnoyers et al, Geostatistical sampling optimization and waste characterization of contaminated premises, Proceedings of Global, 2009.