Difference of ^{137}Cs concentration between Preferential flow and Matrix in forest soil in Fukushima Prefecture

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On March 11, 2011, the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident released large amounts of radionuclides into the environment. The environmental pollution caused by ^{137}Cs is considered to be a long-term problem. Clarifying the dynamics of ^{137}Cs in the environment will help revitalization of Fukushima Prefecture and provision of nuclear disasters in the future.

It is estimated that 70% of the ^{137}Cs released into land areas have been deposited in forested areas. In forests, radioactive cesium deposited on the canopy migrates to the land surface, and most of the radiocesium is now present in soil surface nine years after the accident. Radioactive cesium in soil surface deposited on land surface has gradually penetrated deeper soil layer over time. On the other hand, the mechanism of vertical migration of radioactive cesium in soil has not been elucidated exactly. Especially, infiltration by rainfall, biological disturbance, migration of soil particles, and preferential flow are regarded as important mechanism of downward migration.

The preferential flow is a flow of water that moves quickly downward through the macro pore in soil due to gravity. A study in swiss using dye tracer showed that ^{137}Cs concentration in stained soil (Preferential flow) are higher than in unstained soil (Matrix). However, although the method of this study can show the difference between only the concentration of radioactive cesium in the preferential flow and the matrix, it cannot show the total amount of radioactive cesium at each depth. The purpose of this study is to quantitatively clarify the influence of preferential flow on the vertical migration of radioactive cesium in soil.

The study was conducted on a plots of 1 m by 2 m situated in a cedar forest in the Akougi district of Namiemachi, Futabagun, Fukushima prefecture affected by the FDNPP accident. The soil is an acidic brown cambisol. To stain the preferential flow paths in the soil, we applied 10 L of deionized water containing 2 g L^{-1} rhodamine B with a portable sprinkling device. Two days after dye application, the scraper plate was firmly secure at two points near the tree and far away from the tree in the plot. The soil inside the fixed scraper plate was collected vertically downward at each depth. The sampling depth were set to 0-1 cm, 1-2 cm, 2-4 cm, 4-6 cm, 6-10 cm. At this time, the soil was collected separately into stained soil and unstained soil with spoons. By covering the area around the plot with a shading sheet and using blue light, the fluorescent dye was excited and the dyed soil was clearly visible. The collected samples was dried in a oven at 40 ℃ and sieved through a 2 mm sieve. Thereafter, the concentration of ^{137}Cs was measured using a Ge gamma ray detector.

As a result of the analysis, there was no significant difference between the two points near the tree and far away from the tree. The ^{137}Cs concentration of the preferential flow and the matrix decreased at each depth except for the depth of 0-1cm. The ^{137}Cs concentration of the preferential flow was higher than that of the matrix except for the depth of 0-1cm. Taking the ratio of ^{137}Cs concentration of preferential flow and matrix, in the plots near the trees, 0.57(0-1 cm), 1.07(1-2 cm), 1.27(2-4 cm), 1.62(4-6 cm), 3.02(6-10 cm). This indicated that as the depth increased, the preferential flow and strongly affected the ^{137}Cs

concentration.

These results suggested that ^{137}Cs may have been moved by preferential flow associated with rainfall. It is also considered that the preferential flow path is a stable environment even after more than 7 years from the accident. From these facts, it was shown that the influence of preferential flow is greatly observed in forest soil in Fukushima Prefecture.

Keywords: Preferential flow, 137Cs, FDNPP accident, Scraper plate

