§10. Analysis of U and Th Series Radionuclides in Soil from Toki Area I. Comparison between Gamma - Ray Spectrometry and ICP-MS

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Radiation from terrestrial natural radionuclides, i. e., U-238 and Th-232 series nuclides, and K-40, comprises 80 % of natural radiation exposure. Natural radiation level in Toki-area, Gifu, Japan varies from 70 nGy/h to 140 nGy/h depending on the location [1]. The principal mechanisms of such variation is difference in U and Th content in geological formations that underlie the area and the type of soil derived from the parent materials. In Toki, high radiation levels in some locations are related with granitic rock from Ryoke belt and uranium mine in Tono, while lower levels are observed in a soil derived from Seto Group which contain clay.

The site of NIFS (National Institute for Fusion Science) has been constantly monitored for radiation by ion chamber detector being set up at nine locations near site boundary and five locations beside some buildings that house plasma experiment laboratories. Obtained data has shown that the radiation level tended to be higher in the vicinity of buildings than in the other locations.

Our study was started to clarify the mechanisms that caused such differences. A possibility was that it was an effect of concrete materials of building that contain natural radionuclides in them.

In the present study, we conducted *in-situ* gamma-ray spectrometry measurement utilizing Ge semiconductor detector at several of the stations in Toki area and in NIFS. Soil was collected at each of the station, and was subjected to analysis of U series radionuclides (Bi-214), Th series radionuclides (Ac-228) and K-40 by low background Ge detector. ICP-MS (Inductively Coupled Plasma – Mass Spectrometry) was used to measure U-238 and Th-232.

On flat and uniform ground with no sources other than terrestrial radionuclides, the amount of radioactivity detected by *in-situ* measurement agrees with those obtained by the measurement of soil in the laboratory. If significant deviation was found between the results obtained by the different methodologies, contribution from radiation sources other than those in soil is probable. Error in each analytical procedures, however, may also cause such deviation. It was therefore necessary to evaluate the accuracy of each analytical procedures.

Shown in Table 1 and Table 2 are data obtained by in-situ gamma ray measurement on relatively flat and uniform ground and those obtained by analysis of soil collected at the same location. The soil was pulverized to 150 mesh and was subjected to borate fusion prior to ICP-MS analysis. Approximately 200 grams of soil packed in 200 ml plastic vessel was subjected to gamma-ray measurement. Previous measurement has shown that the error due to loss of Rn-222 from the vessel is 16 % at maximum.

Results in Table 1 and 2 show that values obtained by three methods generally agree within 20 % error. If more significant difference was observed between *in-situ* and *in-vivo* measurement, contribution from sources other than those in soil should be taken into consideration. In the present measurement, U-238 value obtained for soil beside staff building was lower than expected. The cause of the low values are currently under examination.

Table 1. U-238 series radionuclide measurement by ICP-MS, and low background and in-situ Ge detector

	ICP-MS Bi-214	Low background Ge detector Bi-214	In-situ Ge Bi-214
Location	Bq/kg	Bq/kg	Bq/kg
Oniiwa, Mizunami City	46.6 ± 1.0	44.0 ± 0.8	44.7 ± 0.6
Staff building NIFS (no.1)	7.6 ± 0.1	20.8 ± 0.6	21.7 ±
Staff building NIFS (no.2)	10.6 ± 0.0	19.6 ± 0.4	22.9 ±
Kawai	88.7 ± 1.6	94.0 ± 1.3	70.0 ± 2.3

Bi-214 was quantified from 609 keV peak

Table 2. Th-232 series radionuclide measurement by ICP-MS, and low background and in-situ Ge detector

	ICP-MS Th-232	Low background Ge detector Ac-228	In-situ Ge Ac-228
Location	Bq/kg	Bq/kg	Bq/kg
Oniiwa, Mizunami City	157.1 ± 5.4	143.0 ± 1.8	137.3 ± 0.9
Staff building NIFS (no.1)	25.7 ± 0.7	28.1 ± 0.9	23.5 ±
Staff building NIFS (no.2)	27.8 ± 0.2	28.9 ± 0.7	28.1 ±
Kawai	55.5 ± 0.7	61.9 ± 1.9	52.0 ± 1.1

Ac-228 was quantified from 911keV peak

1)Obayashi, H., Amano, H., Komura, K., Sakuma, Y., Kodaira, J., Sakamoto, H., Mizuguchi, Y., Hayashi, T., Tan, K. L., Nuclear Engineering and Design/ Fusion 4, (1987) 425.