§6. Variation Factor for Long-term Background Radiation Monitoring Data at Toki

Yokoyama, S., Shimo, M. (Fujita Health Univ.),
Nishimura, K., Isobe, M., Miyake, H., Hayashi, H., Yamamoto, Y., Tanaka, M.

In the atmosphere and soil, there are natural radionuclides such as U-238, U-235, and their progeny; K-40, which is a component of the soil; and H-3, N-13, and Be-7, which are caused by a spallation reaction between cosmic rays and components in the air. In addition, radioactive fallout, such as Cs-137 ($T_{1/2}$ = 30 y) and Sr-90 ($T_{1/2}$ =29 y), was released into the atmosphere as a result of nuclear tests carried out in the 1950s and 1960s. Furthermore, Cs-134 ($T_{1/2}$= 2 y) was released into the atmosphere and deposited on soil after the Fukushima Daiichi nuclear power plant (1FNPP) accident, and they may still be present.

To ensure the safety of the general public near the National Institute of Fusion Science (NIFS), which houses a high-performance Large Helical Device (LHD), it is important to investigate variations in environmental radiation via long-term monitoring, and to analyze the critical factors. The aim of this study is to show the difference in both the total amount and the depth profile between the radioactive fallout, Cs-137, of past nuclear tests and the 1FNPP accident, and natural radionuclides in soil.

Soil samples were collected using a core sampler (5 cm ϕ × 5 cm high) and a scraper plate (15 cm wide × 30 cm long, 0–3 cm depth) at five points at the NIFS. Points WB, WM, and WH are located at a wooded area of a hill. Point WC is a narrow ravine [where soil was collected a few meters away from a stream (WC-1) and at the side of the stream (WC-2)]. Point IB, which was created in 1996, is a man-made open section of land where lawns were planted.

The collected soil samples were dried at 104 ºC for 24 h. All dry soil samples were sifted to remove small rocks and plant roots, and particle sizes were classified for the soil collected at points WB and WC.

The dry soil samples were placed in U-8 containers. The radioactivity of the soil samples was measured by Ge (Li) semiconductor detectors (GX3018, Canberra Industries Inc. and Model GMX-20200, ORTEC) for 24–26 h.

Classification of the soil particles revealed that the ratio of clay and silt in the soil from points WB and WC-1 was about 15%, while that at point WC-2 was 4–6%. The reason for this difference is that the clay and silt from the latter sample would have been washed downstream.

Fig. 1 illustrates the radioactivity of Pb-214, Cs-137, and K-40 in soil collected by the core sampler. The radioactivity of Pb-214 in soil did not differ between the sampling points. The radioactivity of K-40 in the soil of points WB, WC, WH, and WM was approximately equal. The concentration of K-40 in the soil of point IB was four times as high as that at the other locations. This indicates that lawns were planted and a fertilizer containing potassium was added to the soil, although the original soil type was the same at all locations.

The radioactivity of Cs-137 in the soil was highest at point WB. One of the properties of cesium is that it attaches strongly to clay. The low Cs-137 radioactivity in the soil of point WC-2 may be because that clay, which is a fine particle, and the attached Cs-137 in the surface soils were washed by water from the stream.

Fig. 2 displays the 0–3 cm depth profiles of the radioactivity of Be-7, Cs-134, Cs-137, and K-40 in the soil collected by the scraper plate at point WB. The highest radioactivity of Be-7 was present in the surface soil. This indicates that the origin of Be-7 is radioactive fallout from the atmosphere. The distribution of radioactivity of Cs-134 was also similar to that of Be-7. Thus, it can be concluded that Cs-134 originated from the 1FNPP accident. The radioactivity of Cs-137 in the soil increased with depth, which means that the fallout of radionuclides released by nuclear tests played a large role in the distribution of radioactivity of Cs-137 in the soil. In soil from the area surrounding Fukushima prefecture, the current ratio of radioactivity of Cs-134 and Cs-137 derived from the 1FNPP accident was 0.44. Considering this value, the estimated radioactivity of Cs-137 at depths of 0–1 and 1–2 cm was one-third and one-seventh of the measured radioactivity, respectively. At 0–1 cm depth, the amount of Cs-137 released from the 1FNPP accident may be analyzed by comparing it with a measurement of radioactivity in a non-contaminated area that is due to radionuclides released from the 1FNPP. The activity of K-40 in surface soil was lower than that in the underlayers. Future analysis will be necessary to clarify this finding.

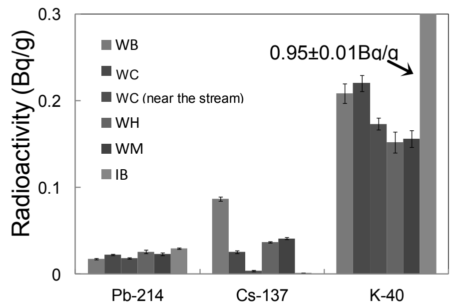

Fig. 1. Radioactivity of Pb-214, Cs-137, and K-40 in the soil at each sampling point.

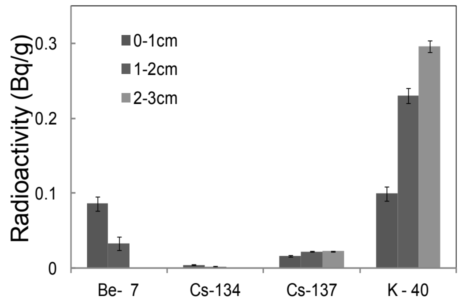

Fig. 2. Depth profiles of radioactivity of Be-7, Cs-134, Cs-137, and K-40 in the soil at the WB point.