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Efforts of JSHWR to the Great Earthquake and a new model for assessing internal dose based on hydrological methodology

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Japan Society of Hydrology and Water Resources (JSHWR) established the "Special subcommittee of countermeasures against disasters caused by the Great East Japan Earthquake" to cope with rapid and remarkable influences with regard to hydrology and water resources within a month after the earthquake occurred. This subcommittee was established aiming to contribute for restoration in the disaster areas, strengthening information exchanges and coopration with the other societies and focusing the problems to be solved from the position of hydrology and water resources. JSHWR urgently asked for research groups to support the initial movements for establishing research activities with regard to hydrology and water resources contributing restoration in the disaster areas. Three groups were funded as the urgent research groups about two months after the earthquake. The groups investigated the destruction of an earth-fill dam, the groundwater changes, and the hydrological dynamism of radioactive materials. Preliminary results of the urgent research were reported at the annual meeting of JSHWR held at the end of August 2011, and further results were reported at the annual meeting of JSHWR next year. The groundwater research group has cooperated with the Japanese Association of Groundwater Hydrology as well as the local governments where the groundwater investigations were made. The radioactive group has further established research projects studying hydrological processes in terms of radioactive materials, and studies of long-term monitoring.

In order to cooperate with other research fields including countermeasures against disasters, we propose a readily-understandable internal dose calculation based on the hydrological methodology. The system of electrical facilities to control Fukushima Daiichi nuclear power plant (NPP) was destroyed by the subsequent tsunamis of the Great East Japan Earthquake. Several radioisotopes leaked from the damaged reactor containment vessels and diffused. The effects of internal exposure caused by radioactivity on food supply have become an issue of great interest. The internal dose calculation which includes complex mathematical model of the human body (computational human phantom) has been developed by radiologists. The International Commission on Radiological Protection (ICRP) recommendation is accepted the model as an accurate method for dose limits. However, it is too challenging for general technologists who do not specialize in radiology. In order to overcome the above difficulty, a new model has been developed in which the human body is treated as a single vessel. The conservation of the number of radioisotopes and radioactivity in the human body is described by the continuity equation. The beta and the gamma ray from cesium-137 are treated as a concrete example because it is noticed due to the NPP accident. Radioactivity in the body decreases exponentially because of radioactive decay. That is why the continuity equation of the number of radioisotopes is described by the first order ordinary differential equation, which can be solved analytically. The equation which describes radioactivity is equivalent to that of the number of radioisotopes because radioactivity is proportional to the number of radioisotopes. Internal total exposure dose is obtained from time integration of radioactivity. The absorbed energy into the human body per one radioactive decay event is estimated based on the Fermi theory of beta decay. The effective dose is calculated from internal exposure dose, absorbed energy per radioactive decay and the body weight. The comparable accuracy of our method calculating the effective dose is demonstrated by comparison with previous research. Our method to calculate radioactivity can be applied to not only the human body but also the soils and agricultural products. In summary, our method provides an understanding of the influence of radioisotopes for general technologists.

Keywords: nuclear accident, urgent survey, internal dose, lumped model