Quantitative Analyses of Radioactive Cesium from the Fukushima Dai-ichi Nuclear Power Plant Accident in Soils

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Tremendous amounts of radionuclides were released from the Fukushima Dai-ichi nuclear power plant (FDNPP) to environments during the severe accident of the FDNPP caused by the Tohoku earthquakes and subsequent tsunamis on March 11th, 2011. Some of radionuclides were released on purpose to atmosphere and sea during emergency venting and disposal of low-level contaminated water after the reactor cooling, respectively, and others by accident through hydrogen explosions of the overheated reactor vessels and leakage of highly contaminated cooling water. Total amount of radionuclides released to atmosphere is estimated to be more than 370,000 TBq [1, 2]. Radionuclides deposited from atmosphere, mostly radioactive I (^{131}I) and Cs (^{134}Cs and ^{137}Cs), caused widespread contamination of cities, agricultural lands and forests of east Japan and have threatened ordinary lives of many Japanese people in different aspects. Inhabitants within 20 km radius from the FDNPP as well as those living in highly contaminated areas outside this perimeter have forcedly evacuated. Contamination of agricultural, animal and marine products has posed serious economical and emotional impacts for their producers and consumers. Decontamination and monitoring of the radionuclides in different compartments of the environment is on-going tasks for scientists and engineers in various fields; understanding their chemical behaviors in soil is one of the major issues.

In this talk, detailed analyses of radiocesiums in soils collected from Fukushima prefecture after the accident will be presented. Soil samples were obtained in the series of environmental monitoring campaigns led by the Department of Nuclear Engineering and Management, the University of Tokyo, which started immediately after the accident to investigate the magnitude of the contamination in soils around the FDNPP not only by radiocesiums but also by short-lived radionuclides such as ^{131}I that were hardly detected in later investigations [3]. Sequential extractions were performed for 12 soil samples to chemically separate radiocesium into various fractions. Mineral residues after the extraction were further size-fractionated, using wet sieving and sedimentation.

Radiocesium, ^{137}Cs, was predominantly found in mineral and ion-exchangeable fractions of the soils and scarcely in water-soluble fractions, as expected from the soil analyses performed in Europe after the accident of the Chernobyl NPP [4]. Size fractionation of the mineral fractions further revealed preferential association of ^{137}Cs with relatively small mineral particles. The distribution of ^{137}Cs among different chemical fractions were compared with those of stable cesium, ^{133}Cs, and discussed in terms of their isotopic exchange, from which one could assess the direction of future re-distribution of ^{137}Cs in the soils. Mineral and organic fractions of some of the soil samples were found to be depleted in ^{137}Cs relative to ^{133}Cs, suggesting disequilibria of ^{137}Cs/^{133}Cs exchange reactions and the presence of chemical fluxes of ^{137}Cs to these fractions. The distributions of ^{137}Cs as well as those of the ^{137}Cs/^{133}Cs ratio were further studied with respect to their correlation with important soil parameters such as the contents of organic carbon and clays. Such correlation analyses helped us to discuss possible mechanisms of Cs uptake by soils and their kinetics.

References

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