Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

*Junko Takahashi[1], Daichi Hihara[1], Takuya Sasaki[1], Yuichi Onda[1]

1. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba

After the Fukushima Dai-ichi Nuclear Power Plant accident on March 2011, several studies including our own showed that the downward migration of ^{137}Cs from litter to mineral soil is more rapid in forests in Fukushima than in forests affected by the Chernobyl accident. Therefore, the downward migration within mineral soil layers is more important in predicting long-term dynamics of ^{137}Cs in forest ecosystems in Fukushima. In this study, temporal changes in the detailed vertical distribution of ^{137}Cs in litter and soil layers for 7 y (2011–2018) at three forest sites (Mixed Forest, Mature Cedar forest and Young Cedar forest) were investigated in Kawamata town, Yamakiya district to quantify the downward migration of radiocesium.

The soil samples were taken in 5 mm increments between 0–5 cm, 1.0 cm increments between 5–10 cm, and 5.0 cm increments between 10–20 cm using a scraper plate. From 2017, the saturation water under litter, 5 cm, 10 cm and 20 cm depth of soil layers were collected using tension-free lysimeter to estimate the amount of downward migration by soluble radiocesium in saturation water. The radioactivity of ^{137}Cs in the samples was determined by gamma-ray spectrometry.

For the Young Cedar site, the total inventory of ^{137}Cs in the litter and soil layers gradually increased with time owing to deposition from the canopy, whereas temporal changes in the total ^{137}Cs inventories were not clear for the Mixed Forest and Mature Cedar sites. The ^{137}Cs concentrations and inventories in the litter layer exponentially decreased with time for all sites, with more than 80–95% of the ^{137}Cs deposited on the forest floor distributed in the mineral soil layer by 2018. As the downward migration from litter to mineral soil progressed, the ^{137}Cs concentration in a few cm of mineral soil surface gradually increased and became higher than the ^{137}Cs concentration in the litter within 2–3 y of the accident. In the Mature Cedar site, the amount of downward migration of soluble radiocesium from litter layer to mineral soil surface was estimated at 0.60 kBq m^{-2} from Aug. 2017 to July 2018 and about 7% of total downward migration that was calculated from temporal changes in the vertical distribution of radiocesium. Both concentration and flux of radiocesium in saturation water were higher in summer than in winter. Because the dissolved organic carbon showed similar trend with radiocesium, it was suggested that radiocesium in litter and mineral soil was dissolved and penetrated downward with the decomposition of litter and soil organic matters.

The ^{137}Cs concentration in mineral soil layers exponentially decreased with depth throughout survey period, and an exponential equation fitted well. The relaxation depth of ^{137}Cs concentration in mineral soil layers estimated by the exponential equation were constantly increasing in the Mature and Young Cedar sites with 0.08 cm y^{-1}. In contrast, there was no temporal increase in the relaxation depth in the Mixed Forest site, although the percentage of ^{137}Cs inventory in subsurface soil layers deeper than 5 cm has increased with time.

Keywords: Fukushima Daiichi Nuclear Power Plant accident , forest soil, Cs-137, scraper plate, tension-free lysimeter

