Development of a Simple Device to Measure the Vertical Distribution of Radiocesium Concentration in Soil.

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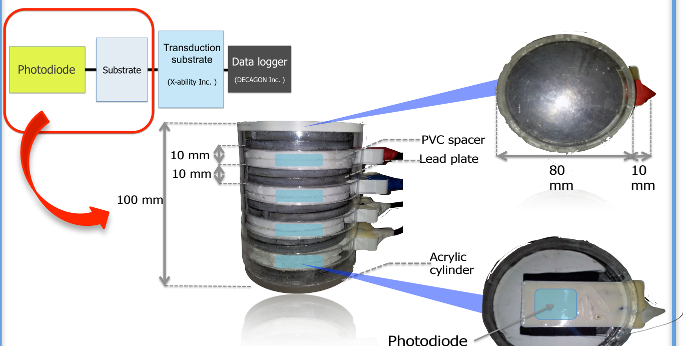
Background & Objective

On March 11, 2011, a great earthquake hit in northeast Japan that caused Fukushima Daiichi Nuclear Power Plant accident. Immediately after the accident, ^{131}I, ^{134}Cs and ^{137}Cs were detected in the fallout. Among them, ^{134}Cs and ^{137}Cs have been fixed so strongly on clay minerals in soil that topsoil in agricultural field has been contaminated. For the decontamination of agricultural field, a simple in-situ is needed to estimate the vertical distribution of radiocesium since the soil sampling method requires a lot of time and costs. Also, it is important for inhabitants to monitor the environments such as soil and groundwater for a long time. In this study, we have developed a new device that can measure vertical distribution of radiocesium concentration and conducted the long-term monitoring.

Materials & Methods

Over view of the system & device



Methods

1. Evaluation of radiation emitted from points of radiation

(1) Measure counting rate (cpm).
(2) Calculate "Leakage coefficient" we defined.

$$L_{ij} = \frac{C_j}{C_i}$$

L_{ij} = Leakage coefficient
C_i = Counting rate of radiation detected by sensor located at same depth with the source point
C_j = Counting rate of radiation detected by sensor located at different depth with the source point

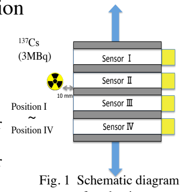


Fig. 1 Schematic diagram of evaluation.

2. Correction method of raw data (Matrix of leakage coefficient)

Introduced a matrix expression for the device to compensate the radioactivity.

$$C_{mea\ j} = \sum C_{cor\ i} L_{ij}$$

$C_{mea\ j}$ = Measured counting rate (cpm)
$C_{cor\ i}$ = Corrected counting rate (cpm)
L_{ij} = Leakage coefficient

3. Field measurement (Iitate-Village, FUKUSHIMA)

Soil sampling

(1) Take soil and cut every 2 cm.
(2) Analyze radiocesium concentration using Ge semiconductor detector.

Device

(1) Set the device in undisturbed paddy field.
(2) Collect data of counting rate from 12 Nov. to 9 Dec., 2012.

Results & Discussion

1. Long-term monitoring

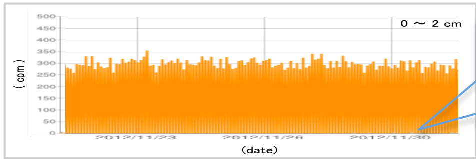


Fig. 2 Measuring example of radiation dose in soil.

The device is possible to measure radiation in contaminated soil for a month.

2. Matrix of leakage coefficient

Table 1 Matrix of leakage coefficient.

	Position1	Position2	Position3	Position4
Sensor Ⅰ	1.000	0.148	0.149	0.055
Sensor Ⅱ	0.160	1.000	0.161	0.142
Sensor Ⅲ	0.122	0.162	1.000	0.155
Sensor Ⅳ	0.039	0.140	0.143	1.000

Table 1 shows effects from outside of measurement range (0.06 to 0.16). Therefore, it is needed to remove influences out of range of measurement.

3. Evaluation of correction method

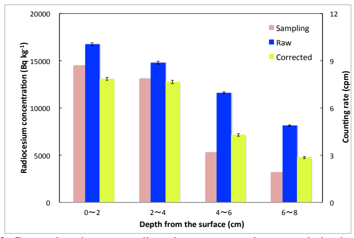


Fig. 3 Comparison between radiocesium concentration at each depth level in undisturbed soil of paddy field in Iitate village, Fukushima and raw and corrected couting rates (Samples were measured in wet weight).

Fig. 3 shows measured counting rate (raw) and corrected counting rate, radiocesium concentration at each 2 cm. A tendency of measured counting rate is different from that of radiocesium concentration of soil sampling. Especially, 4-6, 6-8 cm depth are clear. However, corrected counting rate shows a similar tendency to radiocesium concentration of soil sampling. It appears that correction method could remove radiation effects from outside of measurement range.

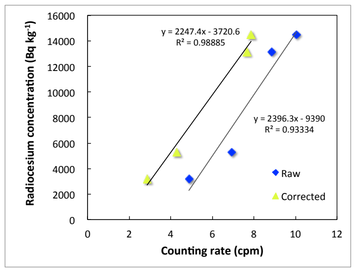


Fig. 4 Relationship between radiocesium concentration by soil sampling and counting rate.

Corrected counting rate shows good correlation with radiocesium concentration at each depth level. The result means that our device can be promising to measure the radioactive cesium concentration in each depth of soil in in-situ fields (Fig. 4).

Conclusion

As a result of a field test of the device in an undisturbed rice field in Iitate-Village, Fukushima, it was confirmed that the vertical distribution of soil radioactivity can be measured well by the developed device.

In addition, it was found from in-site testing for one month that the device would be durable enough to use in the actual field. Therefore, the device can be used to monitor the environments such as soil and groundwater.

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