Evaluation of Natural Radiation Dose of People in Aomori Prefecture and Forest Ecosystem in Rokkasho

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Abstract

The natural background radiation dose is important for evaluating the significance of the dose from the small amounts of radionuclides that are being released from the first commercial spent nuclear fuel reprocessing plant in Rokkasho, Japan. In this study, the background radiation dose of Aomori Prefecture residents was assessed, and a dose evaluation method for the forest ecosystem in Rokkasho was developed to study environmental protection.

Natural radiation consists of cosmic rays, environmental γ-rays and radiation from Rn and internal radionuclides. The cosmic ray dose rate can be estimated from the height above sea level and the magnetic latitude of the target area. Radon concentrations have already been measured throughout the prefecture, and dose rates from Rn were evaluated. Although we previously measured environmental γ-ray dose rates throughout the prefecture, measurement points around Rokkasho were scarce. In this study, the dose rates were measured in areas surrounding Rokkasho to get their detailed distribution. The internal dose rate was also evaluated by analyzing radionuclides in the so-called total diet and individual food item samples collected in Rokkasho and Aomori City. The cumulative γ-ray dose at five locations in the northwestern area of Shimokita Peninsula was measured using glass dosimeters in FY 2009. The dose rates ranged from 22 to 39 nGy h^{-1}, and were within the range of the dose rates in Aomori Prefecture. The sums of the committed effective dose due to annual ingestion of natural radionuclides in the total diet samples and the effective dose rate from ^{40}K cited in the literature were estimated to be 0.55 mSv for agricultural farm workers in a study done during FYs 2008-2009 and 0.59 mSv for office workers in a study done during FYs 2006-2009. Over 98% of these doses were attributed to ^{210}Po, ^{40}K, ^{210}Pb, ^{14}C and ^{228}Ra. Analytical results of vegetables, fruits, mushroom and processed foods (tofu, kon-nyaku and natto) showed that the committed effective doses from natural radionuclides ingested annually through the products were 0.022 and 0.019 mSv for the farm and office workers, respectively, corresponding to 6 and 5% of each committed effective dose.

Mice, moles, and the fox as their predator were selected as representative animals of the forest ecosystem in this study, and their radiation doses derived from natural sources, i.e. environmental γ-rays, Rn, and internal radionuclides, have been planned to be measured during FYs 2006 - 2010. The study for the fox was started from FY 2009 succeeding that for the small mammals. Environmental γ-ray dose rates and Rn concentrations were measured in and around burrows for medium-sized mammalians, presumably foxes, in the southern part of Rokkasho during June-November 2009. A female Japanese red fox (*Vulpes vulpes japonica*) and a female raccoon dog (*Nyctereutes procyonoides viverrinus*) were caught with traps set around some of the burrows. After sacrificing them, their body burdens of natural radionuclides were analyzed. Before dissecting the red fox, its MRI tomography images were taken for construction of a voxel phantom. The environmental γ-ray dose rates ranged from 17 to 33 nGy h^{-1} in and around the burrows, and the dose in the burrows decreased with distance from their entrance. Ranges of the mean ^{222}Rn concentrations in and around the burrows were 2.5E+1 - 1.4E+3 Bq m^{-3} and 4 - 6 Bq m^{-3}, respectively. The

radon equilibrium factor varied from 0.29 to 0.43 around the burrows. The mean internal dose rates of the red fox and the raccoon dog were estimated as 56 nGy h^{-1} and 0.44 μGy h^{-1}, respectively, with dose conversion factors using a very simple phantom. The difference between them was mainly caused by the12 times higher body burden of ^{210}Po in the raccoon dog than the red fox. Voxel phantoms which had internal organs structure were produced for a mouse (*Apodemus argenteus*), a mole (*Urotrichus talpoides*) and a fox. The small animal phantoms were made by size adjustment of the Digimouse, which is a mouse voxel phantom published by the South California University. The phantom of the fox was constructed from the MRI tomography images for the red fox caught in this study.

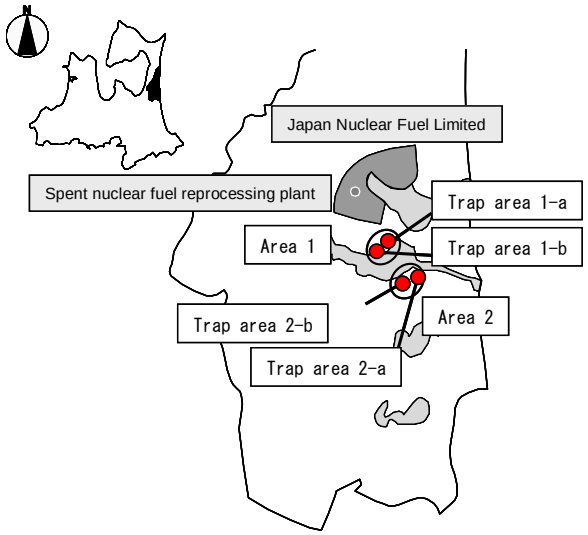

Fig. 1 Sampling sites (●) for medium-sized mammals in the southern part of Rokkasho

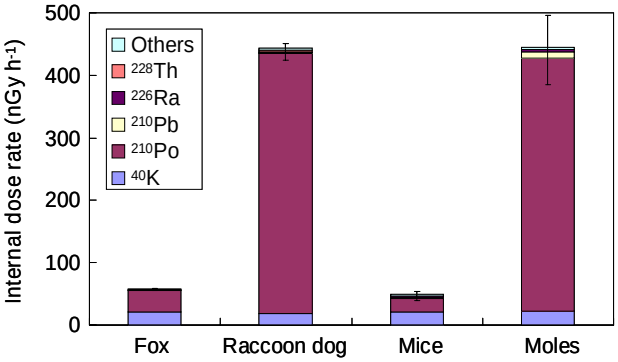

Fig. 3 Mean internal radiation dose rates of a fox, a raccoon dog, mice and moles. The rates and error bars of mice and moles show the mean and standard deviations of results from 20 samples in beech (2006), oak (2007) and coniferous (2008) forests of Rokkasho. "Others" means the sum of doses for ^{137}Cs, ^{228}Ra, ^{232}Th, and ^{234,238}U.

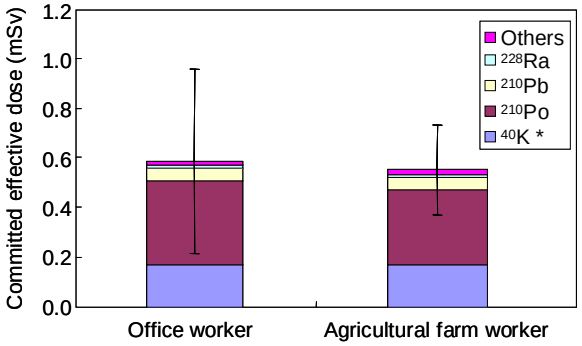

Fig. 2 Mean committed effective dose from natural radionuclides ingested annually through total diet samples of agricultural farm workers in FYs 2008-2009 and of office workers during FYs 2006-2009 in Rokkasho Village and Aomori City. Each error bar shows the standard deviation of results from 16 farm workers and 32 office workers, respectively. "Others" means the sum of doses for ^{14}C, ^{137}Cs, ^{226}Ra, ^{228,232}Th, and ^{238}U.

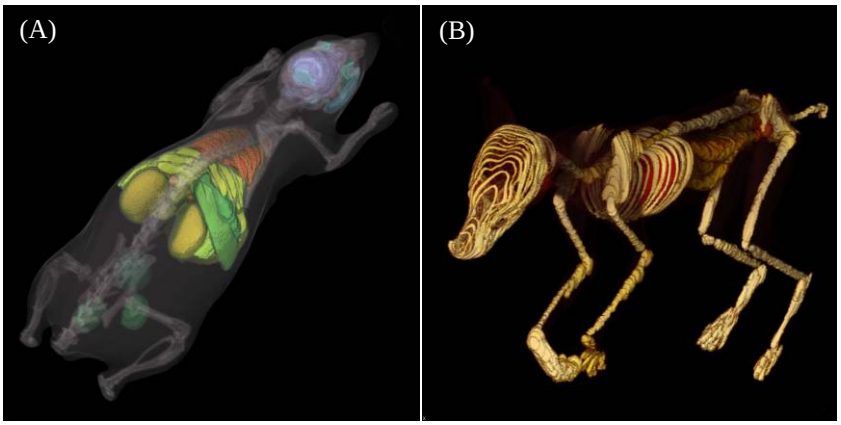

Fig. 4 Diagonal views of (A) a mouse (*Apodemus argenteus*) and (B) a fox (*Vulpes vulpes japonica*) for voxel phantoms