§4. Distribution of Background Radiation in Soil around NIFS Facilities

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With advances in the plasma confinement of the Large Helical Device (LHD), it is important to continuously measure the natural background radiation for ensuring safety from environmental radiation around the National Institute of Fusion Science (NIFS). The natural background radiation depends on various physical and environmental factors, including the physical half-life of radionuclides, diffusion from the soil surface to lower layers by land water, and washout by rain. Thus, it is necessary to investigate such factors around the NIFS facilities.

In a previous study, the radioactivity of Pb-214, K-40, Cs-134, and Cs-137 was measured in soil collected from wooded areas, a developed lawny ground, and the bank of a brook in the woods of the NIFS site. It was found that the concentration of K-40 in the soil from the lawny ground was higher than that in the other soil, possibly because of added fertilizer. Moreover, a slight increase in the Cs-134 activity in a surface layer of soil, attributed to the Fukushima Dai-ichi nuclear power plant accident, was observed[1]. However, in the soil at the bank of the brook, the high concentration of fallout radionuclides (Cs-137) that was measured in 1985 because of nuclear-weapon tests was not observed[2]. In the present study, the concentrations of U-238, Th-232, K-40, and Cs-137 in the soil on the upstream and downstream sides of the brook were measured and compared with distributions of natural radionuclides for the past year.

Soil was collected using a core sampler (5 cm ϕ × 5 cm high) at intervals of a few meters (3 points) along the brook in the WC area of the NIFS site. The collected soil was dried at 110 ºC for 24 h. The dried soil was sifted to remove small rocks and plant roots. Using screens and float-type hydrometers, the particles comprising the dried soil were classified according to their size. The classification of the soil particles indicated that the soil contained more than 90% sand and some silt and clay. The water content of the soil samples was 16–19%. The dried soil was placed in U-8 containers and covered by inner lids, i.e., thin circular plates. The lids were sealed using an acrylic adhesive because gaseous Rn-222 and Rn-220, which are decay products of U-238 and Th-232, respectively, were present in the containers. In addition, the containers were enclosed within sealed polyethylene bags. The concentrations of U-238 and Th-232 in the soil were estimated according to the measured radioactivity of Pb-214 and Pb-212, which are also decay products of U-238 and Th-232, respectively. The soil samples were measured by Ge (Li) semiconductor detectors (Model GMX-20200, ORTEC) for ~24 h.

Figure 1 shows the concentrations of U-238 and Th-232, as estimated according to the radioactivity of Pb-214 and Pb-212, respectively. Samples 1, 2, and 3 were collected at the upstream, midstream, and downstream sides, respectively, of the brook in the WC area. The average concentrations of U-238 and Th-238 in samples 1–3 were 0.030 ± 0.013 Bq/g and 0.056 ± 0.012 Bq/g, respectively. The ratio of U-238 to Th-232 was 1.75:1.97. In a soil sample collected in 1985, the concentrations of U-238 and Th-232 were 0.0268 and 0.606 Bq/g, respectively. The ratio of U-238 to Th-232 was 2.26 [2], which is equal to that of the present study. Figure 2 displays the concentrations of K-40 and Cs-137 in the soil. The concentration of K-40 does not differ among the samples. The concentration of K-40 in the soil collected in the present study is similar to that of previous soil measurements. This shows that the soil type in the WC area has not changed since 1985. The concentration of Cs-137 in sample 1 was higher than that in samples 2 and 3. However, the Cs-137 concentration was lower than the value estimated from a past experimental result. The Cs-137 concentration in sample 1 was higher than that in samples 2 and 3 because the deposited Cs-137 in the soil was transported from the upstream side of the brook to the downstream side. On the other hand, the Cs-137 concentrations in the soil sampled in this study are considerably lower than those of past studies. This is because the deposited Cs-137 in the soil in the WC area was broadly diffused by rain and the brook.

1) Yokoyama S. et al., Annual report of NIFS April 2013-March 2014, 169 (2014).
2) Nagoya Univ., IPPJ-DT-116 (1985).

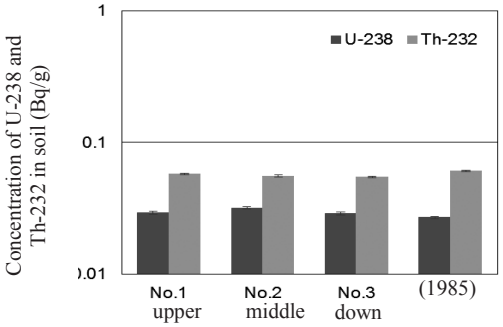

Fig. 1 Concentrations of U-238 and Th-232 in soil at WC area of the NIFS site.

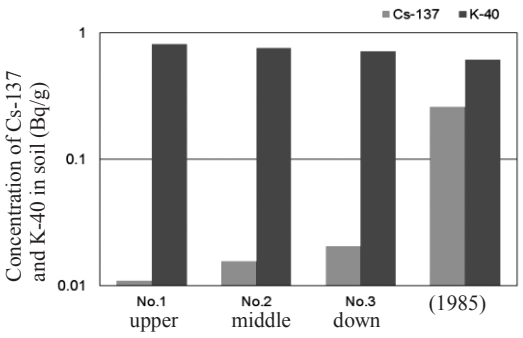

Fig. 2 Concentrations of Cs-137 and K-40 in soil at WC area of the NIFS site.