1–10 Detection of Radionuclide Depth in Soil by Aerial Radiation Monitoring

— Technology for Estimating the Vertical Distribution of Radionuclides in Soil Based on the γ-ray Spectrum —

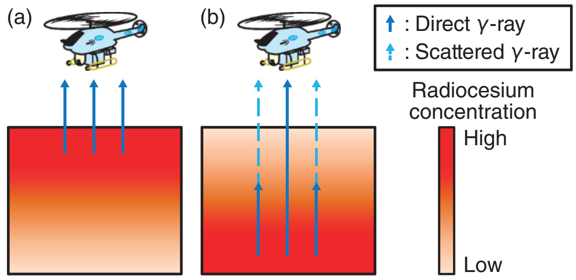

Fig.1-23 Aerial radiation monitoring using an unmanned helicopter
(a) The contribution ratio of direct γ-rays to scattered γ-rays is large when radiocesium is distributed in surface soil; (b) it is small when radiocesium is distributed in deeper soil layers because direct γ-rays are attenuated by soil particles in the upper soil layer.

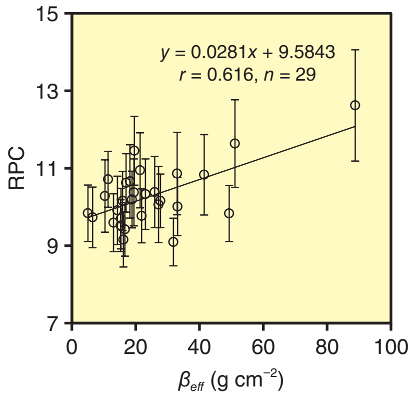

Fig.1-24 Relationship between the result of aerial radiation monitoring and the collection of core soil
It is estimated that the contribution ratio of scattered γ-rays to direct γ-rays obtained by aerial radiation monitoring varies with the distribution depth of radiocesium in the soil. The error bars are the standard deviation of the count rate.

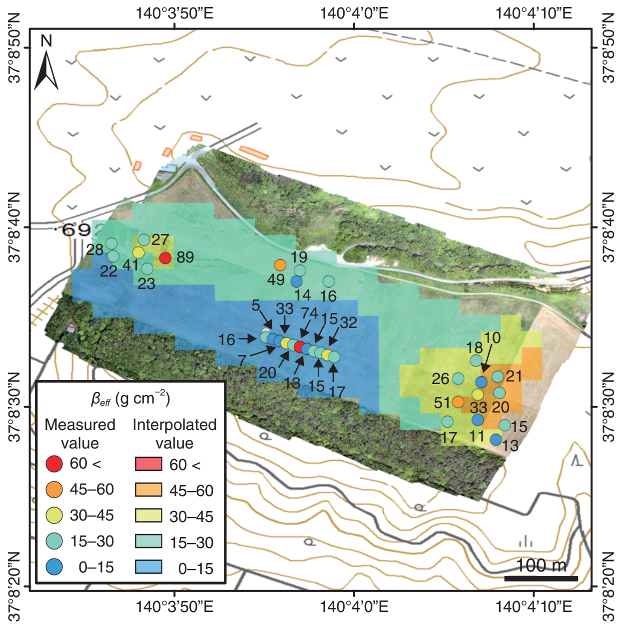

Fig.1-25 Comparison between the estimated value of β_{eff} and actual β_{eff}
The estimated β_{eff} value calculated by the equation in Fig.1-24 was well fitted to the actual result. This figure implies that the estimated β_{eff} value is the average vertical distribution of radiocesium in soil in the selected area.

Seven years have passed since the accident at the TEPCO's Fukushima Daiichi NPS (1F). It has been reported that radiocesium deposited by the accident was transferred into deeper soil with rainfall, inversion tillage (a type of decontamination work) and disturbance by wild animals. It is necessary to readily detect radiocesium depth in the soil from the ground surface. This method would be helpful for determining the depth of decontamination. We have developed an aerial-radiation-monitoring method using an unmanned helicopter (R-Max G1, YAMAHA Co., Ltd.), which is used to rapidly and easily investigate the spread status of radiocesium on a wide scale.

In the present study, we succeeded in developing a method for acquiring radiocesium soil depth based on the characteristics of the γ-ray spectrum obtained by aerial radiation monitoring. To validate the theory in Fig.1-23, the contribution ratio of scattered γ-rays to direct γ-rays is compared to the vertical distribution of radiocesium in core soil at the same point in the farmland (Fig.1-25). Inversion tillage was performed in the farmland, except in the southern area. The value of the ratio of peak to Compton-scatter peak heights (RPC) is calculated based on the ratio of the counting rate of scatted γ-rays (50–450 keV) to that of direct γ-rays (450–760 keV) for γ-rays obtained by aerial radiation monitoring. We used the $LaBr_3$(Ce) detector that showed good energy resolution for ^{137}Cs. The vertical distributions of radiocesium in the core samples (0–60 cm) were obtained by random soil sampling using a core sampler in farmland. The vertical distribution of radiocesium in soil was expressed as a parameter, effective relaxation mass depth (β_{eff}). As β_{eff} increased, radiocesium distributed more deeply into the soil.

As shown in Fig.1-24, good agreement was observed between the RPC and β_{eff}. The map of estimated β_{eff} in the entire field in Fig.1-25 was created based on the above-mentioned equation. The result of core soil sampling is shown as a black circle in the result for aerial radiation monitoring over all farmland. The vertical distribution of radiocesium from farmland on a wide scale was investigated by aerial radiation monitoring using an unmanned helicopter. This method would be helpful for performing decontamination in the difficult-to-return zone over a wide scale.

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Reference

Ochi, K. et al., Estimation of the Vertical Distribution of Radiocesium in Soil on the Basis of the Characteristics of Gamma-Ray Spectra Obtained via Aerial Radiation Monitoring Using an Unmanned Helicopter, International Journal of Environmental Research and Public Health, vol.14, issue 8, 2017, p.926-1–926-14.