From Japan to the World

Studies in the Department of Radioecology, Institute for Environmental Sciences

Yuichi TAKAKU*¹

The Institute for Environmental Sciences (IES) was established in 1990 at Rokkasho, Aomori Prefecture, Japan, as a juridical foundation by the former Science and Technology Agency (present Ministry of Education, Culture, Sports, Science and Technology). The main targets of our research are the behavior of radionuclides released from the first commercial reprocessing plant in Japan, located in Rokkasho and the biological effects of low dose-rate radiation. This research has been done by the Department of Radioecology and the Department of Radiobiology, exploiting four facilities: Artificial Climate Experiment Facility (ACEF), Closed Ecology Experiment Facilities (CEEF), Low-Dose Radiation Effects Research Facility (LERF) and Advanced Molecular Bio-Science Research Center (AMBIC). In this paper, we give an introduction to the research works of the Department of Radioecology.

The Department of Radioecology studies the behavior of radionuclides in the environment and radiation dose evaluation from them to the local population and to the environment itself. For this purpose, we constructed a computer model to simulate the behavior of radionuclides in the environment and make radiation dose assessments. The model is an integrated one covering a broad range of transfers of radionuclides in various environmental media. It consists of a radionuclide atmospheric dispersion model and a terrestrial and aquatic transfer model. The simulation results are compared and validated with measurements from around the plant. Site-specific parameters and submodels used in the model have been obtained through various research works in the field and in laboratories. We have two facilities, ACEF and CEEF, for those works in the laboratories.

The ACEF is for studying the effect of various climate conditions on the transfer of radionuclides in the environment. For that purpose, one large and five small artificial climate experiment chambers were installed in the ACEF. The large chamber is 13 m high by 11 m long by 12 m wide (**Fig. 1**) and has functions to control meteorological elements in the range given in **Table 1**. It has apparatuses for simulating rainfall, snowfall and fog and can simulate Yamase condition, which is a common local climate condition in Pacific Ocean side of the Tohoku area, with low temperature and fog in spring to early summer. We are now studying the weathering effects of

various meteorological elements such as wind, rainfall and fog on the retention of iodine on the surface of grass leaves.

The five small chambers, which are 2.5 m high by 2.7 m long and wide, were also set up for various experiments. Two of the chambers are installed in a radiation controlled area of ACEF. Each of the chambers can control temperature, humidity and light intensity. Those chambers are used for experiments about the behavior of cesium and iodine in soil environments and the cultivation of experimental plants.

The CEEF was constructed for studying the behavior of gaseous material such as $^{14}\text{CO}_2$ and HTO. It has air-tight plant cultivation chambers in which various plants can be sustained for a certain period without an exchange of materials with the outside environment. We studied about the transfer of ^{14}C and ^3H from the environment to plant body by using ^{13}C and ^2H as tracers, respectively. The transfer of $^{13}\text{CO}_2$ and HDO from the atmosphere to rice, grass, leafy and root vegetables were investigated to construct each dynamic model. These models can simulate the retention of target nuclides in their edible parts cultivated in varying atmospheric concentration of the nuclides.

We also studied the method of assessing radiation dosage to the human body and to the environment itself. The dose conversion factors of ^{14}C and ^3H now in use for radiation protection are conservative because of the lack of data for their metabolism in the human body. We are trying to establish more realistic dose conversion factors through the experiments with volunteers using ^{13}C and ^2H as tracers. After labeled component of sugar, protein or fat, such as glucose, amino acid or fatty acid, were orally administered to the volunteers, the excretion of ^{13}C and ^2H to breathe air, urine and hair was monitored to construct a dynamic metabolism model of each component.

For the protection of the environment itself, the dose evaluation method for wild organisms is required. We constructed voxel phantoms of various wild organisms such as mouse and fox, and obtained dose conversion factors of internal and external radiations using the phantom by a Monte Carlo method. Most of the background radiation to wild organisms generally originated from internal irradiation of alpha-ray from ^{210}Po .

Fig. 1 A view of Large Artificial Climate Experiment Chamber.

*¹ Department of Radioecology Institute for Environmental Sciences;
1-7 Ienomae, Obuchi, Rokkasho-mura Kamikita-gun, Aomori 039-
3212, Japan.
E-mail: ytakaku@ies.or.jp

Table 1 Control range for various climatic parameters of large chamber.

Parameters	Control range	Note
Temperature	-25~50°C	
Humidity	20~90%RH	
Solar radiation	15,000~50,000 lx	2.5 m from the Light Source
Rainfall	10~100 mm/h	
Acid rain	10~20 mm/h	~pH 3
Snowfall	50~250 mm/day	
Fog	~2 g/m ³	5~100 micro meters
Acid fog	~2 g/m ³	5~100 micro meters, ~pH 3
Wind	~0.5 m/sec	

Finally, we describe our new research projects. The prediction of soil-to-plant transfer factors of radiocesium to local soil are important for taking countermeasures against the contamination of field soil by unexpected releases. We are studying the relationship between various soil characteristics

and transfer factors and then searching for countermeasures to control or reduce the transfer. The research on the transfer factors of alpha-emitting radionuclides and the biological effects of radiation on wild organisms are also important themes in future.