Dose Assessment of Natural Radiation and Distribution of Natural α–emitting Radionuclides in the Environment

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Abstract

Natural background radiation doses for residents and the ecosystem in Rokkasho, Japan are important for evaluating the significance of the dose from radionuclides discharged from the first commercial spent nuclear fuel reprocessing plant located there. The aims of this study were to establish methods for measuring the environmental γ-ray radiation dose to people in their actual living environment and the natural radiation dose to biota in the aquatic environment of Lake Obuchi neighboring the plant. Since the background level of natural α-emitting radionuclides is also useful as a reference for such radionuclides as Pu assumed to be discharged from the plant, this study also had another purpose of obtaining the concentration level of natural α-emitting radionuclides in various environmental samples.

Environmental γ-ray dose rates in various working and living environments in Hachinohe City were measured for a year in FY 2014 with glass dosimeters. Environmental γ-ray dose rates to people living in the city were also measured for 1 week in each season by using personal electrical dosimeters that were able to log data. Using results obtained, we examined whether measured dose rates in various environments can reproduce personal dose rates. Self-dose of the detectors and the cosmic ray dose were corrected by using data from control detectors in a box shielded with 5-cm-thick lead. The mean personal dose rate for 10 volunteers was found as 0.20 mSv y^{-1} and similar to the value of 0.22 mSv y^{-1} estimated using measurement results in various environments obtained with glass dosimeters and the mean spending time in each environment from the literature. This showed that the personal dose rate measured by the personal dosimeter could be reproduced by the combination of the measured dose rates in various environments and the mean spending time.

To estimate radiation dose to biota in Lake Obuchi, salmon (*Oncorhynchus keta*) and flatfish (*Platichthys stellatus*) were collected and analyzed for radionuclides to obtain internal radiation dose rates. Internal dose rates of the salmon and flatfish were evaluated to be 1.2E+2 nGy h^{-1} and 8.5E+1 nGy h^{-1}, respectively, using dose conversion coefficients for a pelagic fish calculated by the ERICA-tool. Polonium-210 burden in their bodies contributed 63 – 71% of these dose rates. Voxel phantoms of the salmon, flat fish, Japanese pond smelt (*Hypomesus nipponensis*) and Pacific herring (*Clupea pallasii*) collected from Lake Obuchi were constructed on the basis of X-ray computed tomographic (CT) images for estimating their radiation dose rates accurately. Internal and external dose rates of a seagrass (*Zostera marina*)、Japanese pond smelt and Pacific herring were estimated by the Monte Carlo code (EGS5) using each voxel phantom developed by us so far, getting the dose rates of 7.4E+1 nGy h^{-1}, 8.7E+1 nGy h^{-1} and 1.2E+2 nGy h^{-1}, respectively.

Natural α-emitting radionuclides were determined for samples of various environmental media in Rokkasho: soil, lake water, precipitation and aerosol samples. Soil samples from five grass-field sites in Rokkasho were analyzed, and we found that ^{210}Po in the surface layer was in the highest concentration

among natural α-emitting radionuclides in most of the sites. Mean concentration of ^{210}Po in soil samples in 0 to ~60 cm depth was found to be ~1,000 times larger than the assumed $^{238, 239, 240}$Pu concentrations discharged from the plant. In water samples collected in the Obuchi River and Lake Obuchi, ^{238}U had the highest concentration among the natural α-emitting radionuclides excluding a site near the Futamata River estuary. We found 88 – 90% of ^{238}U in the waters was presented as dissolved phase passing through a filter with 0.2 μm pore size. Daily variation of the α-emitting radionuclide concentrations in atmospheric deposition and aerosol samples was observed during about one week in four types weather conditions; rain, Kosa (yellow dust), a typhoon, and snow. Polonium-210 was found in the highest concentration of alpha-emitters in both deposition and aerosol samples in every weather condition.