(4) External doses to the public from contaminated land

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Abstract–A significant amount of radioactive material was released into the environment by the accident at the Fukushima Daiichi Nuclear Power Plant (Fukushima I NPP) of the Tokyo Electric Power Company Holdings, Inc., which was caused by the Great East-Japan Earthquake and tsunami that struck Japan on 11 March 2011. The radioactive materials were widely deposited on the ground around the Fukushima I NPP, where they elevated the radiation dose. To protect the public from radiation exposure, the effective doses in the environment contaminated with radionuclides need to be determined. In particular, because of the relatively long half-lives of cesium and high energies of radiated photons, radioactive cesium (^{134}Cs and ^{137}Cs) deposited on the ground after the accident is one of the most important nuclides for estimating medium-term to long-term doses resulting from external exposure in Fukushima. Effective doses are usually estimated on the basis of measurable quantities by using conversion coefficients that are calculated for a particular situation of each exposure. The International Commission on Radiological Protection (ICRP) provided a database of conversion coefficients to convert particle fluence or air kerma to effective dose under idealized irradiation situations in the ICRP *Publication 116*. However, for estimating the external doses to the public from contaminated land, directly applying the data of the *Publication 116* is difficult because the radionuclides are distributed in the soil and isotropically emit radiation. In addition, the effective doses need to be estimated from the activity concentration, personal dose equivalent Hp(10), or ambient dose equivalent H*(10) that have been measured in Fukushima. In this work, a database of conversion coefficients to convert the activity concentration to the effective dose rate for various ages that represent general population has been constructed for external exposure to radioactive cesium distributed in the soil, and the relationships between the personal dose equivalent rate, ambient dose equivalent rate, and effective dose rate have been analyzed. The age-dependent conversion coefficients were calculated for planar sources of radioactive cesium at source depth of 0.0, 0.5, 2.5, 5.0, 10.0 and 50.0 g/cm^2 in the soil by incorporating the ICRP reference phantoms for newborns; 1-, 5-, 10-, and 15-year-old children; and adults into the Particle and Heavy Ion Transport Code System (PHITS), which is a Monte-Carlo simulation package. The definition of the effective dose given in the ICRP 2007 Recommendations was applied to the dose estimation not only for adults but also for children and babies here. The personal dose equivalent rate monitored by a personal dosimeter worn on the bodies of the public and the ambient dose equivalent rate were calculated in the same environmental radiation fields, and were compared with the effective dose rates. From the results, it was found that the personal dose equivalent provides a good estimate regarding the effective dose in the contaminated environment and does not exceed the ambient dose equivalent value at a height of 100 cm above the ground, while the effective doses for younger people are higher than those for adults. This means that the radiation exposure of the public in Fukushima can be controlled adequately by monitoring the personal dose equivalent using a dosimeter. In addition, the activities of the ICRP Task Group 90 for developing age-dependent conversion coefficients for external exposure to various radionuclides in air, soil and water are also introduced in the workshop.