Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

In Situ Gamma Spectrometric for Depth Distributions Cs-137 in soil

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1. Introduction

In situ gamma spectrometry methods have been shown to be a rapid and useful for quantification of radioactive contamination in the ground. In the peak to valley methods, the ratio of the peak count-rate and the background corrected valley count-rate is used as the difference of parameter related values. This paper describes peak to valley method and modeling used to approximated activity depth distribution for the Cs-137 contamination soil. To estimate the depth distribution underground, a MCNP Modeling and measurement results are presented.

2. Methods and Results

There have been several methods proposed to describe the activity depth variation from in situ measurement models..

2.1 Activity Depth Models

The exponential model and Gaussian Models have been adopted and are physically realistic for the distribution from surface deposition activity. The exponential model's specific activity S(z) is given by

$$S(z) = S_0 e^{-\alpha z} \quad (1)$$

Where So is the specific activity at the soil surface(γ sec^{-1} kg^{-1}), a is the parameter describing the rapidity of the falloff

The Gaussian distribution of activity was given by

$$S(z) = S_m e^{-\alpha(z-Z_0)^2/2\sigma^2} \quad (2)$$

Where S_m is the maximum specific activity which occurs at depth Z_o(γ sec^{-1} kg^{-1}) and ρ is the width of the Gaussian activity peak. The mean and width of the buried peak distribution was approximately proportional provided that the soil type. The Gaussian distribution width Zo/ρ=0.65 in terrestrial soil could be approximated [1,2].

2.2 Methods for Activity Depth Distribution

The peak to valley ration method is based on the observation that, while the unscattered flux(detected in the photopeak) decreases rapidly with deeper penetration of the radionuclides, the flux of the forward scattered photons(measured in the valley between the Compton edge and the photopeak)will have a different function of the concentration profile. The peak to valley ration is defined as a spectrally derived coefficient Q. The parameter Q can be defined as $Q=A/B_T$. A is the net peak area of the photopeak at energy E. BT is the integral of the selected E interval of the valley region. The vertical activity distribution occur, Q can be related to the vertical activity distribution such as the mean mass per unit area $\beta=\rho/a$(g cm^{-2}). Where a is the relaxation length(cm^{-1}) and ρ is the soil density.

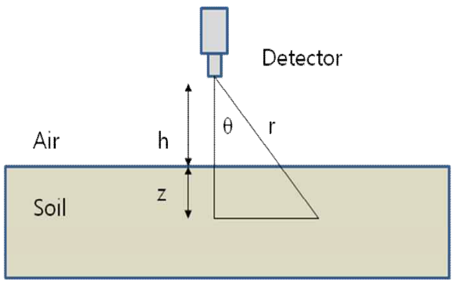

Fig. 1 Diagram of infinite half space source geometry depicting source volume element of the soil

Fig. 2 shows the forward scattered(valley) region of the gamma ray spectrum, which occurs between the full energy peak(0.662 MeV) and the Compton edge(0.478 MeV) of ^{137}Cs.

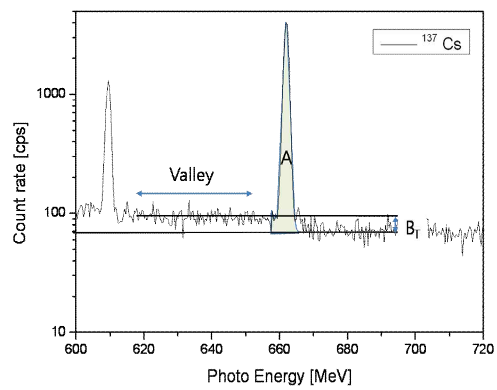

Fig. 2 Valley, peak and background in the experimental gamma spectrum of ^{137}Cs

2.3 Modeling for various depth

The photon transport from sources in the soil to the detector was simulated in order to calculate the photon fluence rate of primary and scattered photons for various depth distributions. For ^{137}Cs the evaluation of the dependence of the peak to valley ratio was calculated to 1m depth from surface soil layer. The photon transport was simulated by a Monte Carlo simulation program, MCNP code. The composition of soil and air was taken from ICRU report 53[3]. For each source depth and energy, 1×10^8 photon histories was simulated the distributions of efficiency were calculated for the height of 1m and 50cm above the surface for an in situ gamma-ray measurement. The results of the calculation for a mono-energetic point source(0.662 MeV) was shown for the efficiency and depth distribution.

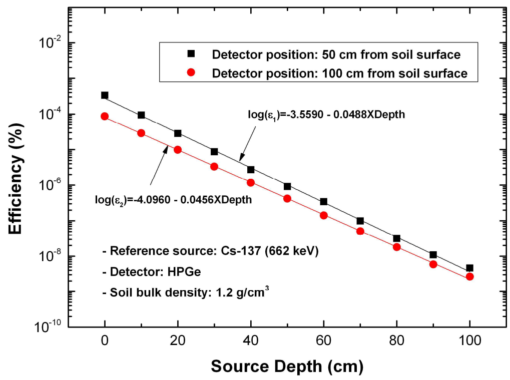

Fig. 3 The calculated results of distribution of efficiency for the different depth of the point source

2.4 In-situ measurement

In situ Object counting system(ISOCS) from Canberra which consists HPGe portable detector and a data collection with processing system. The data processing system is comprised of a MCA(Inspector 1000) and Genide-2000 software. The detector cooled by liquid nitrogen was fixed 50cm from the ground level without shield. The soil depth was change to 50 from the surface with every 10cm interval depth. In the in situ measurement, the energy peak of ^{137}Cs(0.662 MeV) of point sealed source was used. The observed function of the vertical mass depth distribution (β) and calibration correction(Q) was calculated to estimated the depth distribution of the source position and radioactivity.

3. Conclusions

The peak to valley ration is a function of the distribution parameter and can be used for the rapid estimation of the ^{137}Cs concentration of depth profile. The method in situ gamma ray spectrometry for the quantifying ^{137}Cs in soil using parameters form the spectrum providing more information on the vertical source characterization.

REFERENCES

[1] J. MacDonald, C. J. Gibson, P. J. Fish and D. J. Assinder, An Experimental Compression of In-Situ Spectrometric Methods for Quantifying Cs-137 Radioactivity contamination in the Ground, IEEE Transactions on Nuclear Science, Vol. 46, No. 3p. 429, 1999.

[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.

[3]ICRU, In-situ gamma-ray spectrometry in the environment. Reported by the International committee for radiological units, No. 53, 1994

[4] A. N. Tayler, Monitoring anthropogenic radioactivity in salt marsh environmental through in situ gamma-ray spectrometry, J. of Environmental radioactivity 45, P. 235 1999.