Project Research — **Establishment of Optimal Risk Management**

Assessment of Radioactive Material Diffusion in the Environment and its Remediation

Background and Objective

An urgent task is to clarify the current status of environmental contamination caused by the release of radioactive materials from the Fukushima Daiichi Nuclear Power Plant accident in order to assess the environmental impact and the environmental remediation necessary. The degree of this environmental contamination greatly exceeds that expected for nuclear power plant accidents in the governmental guidelines in terms of the amount of radiation and damage, and thus it cannot be dealt with by conventional assessment methods.

The target of this study is to clarify the current status of the above environmental contamination using cutting-edge simulation techniques, focusing on the atmosphere, ocean, and groundwater, as well as to develop techniques for assessing the amount of radioactive materials falling from the atmosphere to the ocean and ground, which causes the spread of contamination. We also clarify the current status of soil contamination as a step toward environmental remediation as well as developing environmental monitoring techniques that can be applied to forests, which account for the majority of the contaminated region.

Main results

1 Clarifying the Current Status of Air Contamination and Developing Assessment Techniques

It is necessary to clarify how radioactive materials released from the Fukushima Daiichi Nuclear Power Plant into the atmosphere have been transported and dispersed in the atmosphere and deposited on the ground surface. The research team developed an atmospheric dispersion model to simulate the atmospheric concentration and deposition of radioactive materials in the Kanto and Tohoku regions (V11054). The simulated results show that the model well reproduced the temporal change in the atmospheric concentration of radioactive materials in the Kanto region (Fig. 1). The research team also discussed what part of the model should be improved for a more detailed and accurate analysis of the deposition processes of radioactive materials.

2 Clarifying the Current Status of Ocean Contamination and Developing Assessment Techniques

The advection and diffusion of radioactive materials released into the ocean from the Fukushima Daiichi Nuclear Power Plant was simulated using the regional ocean model developed by the Environmental Science Research Laboratory. The research team clarified the status of dispersion, such as the peaks in the concentration of radioactive materials in the surface layer of the ocean offshore from the Fukushima coast, and predicted the future trend of the decrease in the concentration (V11002) (Figs. 2 and 3). These simulation results were reported by TEPCO to the Nuclear and Industrial Safety Agency and then opened to the public (http://www.tepco.co.jp/cc/press/11052103-j.html). The simulation of oceanic diffusion has made it possible to estimate the amount of radioactive materials directly released into the ocean from the Fukushima Daiichi Nuclear Power Plant.

3 Decontamination of Soil and the Assessment of Long-term Environmental Impact

Conventional decontamination techniques to restore the environment and their effects should be summarized, and the current status of environmental contamination should be monitored using simple methods. The research teams simplified a method for measuring the distribution of radioactive elements in soil using a handy CsI (TI) scintillation spectrometer with a collimation technique*1 (V11026) and a method for estimating radioactive concentration in soil using a Geiger-Müller (GM) counter*2 (V11052). It was shown that these measurement methods made it possible to easily clarify the current status of environmental radio-contamination, such as the distribution of radiocesium at different depths in the soil (Fig. 5). Another research team clarified how the dose rate is affected by the amount of radiocesium on trees, which depends on the tree species and location, with the aim of establishing a radiation management system for streamlining the clarification of the status of contamination in forests and for implementing necessary decontamination work (V11027) (Fig. 4).

*1 The spatial dose rate refers to the radiation dose from surrounding radioactive materials per unit time in a target space and is given in microsieverts per hour (μSv/h).
*2 GM counters are devices used to measure the amount of radioactive materials in samples as a count rate by detecting the ionizing radiation in a GM tube filled with a gas used for detection.

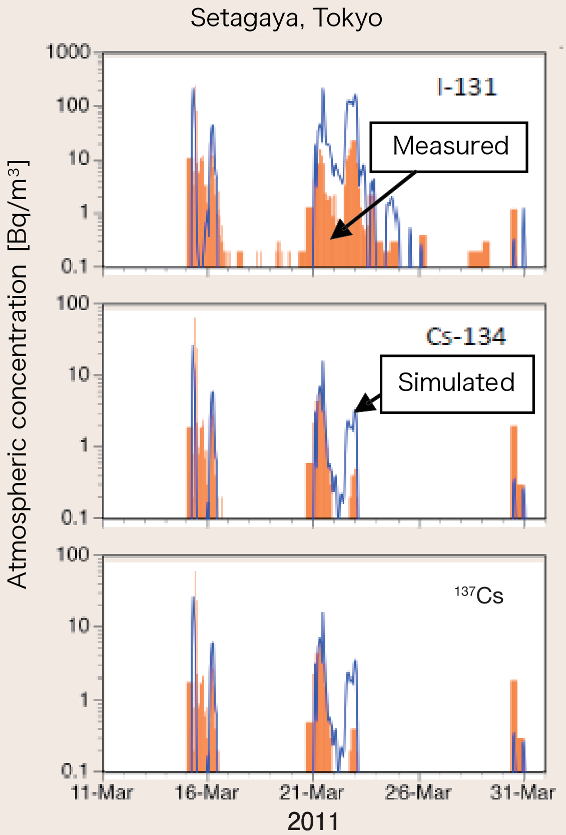


Fig. 1: Atmospheric concentrations of radioactive materials

The atmospheric dispersion model shows the spatial and temporal changes in the atmospheric concentration of radioactive materials released from the Fukushima Daiichi Nuclear Power Plant. The results shown are for March 2011 at a location (Setagaya, Tokyo) approximately 255 km from the power plant.

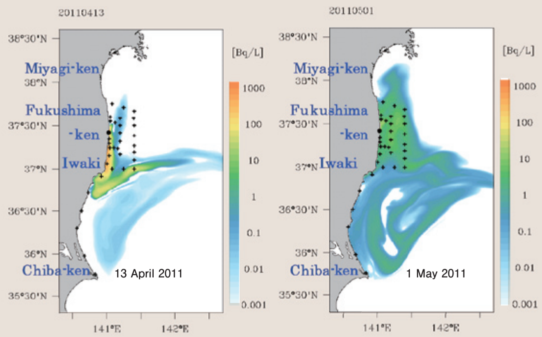


Fig. 2: Diffusion of radioactive materials in surface layer of the ocean (simulation results)

Simulation results indicate that radioactive materials released into the ocean diffused along the coast then into the open ocean with the presence of a meso-scale eddy (April 13). The materials then spread as far as offshore of the Chiba coast (May 1). (The dots in the figure represent monitoring points.)

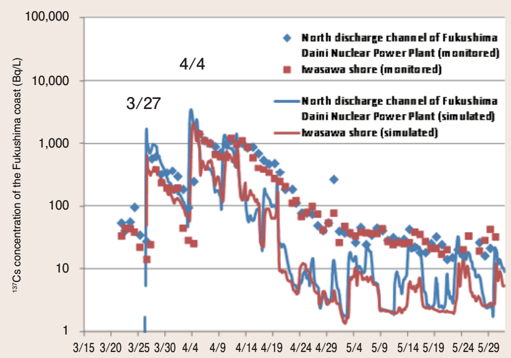
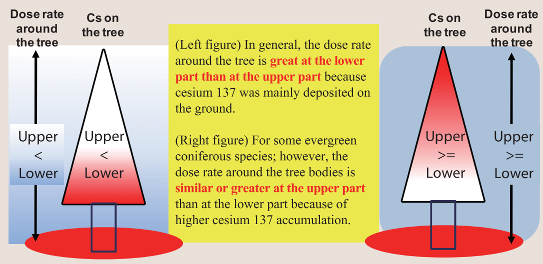


Fig. 3: ^{137}Cs concentration in the surface layer of ocean

Simulation results indicate an increased ^{137}Cs concentration in the surface layer of the ocean (after March 27) caused by the direct leakage from the nuclear power plant and a peak in ^{137}Cs concentration on April 4.



Camphor, Japanese red pine, Moso bamboo, Wax myrtle, Viburnum awabuki	Evergreen species	Cypress, Himalayan cedar, Japanese cedar
Metasequoia, Trident maple, Cherry blossom (someiyoshino), Flowering dogwood, Sycamore, Horse chestnut	Deciduous species	-

Fig. 4: Radiocesium contaminations of trees and the corresponding gamma-ray dose rates

Gamma-ray dose rates around trees and the cesium radioactivity of some parts of the trees were measured for various species. The results revealed that specific evergreen coniferous trees, such as Japanese cedar and Hinoki cypress, had higher radioactivity at their tree tops, and an affected dose rate around their canopies (red parts in the figure). This could be strongly associated with conditions of the fallout, the foliar morphology, and the timing of leaf expansion and defoliation.

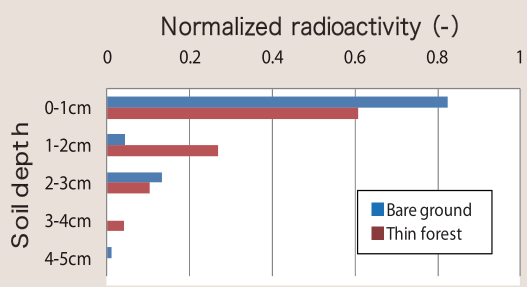


Fig. 5: Depth distribution of radioactive materials in soil

Radioactive materials diffuse to a greater depth in forested areas with large voids in the soil, whereas they remain in the surface layer of bare land. This indicates that the proportion of radioactive materials at each depth in soil depends on the soil properties.