

## Demonstration of depth dependent distribution using in situ gamma spectrometry for final status survey in KRR site

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### 1. Introduction

In situ gamma spectrometry has been used several situations and environments which has proven to be a powerful tool in demining the residual radioactivity in soil. The main limitation of in situ gamma spectrometry lies in determining the depth distribution of radionuclides [1]. For the radionuclides that have a depth dependent distribution in the soil, the distribution is assumed to three simple cases: homogeneous with depth such as natural radionuclides, contamination deposit on the surface such as the early stage of accident and exponential decreasing distribution. The contamination was deposited on the surface and migrated to the deeper layer during that time.

In this study, 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  $^{137}\text{Cs}$ . Using peak to valley method with single parameter (Q) made a correlation with exponential depth distribution and initial activity using calibration pad in the laboratory. The correlation results were applied to evaluate a residual radioactivity after remediation in decommissioning KRR site.

### 2. Methods and Results

To identify soil depth profiles collected and analyzed samples by conventional gamma spectrometry in laboratory. We made an in situ gamma spectrometry of the  $^{137}\text{Cs}$  activity depth distribution, the different activity calibration pads were made and analyzed correlation with spectrum characterization with depth distribution. There have been several methods proposed to describe the activity depth variation from in situ measurement models. The peak to valley method only yields information about a single depth parameter; the technique can only be effectively applied to simple profile shape such as a Gaussian or exponential distribution. For in situ gamma spectrometry, we used a portable HPGe detector with 40% relative efficiency.

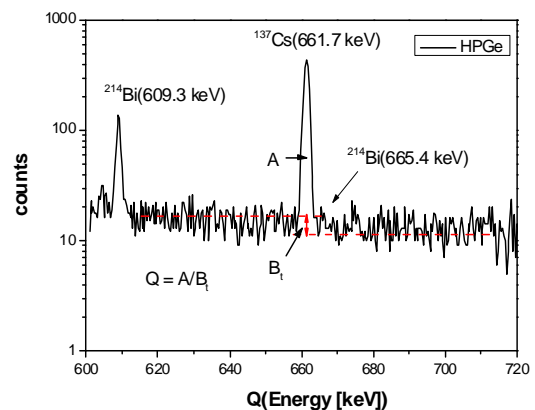
#### 2.1 Estimation of depth distribution of $^{137}\text{Cs}$

This study, 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  $^{137}\text{Cs}$ . 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. Fig. 1 shows the forward scattered region and gamma – ray spectrum which occurs between full energy peak and the Compton edge.

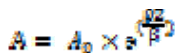
$$Q = \frac{A}{B_T}$$

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 [2].



**Fig. 1.** The measured spectrum for Q values from the full energy peak (A) and Compton scattering (BT) regions.

From in situ measured spectrum, the difference ( $B_T$ ) determined the 610-665 keV region and the 665-710 keV region integrals, and corrected the contribution of 665 keV of  $^{214}\text{Bi}$ . The Q value could calculate using the ration of full energy peak with the scattering region. Fig. 1 shows the in situ measured spectrum for calculation of the Q values. The soil depth profiles collected and analyzed by conventional gamma spectrometry, we determined the top layer of each soil initial activity ( $A_0$ ) and relaxation coefficient ( $\beta = \rho/\alpha$ ) by fitting expression to the activity concentrations found in each layer as a function of the depth mass ( $\rho z$ ).



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### 2.2. In situ calibration correction

The observed result of relaxation coefficients around Fukushima area was reported 30% of value is 0.8 ~ 1.2  $\text{g}/\text{cm}^2$ . The activity depth distribution was constructed of relaxation coefficient for exponential distribution of 0.25 ~ 2.0  $\text{g}/\text{cm}^2$ , surface contamination of 4.17  $\text{g}/\text{cm}^2$  and homogeneous distribution of 0.15  $\text{g}/\text{cm}^2$  using the calibration pad sources. In situ Object counting system (ISOCS) system consists HPGe portable detector and a data collection with processing system. The detector was fixed 50cm for measuring the depth distribution without shield in laboratory. The soil depth was change exponential distribution, surface contamination and homogeneous distribution from the surface to 10 cm depth with every 1cm interval depth. The Calibration pad source contaminated with  $^{137}\text{Cs}$  was made to demonstrate the depth distribution using in situ measurement. The size of the sources was 50cm by 50cm with 1cm thickness and density was about 1.0  $\text{g}/\text{cm}^3$ . The PE solution (PAA + PDADMAC) were applied to the contaminated soil for fixing the calibration pad. The pad sources was made 800 ml of each solution with 2.2 kg of soil and dried at room temperature.

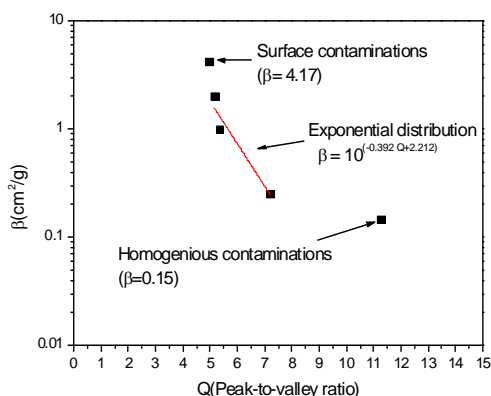


Fig. 3. The in situ measurement results of relations between Q and  $\beta$  in laboratory.

The peak to valley method could be applied to establish the relation between the spectrally derived coefficient (Q) with relaxation coefficient ( $\beta$ ) and initial activity ( $A_0$ ). The in suit measurement results of varied exponential distributions are given in the Fig. 3 and Fig.

4. The two extreme distribution (surface and homogeneous) does not agree with the relation of exponential distribution.

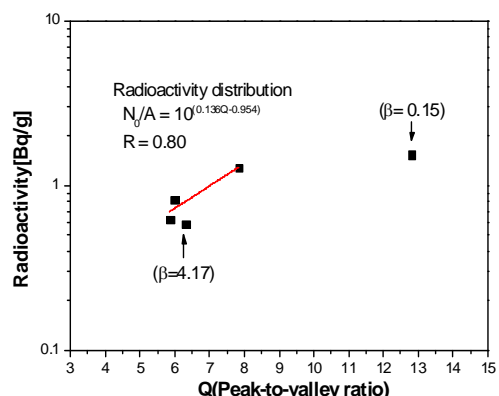


Fig. 4. The in situ measurement results of relations between Q and initial activity in laboratory.

### 3. Conclusions

The in situ measurement provides techniques with rapid, cost-effective and spatially representative mapping contamination distributions. The vertical activity distribution ( $\beta$ ) and initial activity of  $^{137}\text{CS}$  could be identifying directly through in situ measurement. The technique has a limitation for applying simple profile shape and low level contamination.

### REFERENCES

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- [2] P. Zoombori, I. Nemeth, A. Andrasi, In-Situ Gamma Spectrometric Measurement of the Contaminated in Some Selected Settlements of Byelorussia(BSSR), Ukraine(UkrSSR) and the Russian Federation(RSFSR), J. Environ. Radioactivity 17, p 97. 1992.