Priority Subjects with Limited Terms — **Establishment of Optimal Risk Management**

Assessment of Radioactive Material Diffusion in the Environment and its Remediation Effectiveness

Background and Objective

Preliminary assessments must be carried out on the environmental impact of radioactive materials on the atmosphere, ocean, and groundwater in the case of severe accidents as well as the effectiveness of preventive measures against nuclear power plant accidents in order to evaluate and continuously improve the safety of nuclear power plants.
The target of this study is to develop techniques for predicting the dispersion of radioactive materials into the atmosphere, ocean, and groundwater as well as for monitoring radioactive materials and assessing the migration of radioactive materials in marine organisms and forests. Through the development of these techniques, we aim to contribute to improving the safety of nuclear power plants through the assessment of environmental impact.

Main results

1 Developing assessment techniques for the atmospheric diffusion of radioactive materials

An atmospheric transport model for wide areas has been developed to simulate the transport and deposition of radioactive materials to the ground surface. The long-term cumulative amount of radioactive materials, released from Fukushima Daiichi Nuclear Power Plant and deposited on the ground surface, has been estimated (Fig. 1). Models for wet and dry deposition were also incorporated into another dispersion model used to assess the safety of nuclear power plants over relatively small areas. Such added features have enabled the developed model to be used for estimating the amount of deposited radioactive materials during the safety assessment of nuclear power plants.

2 Developing assessment techniques of ocean diffusion of radioactive materials and transfer to marine organism

The amounts of ^{137}Cs, ^{134}Cs, and ^{131}I directly released from Fukushima Daiichi Nuclear Power Plant were estimated from the results of monitoring the adjacent sea. On the basis of the estimation results, the oceanic dispersion of these radioactive materials over wide areas off the coast of Fukushima was simulated by considering the fallout of materials from the atmosphere. The simulation results were in good agreement with the monitoring results for the target area (Fig. 2).*1 Concentrations of the radioactive cesium in marine organisms were estimated using a food chain transfer model. A simulation showed that decreases of the calculated concentrations over time in plankton feeding fish such as Japanese sand lance and carnivorous fish such as olive flounder were similar to those observed in the monitoring results (Fig. 3).*2 The estimated amounts of directly released radioactive materials were reported by TEPCO to the Nuclear and Industrial Safety Agency and are also included in the report by the Investigation Committee on the Accident at Fukushima Nuclear Power Stations of TEPCO.*3

3 Development of a method for predicting migration of radioactive materials in ground

A numerical simulation method has been developed to assess accurately the migration behavior of radioactive materials in ground by groundwater via groundwater as a transport medium. The developed method was applied to the simulation of groundwater flow and migration of radionuclides at a model site over several decades. In the future, the method can be used to evaluate the safety of interim storage facilities and disposal facilities for radioactive wastes.

4 Assessment of the long-term environmental impact of radioactive material

Radiocesium (^{134}Cs+^{137}Cs) concentrations, primarily derived from the Fukushima nuclear power plant accident in March 2011, were measured in litterfalls of cherry and 6 other woody species at Abiko. The concentration in litterfalls of cherry, horse chestnut, and trident maple collected in late autumn was fewer than those collected in early autumn, and the reduction in radiocesium concentration in the litterfall was nearly synchronous with potassium concentrations (Fig. 4). It is possible that this phenomenon occurred due in part to physiological features of the plants which led to a translocation of potassium from leaves to the body/twigs.

*1 TSUMUNE DAISUKE, et al., Biogeosciences Discuss., 10, 6259-6314, 2013 (doi:10.5194/bgd-10-6259-2013).
*2 TATEDA YUTAKA, et al., Journal of Environmental Radioactivity. 2013, vol. 124, p. 1–12.
*3 Report by Investigation Committee on the Accident at Fukushima Nuclear Power Stations of TEPCO, 20 June 2012. http://www.tepco.co.jp/nu/fukushima-np/interim/index-j.html, 2013/3/19

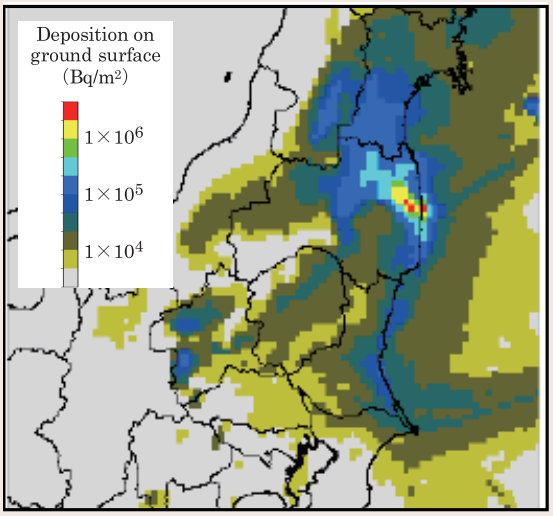

Fig. 1: Example of simulation to determine the cumulative amount of radioactive materials deposited on the ground surface over wide areas using an atmospheric transport model

The cumulative amount of radioactive materials deposited on the ground surface was estimated using a model developed to simulate the concentration and amount of deposited radioactive materials. The estimation is based on detailed meteorological data of March 2011, obtained using a meteorological model, and the amount of released radioactive materials estimated by the Japan Atomic Energy Agency. The simulation reproduced the distribution of the cumulative amount of radioactive materials deposited on the ground surface obtained by aircraft monitoring and the radiation dose monitored at each monitoring point with reasonable accuracy.

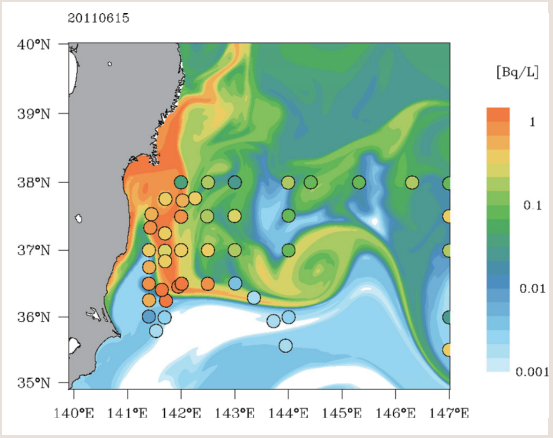

Fig. 2: ^{137}Cs concentration on the ocean surface (off the coast of Fukushima)

The ^{137}Cs concentrations in the ocean in the middle of June 2011 obtained by simulation were in good agreement with the monitoring results, confirming that the concentration distribution is affected by medium-size vortices in the ocean. Color contours represent the simulation results, and color plots represent the monitoring positions and concentrations.

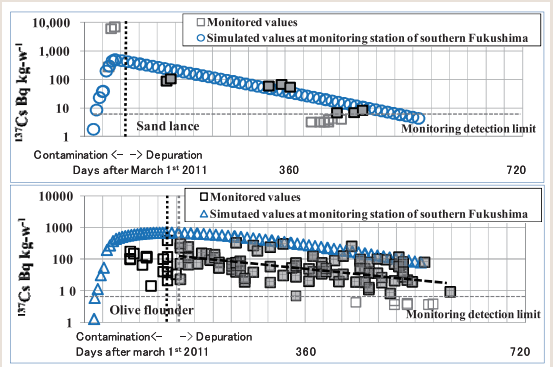

Fig. 3: ^{137}Cs concentrations in marine organisms obtained by simulation and monitoring (along the southern coast of Fukushima)

Regarding plankton feeding fish such as Japanese sand lance (top) and coastal carnivorous fish such as olive flounder (bottom), the ^{137}Cs concentrations in their muscles, including those resulting from transfer through the food chain, decreased after March 2011 and August 2012, respectively, according to the simulation result, which was similar to the monitoring results. This indicates that the migration processes of radioactive cesium, being governed by their contamination from seawater, transfer through prey ingestion, and excretion from organisms by their metabolism, were accurately simulated by the technique developed to assess the dynamic migration of radioactive cesium in ecosystem.

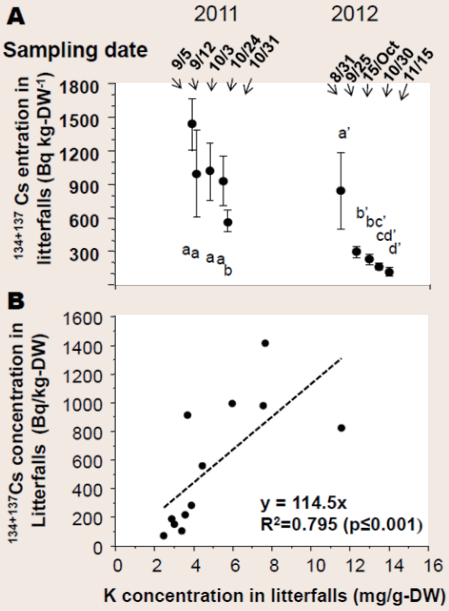

Fig. 4: A correlation between radiocesium concentration and potassium in cherry litterfalls

Radiocesium concentrations in litterfalls of cherry collected between 5 Sep and 31 Oct, 2011, and 31 Aug and 15 Nov, 2012 gradually decreased as the sampling date in successive years (top). A strong correlation is observed between radiocesium concentrations and potassium concentrations in cherry litterfalls (bottom).