JAEA staff measuring radiation on the reservoir (instrument seen in the center is the radiation detector).

Visualizing depth distribution of radioactive cesium

Clarifying the contamination situation without sampling

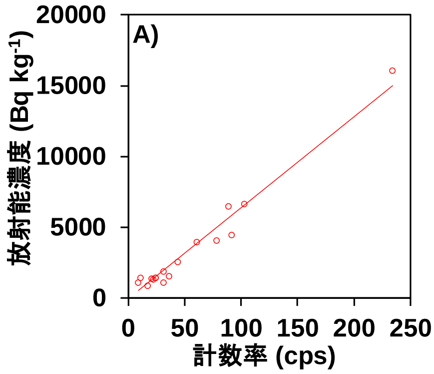
In order to clarify the situation of contamination by radioactive cesium in bottom sediment of lakes and bonds, Japan Atomic Energy Agency (JAEA) developed a simple method to quickly evaluate depth distribution of radioactive cesium in sediment without taking samples. The method was applied to the observation of a real reservoir in Fukushima Prefecture. As a result, we succeeded in measuring the depth distribution of radioactive cesium for the entire region of the reservoir. The method is expected to improve the efficiency of monitoring radioactive cesium deposited in lakes and ponds (reduction of the measurement time, cost and amount of work). Also, the method will contribute to the medium-to-long term evaluation of lakes and ponds towards the restart of agriculture in the difficult-to-return zones.

◇ How was the conventional method to measure the distribution of radioactive cesium in lakes and ponds?

Radioactive cesium was first adsorbed in surface soil, then it has been flowing into rivers by rainfall as time passes. Finally, the radioactive cesium was deposited in lakes and ponds. In the conventional method to measure the contamination situation of radioactive cesium at the bottom of lakes and ponds, it was neccesary to collect bottom sediment with columnar shape, and it was divided into the layer, then the radiation of each layer was measured. This method had disadvantage that it took long time to measure the sample.

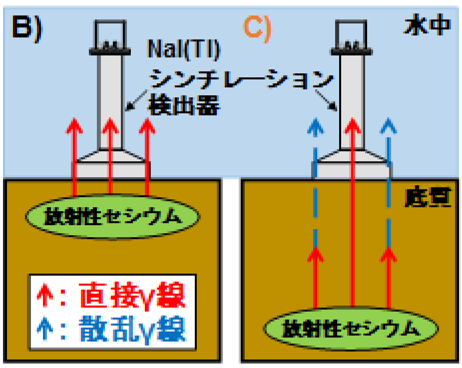
◇ Relation between counting rate of radiation at the surface of bottom sediment and concentration of radioactive cesium

In the previous studies, it was clarified that the concentration of radioactive cesium in the bottom sediment increases with the count rate of radioactivity at the surface of bottom sediment measured by a radiation detector (shown as A in the right figure). This relation is being used for the monitoring of the concentration of radioactive cesium in reservoirs in Fukushima Prefecture.

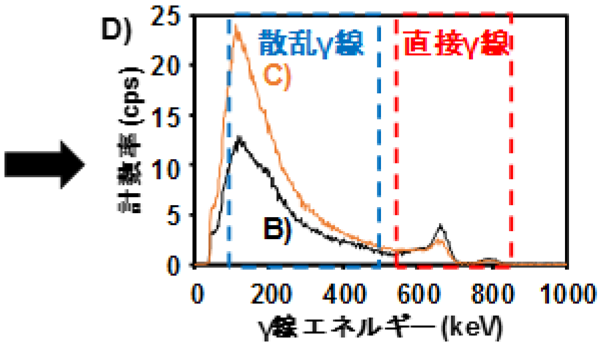


※Concentration of radioactivity：Radioactivity contained in 1 kg sample.
Counting rate : Number of radiation counted by a radiation detector in a second.

◇ How was the depth distribution of radioactive cesium in bottom sediment measured?



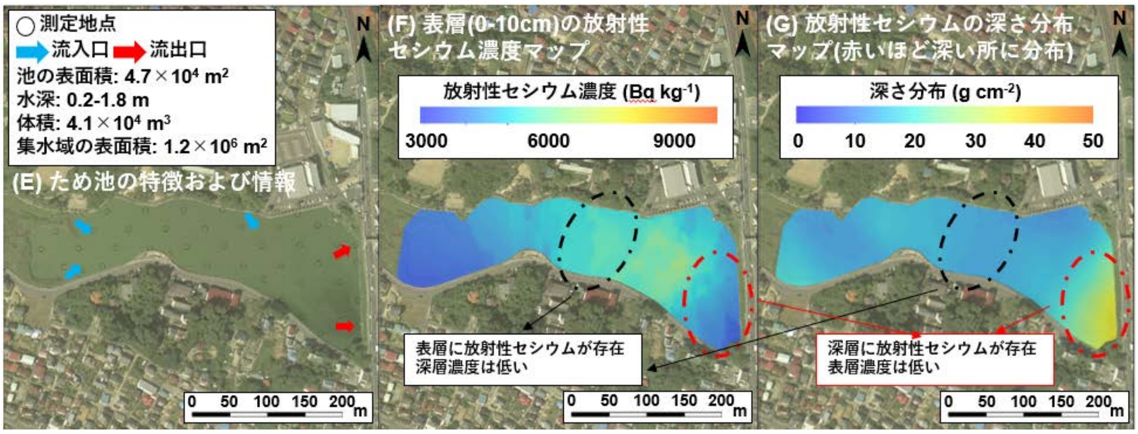
底質表面でのγ線スペクトルの測定イメージ
B) 放射性セシウムの分布深さが浅い場合
C) 放射性セシウムの分布深さが深い場合



底質中の異なる放射性セシウムの分布深さにおけるγ線スペクトルの変化
・C)はB)に比べ散乱γ線の計数率が大きく、直接γ線の計数率が小さい
（放射性セシウムの分布深さにより変化）

In the development of the present method, we focused on the fact that **the intensity of gamma-ray measured by a radiation detector depends on the depth distribution of radioactive cesium in bottom sediment**. For example, if radioactive cesium exists at the surface of bottom sediment, large amount of gamma-ray emitted from radioactive cesium is directly detected (shown as B in the upper figure). On the other hand, if radioactive cesium exists in the deep region of bottom soil, the intensity of gamma-ray becomes low because the direct gamma-ray is shielded or scattered by soil particles. But in this case, the intensity of the scattered gamma-ray rather increases (shown as C in the upper figure). Therefore, we can estimate the depth distribution of radioactive cesium by measuring the intensity ratio of the direct gamma-ray to the scattered gamma-ray (shown as D in the upper figure). We statistically evaluated the relation between the intensity ratio and the "depth distribution" of radioactive cesium in bottom sediment. As a result, it was elucidated that the depth distribution of radioactive cesium can be precisely estimated based on the spectral analysis of gamma-ray measured by the radiation detector. By the development of this method, it became possible to estimate the depth distribution as well as the concentration of radioactive cesium at the surface of bottom sediment by the same measurement method as before. The method is expected to contribute to the reduction of the investigation time and cost.

◇ What is clarified by the measurement of real reservoirs?



We have investigated real reservoirs, and evaluated the concentration of radioactive cesium and its depth distribution by the newly developed method (shown as E in the upper figure). As a result, it was found that the concentration of radioactive cesium at the surface of bottom sediment was not homogeneous (shown as F in the upper figure). This is because there are multiple water inlets to the reservoir. In addition, it was also found that radioactive cesium is distributed in the relatively deep region near the water outlet (shown as G in the upper figure). This is because, 1) radioactive cesium migrates from the upstream to the downstream with the waterflow, and 2) the bottom sediment is actively stirred near the water outlet. By combining the concentration of radioactive cesium in the surface of bottom sediment (shown as F in the upper figure) and its depth distribution (shown as G in the upper figure) measured by the newly developed method, it became possible to know the three-dimensional distribution of radioactive cesium.

◇ From a researcher

Kotaro Ochi of the Fukushima Remote Monitoring Group, Fukushima Environmental Safety Center, who is in charge of developing this method talked as follows. “In order to know the validity of the estimation by gamma-ray spectral analysis, we applied a statistical method to the evaluation. This is really an unprecedented approach. The principle of the evaluation method was difficult for us, so it took long time to understand it. But finally, we succeeded in presenting the accuracy of the estimation results. From now on, we will apply the present method to various lakes and ponds. By doing so, we will elucidate more detailed migration and diffusion processes of radioactive cesium.”.

This report was edited after revising the contents of the press release on October 31, 2018.

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