In situ radioactivity measurement at underwater sediment at Fukushima prefecture

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1. Introduction

Collecting samples has been conducted to measure radioactivity in various environment, such as ground, air, and underwater. Analyzing the sample in a laboratory provide accurate radioactivity, however, it requires a considerable amount of time and cost [1]. In the point of prompt reaction, *in situ* measurement can estimate the radioactivity instantly in environment, even in challenging situation where collecting sample is difficult such as underwater sediment [2]. We developed gamma spectrometry with NaI(Tl) scintillation detector to measure radioactivity at the bottom of underwater. And we conducted surveys in Fukushima prefecture to verify its performance of measuring radioactivity. We derived a conversion factor between count rate and radioactivity and its application enables rapid radioactivity measurement at underwater sediment.

2. Method and Materials

· In situ underwater monitoring system

A 3″φx3″ NaI(Tl) was connected to a signal processing unit (SI Detection Co. Ltd., HAMPack MCA 527, KOR) which included a high voltage supplier, preamplifier, amplifier, and multi-channel analyzer (MCA). The detector package was sealed with stainless steel housing for waterproof below 10 m depth. A 10 mm thickness of lead shield was attached to the outside of the housing for radiation shielding. The bottom of the detector was composed of MC Nylon to minimize attenuation of gamma-ray. A controller containing a laptop, GPS controller, and battery to check the measurement information was connected by line.

· Survey sites

Two rivers and one reservoir in Fukushima prefecture were selected as survey sites. A reservoir (point 1) was located 2 km far away from Fukushima Daiichi nuclear power plant (FDNPP). One river (point 2) was located at the northwest of FDNPP 15 km far away and the other river (point 3) was located at the south of FDNPP 4 km far away. These locations were expected to contain ^{137}Cs in sediments as high, medium, and low concentration, respectively. Each measurement was conducted at the bottom of underwater for 120 s.

· Analyzing sediment samples

Sediment samples were sampled at the bottom of two rivers right after in situ survey. Each sample was collected up to 30cm and divided into 5 cm depths. The samples were analyzed by HPGe to measure radioactivity. The measured radioactivity was compared with the peak count rates of the gamma-ray spectrometry.

3. Results

· Measurement of gamma-ray spectrometry

Figure 1 shows the gamma-ray spectra measured at three points. At point 1, it showed high count rates of the peaks of ^{134}Cs and ^{137}Cs, and at point 2, the radioactivity of ^{137}Cs showed moderate. The radioactivity of ^{137}Cs at point 3 showed very low compared to other points, and even the ^{134}Cs peak was not observed owing to its low concentration.

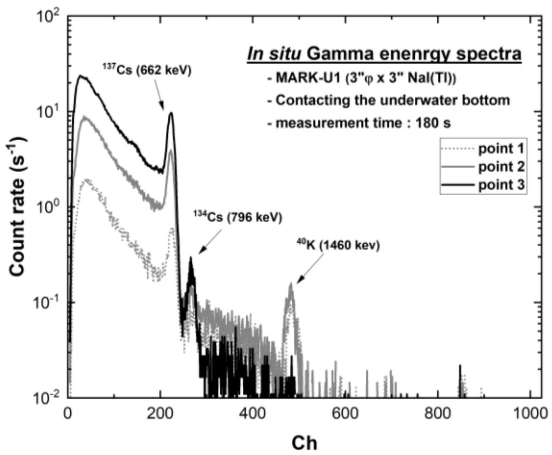

Figure 1 Gamma-ray spectra using NaI(Tl) at the bottom of underwater

· Linearity of ^{137}Cs concentration and count rates

We compared the concentration of ^{137}Cs and count rates at 662 keV. Figure 2 exhibits that the peak count rate increases linearly as ^{137}Cs concentration increases. From the results, a linear coefficient was derived to estimate the ^{137}Cs concentration from peak analysis. The concentration of ^{137}Cs was estimated in the range of 7,294 – 26,832 Bq/kg at point 1 using the coefficient.

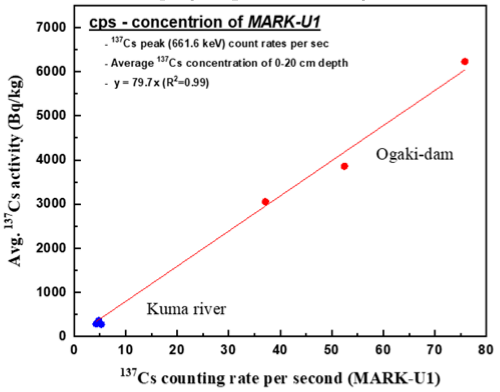

Figure 2 Comparison of ^{137}Cs peak count rates with radioactivity

4. Discussion

In this study, we measured the concentration of ^{137}Cs at the bottom of underwater at Fukushima prefecture. From the results, we verified the performance of monitoring systems and derived a conversion factor to estimate ^{137}Cs from gamma-ray spectrum. It means that the in situ underwater measurement assures the rapid and reliable estimation of radioactivity in contaminated environment.

As a limitation of low concentration of ^{134}Cs, the radioactivity of ^{134}Cs was only measured at point 2. Due to insufficient information, and low energy resolution of NaI(Tl), ^{134}Cs activity was not estimated by gamma-ray spectrometry. Collecting samples at contaminated area and application of a scintillator with good energy resolution is need to improve the performance of the monitoring system.

5. Conclusion

We developed an environmental radiation monitoring system at underwater sediment. In situ measurement near FDNPP was conducted to measure the radioactivity of the sediment. Samples were collected and analyzed by HpGe to measure the radioactivity. From the comparison of gamma-ray spectrum with the radioactivity, the conversion factor was derived to estimate ^{137}Cs concentration from in situ measurement.

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