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 Hirosaki City were measured for a year in FY 2015 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 electronic dosimeters that were able to log data. Using results obtained, we examined whether measured dose rates in various environments can reproduce personal dose rates. The mean personal dose rate for 10 volunteers was found as 0.18 mSv y^{-1} and slightly lower than the value of 0.22±0.03 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 substantially reproduced by the combination of the measured dose rates in various environments and the mean spending time.

To estimate radiation dose to biota in the Obuchi River, Pacific oyster (*Crassostrea gigas*) and blue mussel (*Mytilus galloprovincialis*) were collected and analyzed for radionuclides to obtain internal radiation dose rates. Voxel phantoms of the bivalves were constructed on the basis of their X-ray computed tomographic (CT) images for accurately estimating their radiation dose rates. Internal and external dose rates of chum salmon (*Oncorhynchus keta*), starry flounder (*Platichthys stellatus*), oyster and blue mussel were estimated by the Monte Carlo code (EGS5) using each voxel phantom developed by us, getting the dose rates of 1.3E+2 nGy h^{-1}, 1.1E+2 nGy h^{-1}, 1.4E+2, and 1.7E+2 nGy h^{-1}, respectively. Polonium-210 burden in their bodies contributed 46 – 80% of total dose rates.

Natural α-emitting radionuclides were determined for samples of various environmental media in Rokkasho: soil, lake water, precipitation and aerosol samples. Soil samples from sites in five forests 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 litter and soil samples in 0 to ~5 cm depth was found to be 9,800 and 4,300 times larger than the assumed $^{238, 239, 240}$Pu concentrations discharged from the plant, respectively. In surface water samples collected in the Obuchi River and Lake Obuchi in and after rainfall, ^{238}U had the highest concentration among the natural α-emitting radionuclides.

The natural α-emitting radionuclide concentrations in the water samples were not affected by the rainfall. Daily α-emitting radionuclide concentrations in atmospheric deposition and aerosol samples were observed during about one week in three types of weather conditions: rain, Kosa (yellow dust) and snow. Polonium-210 was found to have the highest concentration of alpha-emitters in both deposition and aerosol samples in every weather condition studied.

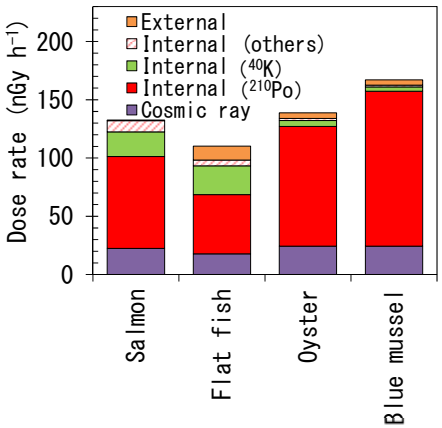

Fig. 1 Internal and external dose rates of salmon (*Oncorhynchus keta*), flat fish (*Platichthys stellatus*), oyster (*Crassostrea gigas* Thunberg) and blue mussel (*Mytilus galloprovincialis*) estimated by the Monte Carlo code (EGS5) using each voxel phantom developed by us. Radiation dose rates from cosmic rays is evaluated from vertical distribution of dose rates measured by using glass dosimeters in Lake Obuchi during FYs 2011 – 2013.