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EGS4 CALCULATION OF A NaI SCINTILLATION SURVEY METER FOR THE EVALUATION OF ^{137}Cs CONTAMINATION IN SOIL

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Abstract

When one measures some objects having the same radioactive density, the measurement results depend on the volumes. If the objects are small, the results are also small. But, because there is a limit, if the volume is increasing without limit, the result is saturated at some volume.

When the soil contaminated by a radioactive material is measured, we usually use a NaI scintillation survey meter. The conversion constant is necessary, because the units of a NaI scintillation survey meter indication is mSv/h, but we want to know the units of the radioactivity density, Bq/g. We made a sample from contaminated soils to calculate this constant. It's desirable that the sample volume be sufficiently large so that the measurement result is saturated. We used the EGS4 code to investigate the relationship between the sample volume and the counting rate. We found that the measured counting rate was not saturated with a typical sample volume, so we thus need to use a correction factor to obtain the conversion factor.

1 Introduction

We usually use a NaI scintillation survey meter when we investigating ground contaminated due to radioactivity. The units that the NaI scintillation survey meter indicates are mSv/h, but we want to know the units of radioactive in density Bq/g. We thus need conversion constant from mSv/h to Bq/g. We made the soil sample contaminated by radioactivity to calculate the constant. If the sample volume was smaller than a volume that was large enough for saturation, the measurement result depended on the sample volume. When we used the constant to investigate the ground contamination level, it was necessary to understand the soil volume for the saturation. If we didn't know the saturation volume, there was a risk that we would estimate the radioactive density to be too small.

While the volume is increasing, the measurement result of the NaI scintillation survey meter is also increasing. But, because there is a limit, we expect that even if the volume is increasing, the result becomes saturated at some volume. When the measurement results were same, we couldn't discriminate the volume effect from the radioactive density effect. We thus need to know saturation volume.

In reality, it's difficult to make a large soil sample contaminated by a radioactive material. We therefore used EGS4 to simulate saturation volume, and compared the calculated constant.

2 Method

At first, we made a cylindrical sample of soil. The soil was contaminated by ^{137}Cs. We measured the radioactive density by a Ge-detector. The cylinder diameter was 30cmϕ and the height was 30cm. We measured the counting rate by placing the NaI scintillation survey meter at the surface, and then inserted it at depth of 5cm and 15cm (Fig.1). We calculated the conversion constants in each case.

In the simulation, we set the cylinder height as 30cm, the same as in the experiment. The cylinder volume was increased by increasing the radius(Fig.2). We calculated the counting efficiency for each radius, the position of the NaI crystal was the same as in the experiment. The measurement results of the NaI scintillation survey meter were calculated based on the counting rates. We calculated the counting rates by multiplying the calculation efficiency by the total radioactivity in the cylinder.

The size of a crystal of NaI was 1 in. f and the height was 1 in. We made a user code starting from 'ucnai3p.mor' (Fig.3). In a 'ucnai3p.mor', the outside of cylinder was made by Al, but we changed it into soil contaminated by radioactivity as a photon source. The gaps between the soils and the NaI crystal were 1mm. Much material data were for EGS4, but no soil date. We thus substituted Al for soil, because the atomic number is comparatively the same. However, we exchanged parameter of the Al density for 1.6g/cm^3.

In the experiment, we used the radioactive isotope ^{137}Cs, and thus the energy of the γ-ray was 661kev. The irradiation point was assumed to be uniform inside the soil; isotopic emission was also assumed. The number of incident photons was 5000000 (Fig.4).

3 Result

We show the simulation results for the counting rates surveyed at the surface as well as inset 5 cm and 15 cm depth in (Fig.5). Because we assumed the radioactive density to be uniform in the cylinder, the whole radioactive was increased in proportion to the square of the radius. On the other side, the counting rate was saturated at a certain radius. It's shown by a comparison between the counting rates and the whole radioactivity that the assumed the radioactive density was 1Bq/g in Fig.6. The counting rates fall at the surface, 5 cm and 15 cm, in that order. But, the point counting rate is saturated, and there is no wide difference. We compared the experiment result with simulation result as 15cm, we discovered that the experimental volume didn't get reach the volume of saturation. Thus if we used the conversion constant calculated by the experiment to estimate the radioactive density in the contaminated ground, it was necessary to revise the results.

4 Conclusion

According to the simulation results, when we use the conversion results obtained by experiments, the estimated radioactive density in the ground is 30% larger than saturation. At a depth of 15cm, the conversion constant obtained by experiment was 18.9[(Bq/g)/(μSv/h)]. On the other hand, the conversion constant obtained by a simulation was 14.5[(Bq/g)/(μSv/h)].

We discovered that the counting rate of the NaI scintillation survey meter became saturated comparatively quickly. When we measured ground contaminated by radioactivity, different measurement results came from the different radioactive density, because the counting rate from the soil already reached saturation.

The volume of the sample used in this experiment didn't amount to the saturation. But we could use the conversion constant to estimate the radioactive density in the ground by comparing with the simulation results. At that time, it was necessary to use correction factor.

We could not estimate the conversion constants by a simulation entirely, because sometimes conversion constants are needed for every NaI scintillation survey meter. Actual measurements are necessary. But there are some difficulties for actual measurements. We concluded that we could calculate the conversion constant for an arbitrary sample by comparing with the simulation results.

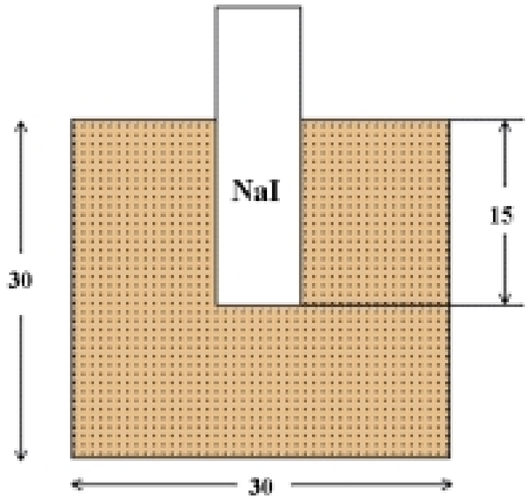

Figure 1: Experimental set up. Inserted NaI into the cylinder made by soil that contaminated by ^{137}Cs.

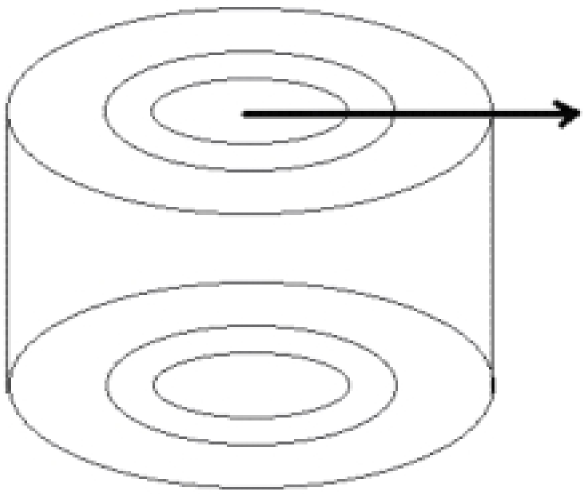

Figure 2: Increase cylinder radius and increase cylinder volume.

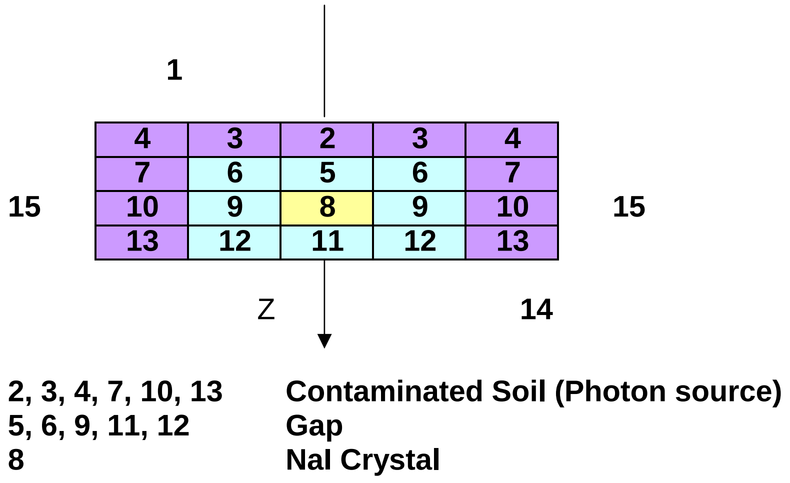

Figure 3: Cylinder structure based on 'ucnai3p.mor'. NaI crystal is surrounded by gap. Gap is surrounded by contaminated soil. Photons come to NaI from soil.

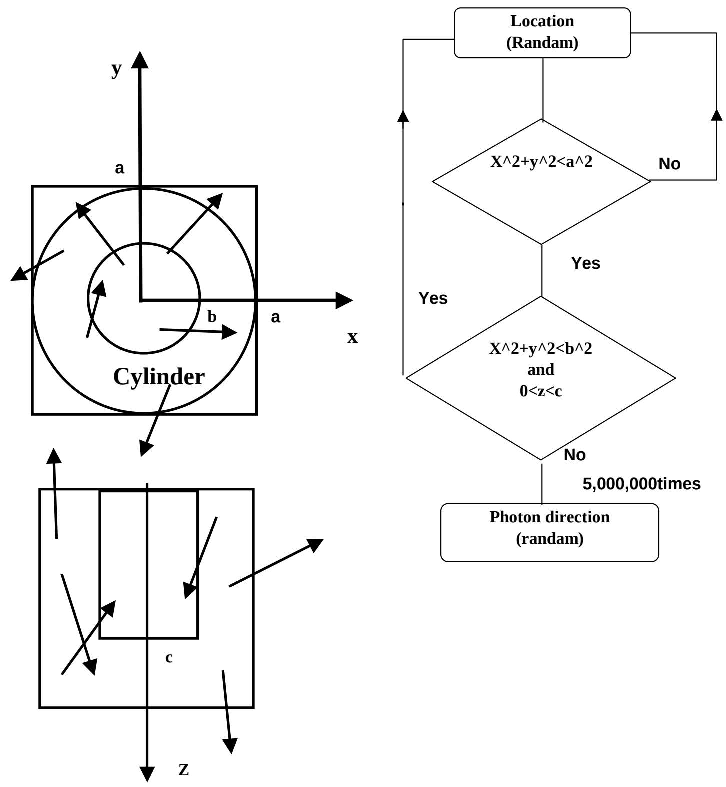

Figure 4: Flowchart of location and direction about photon.

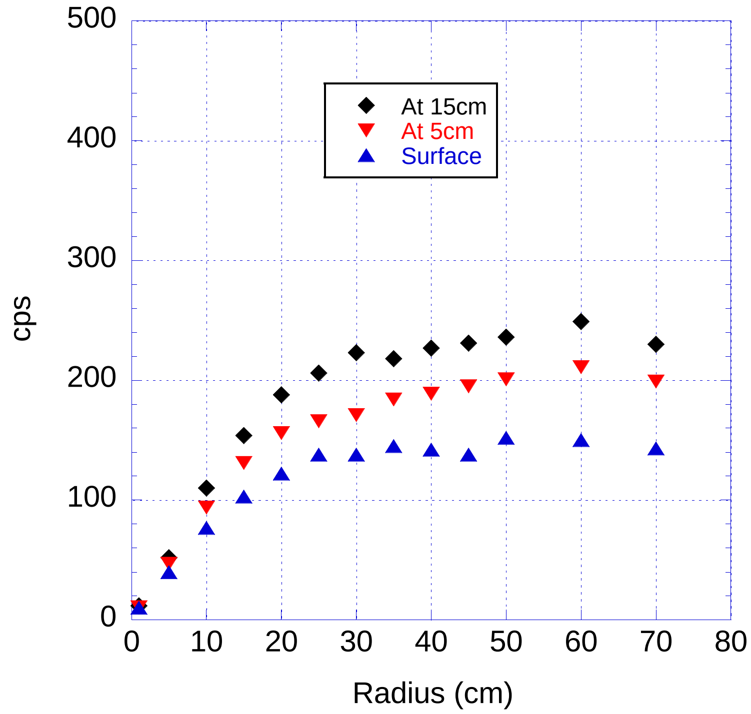

Figure 5: Counting rate comparison with surface, 5cm and 15cm.

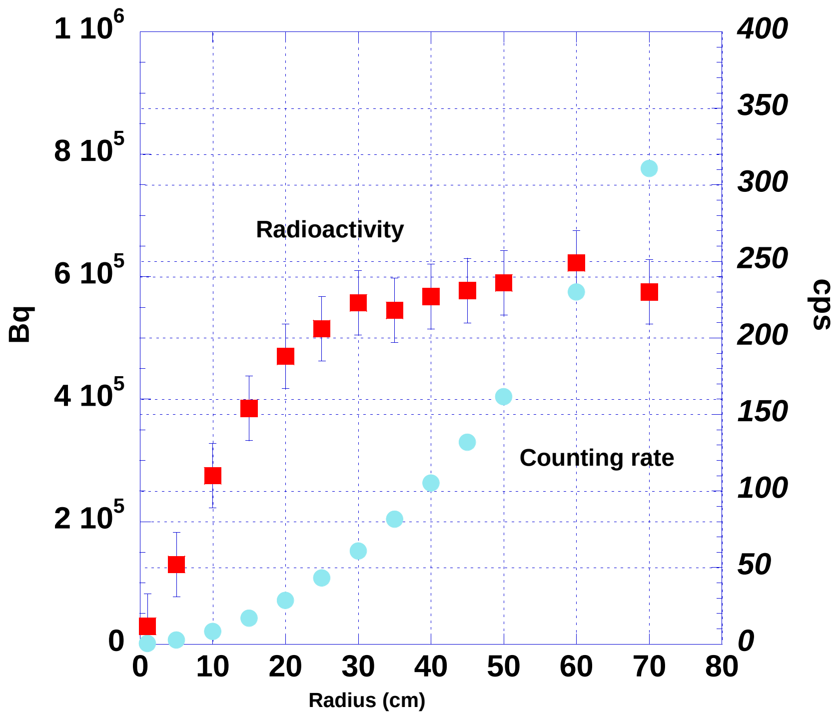

Figure 6: The change of counting rate, and whole radioactivity in cylinder at inserted in 15cm.