Report on “Radiation Disaster Recovery Studies”

Course: Radioactivity Environmental Protection

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○Regarding“Radiation Disaster Recovery Studies”

（Describe your thoughts, the process you engaged in and your research progress regarding Recovery from Radiation Disaster.）

Triggering by the big earthquake and massive tsunami that occurred at offshore of the Pacific Ocean led to the Fukushima nuclear power plant accident on March 11^{th,} 2011 [1]. The nuclear power plant accident was known as one of the biggest nuclear disasters in the world following Chernobyl in April 1986 and Three Mile Island in March 1979. By accident, there was a tremendous amount of radioactive materials released into the air with the radioactivities of ^{131}I, ^{132}Te, ^{134}Cs, and ^{137}Cs were estimated to be 160, 88, 18 and 15 PBq [2]. When they deposited on the ground soil or felt down on aquarium medium, they made the vast radioactivity contaminated regions along with the Tohoku prefectures of Japan [3]. Short half-live radionuclides as ^{131}I, ^{132}Te were decayed out after several months of the accident. In contrast, ^{134}Cs and ^{137}Cs with long half-live of 2 and 30.1 years, respectively, take several years to a hundred years for decay [4].

The harmful effects of radioactive cesium on the human body have been investigated and reported by many researchers. The researches were carried out based on laboratory animal organisms by exposing to ^{137}Cs sources. Besides, surveys on the people living in highly contaminated regions after the Chernobyl accident were also conducted. The collected data indicated that radioactive cesium is highly concentrated in kidneys, myocardium, skeletal muscles, spleen, and lungs, testicle, and liver. Also, by the results, the function and metabolic activity disorders of the cardiovascular system, liver, kidney, immunity system, and haemopoetic system rated with the external exposure and internal exposure [5]. The death cases were noted with the radioactivity concentration of ^{137}Cs amounted to 192.8 Bq/kg with adults and 645.3 Bq/kg with children in kidneys. The impact of ^{137}Cs on the human body shows that the protection of exposure to radiation, especially internal exposure, is crucial work.

On the other face of radiation impacts on the ecosystem, recently, researches on the effects of radiation to pines living in highly contaminated regions surrounding the Fukushima nuclear power plant showed that morphological effects of the pines are proportional to the exposure dose level of the ambient [6]. Besides, the impacts of radiation on the animals have been pointed by the forewing size reduction, growth retardation, high mortality rates and high abnormality rate in the pale grass blue butterfly [7], the abundance reduction of birds [8], butterflies and cicadas [9], body weight and head size reduction of monkey babies [10].

With the harmful effects due to radioactive cesium as mentioned above, the environmental dynamics

of them in an ecosystem is necessary to evaluate. Ordinarily, for the radioactive cesium released from the Fukushima nuclear power plant, the movement directions are considered in two ways such as migration in the soil and dispersion in the aquarium mediums. My doctoral thesis was chosen about the investigation of the environmental dynamics of radioactive cesium released from Fukushima nuclear power plant accident to make the migration process of radioactive cesium in soil clearer.

The thesis results suggested that although physical migration of radioactive cesium in the soil is fast moved down to deep layers, this process occurred after several months of the accident, then it was slowed down following time. Later years, the migration process is continued, however it is said that the radioactive cesium is mainly concentrated on around 5 cm soil layer from surface soil. The results from the research on the absorption of young pines indicated that the radioactivity concentration in plant is rated with that in the contaminated soil and the internal dose in the plants was estimated approximately 60 percent of total exposure dose. The results have meaning in monitoring the distribution of radioactive cesium in soil and estimating the absorption of young plants via root uptake.

○Title of Doctoral Thesis

Investigation on environmental dynamics of radioactive Cs released from Fukushima nuclear power plant accident

（福島原発事故に伴い放出された放射性 Cs の環境動態についての研究）

○Summary of Doctoral Thesis

（Describe so as to be easily understood, by relating it to“Radiation Disaster Recovery Studies”.）

The radionuclides released from the Fukushima nuclear power plant accident had made the soil contaminated in a vast region. This research has an aim to investigate the environmental dynamics of radiocesium in the soil environment to plant by root uptake process. To make the environmental dynamics clearly, estimation of the movement level in soil, and transfer from soil to plant are conducted.

Chapter I: The background and circumstance of the Fukushima Nuclear Power Plant accident and its effects on the environment are introduced briefly. Besides, the reason for choosing the Iitate village as a research location is explained.

Chapter II: Describe a method for soil sampling and young tree sampling in this investigation. These collected soil and young tree samples are prepared and measured by Imaging plate measurement and gamma measurement systems. The acquired results are used for further analysis in the next Chapters.

Chapter III: Introduce a technique for determining the shape of the depth profile of radiocesium in soil by using an imaging plate combined with the unfolding algorithm and PHITS code simulation.

By the proposed technique, the depth profile of radiocesium can be plotted with millimeter depth-bin width, which is quite difficult to be obtained by conventional techniques (sliding soil core).

Chapter IV: Migration velocity and diffusion coefficient are ordinarily considered as radiocesium movement indexes in soil, and they are solutions of the equation which are derived from Bossew and Kirchner-model for transportation of radionuclides in soil. The migration velocity by this model is independent of the time factor. However, observation results from previous researches of other authors shown that the migration velocity is a function of time. Therefore, in this study, an equation of migration velocity is assumed as an exponential function of time and applied for fitting the depth profiles of those obtained by the method in Chapter III.

Chapter V: In this chapter, the study aims to propose a soil-to-plant transfer coefficient formulation expressed using a soil-to-root transfer factor and root-to-plant translocation factor. The soil-to-root transfer factor is assumed as a ratio of radioactivity concentration in root to radioactivity concentration in soil at the same soil layer. The proposed formulation is applied for calculating the soil-to-plant transfer coefficient of young trees collected at Iitate village.

Chapter VI: Summarize the research results and suggestions for further research

○Other theses published in academic research journals

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[9]. Moller A P, Nishiumi I, Suzuki H et al., 2013. Differences in effects of radiation on abundance of animals in Fukushima and Chernobyl. Ecological Indicators, 24:75-81

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