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Towards prediction of redistribution of fallout radiocesium on forested area discharged from Fukushima Nuclear Power Plant

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Redistribution of fallout ^{137}Cs on forested area discharged from Fukushima Nuclear Power Plant (FNPP) is an issue of major concern for the people in Fukushima and its surrounding areas. To approach this question we investigated global fallout ^{137}Cs (^{137}Cs-GFO) from nuclear weapon tests in the atmosphere in the 1950s and 60s, and ^{137}Cs distribution derived from FNPP (^{137}Cs-FK) within the whole trees contaminated directly. We examined concentrations and amounts of ^{137}Cs-GFO in surface soils (0–5, 5–15 and 15–30 cm in depth) of 3470 samples at 316 sites all over Japan, which were collected just before the accident of FNPP. We determined ^{137}Cs-GFO activities by NaI well-type scintillation counter with its accuracy verified using measurements by a germanium detector. We divided 316 sampling sites into 10 groups separated by one longitudinal line and four transversal lines on the terrain of Japan islands, then analyzed rainfall and geomorphological effects on ^{137}Cs-GFO inventories. In addition to this dataset, we collected three whole tree samples of 26 year-old *Quercus serrata* at a contaminated area by FNPP accident in April, 2014 and examined concentrations of ^{137}Cs-FK of above- and belowground tree parts by a germanium detector.

We estimated an average of ^{137}Cs-GFO inventories of forest soils in Japan to be 1.7 $\pm$ 1.4 kBq m^{-2} as of 2008. ^{137}Cs-GFO inventories varied largely from 0–7.9 kBq m^{-2} among the country and accumulated greater in the north-western part along the Sea of Japan side. We detected rainfall effect on ^{137}Cs-GFO inventories, which were greater where winter rainfall was large. As for vertical distribution of ^{137}Cs-GFO, 44% of ^{137}Cs-GFO remained within the uppermost 5 cm of soil profiles whereas the rest of 56% existed in 5–30 cm in depth. This indicated that considerable downward migration of ^{137}Cs-GFO has happened during these fifty years in forest soils in Japan. However, multiple linear regression analysis by geomorphological factors related to soil erosion, such as inclination angle or catchment area calculated from Digital Elevation Model, showed almost no significant effects on distribution of ^{137}Cs-GFO.

With regard to tree samples directly contaminated by FNPP accident, concentrations of ^{137}Cs-Fk of coarse roots and stem woods were 100–400 Bq kg^{-1}. Concentrations of ^{137}Cs-Fk of fine to medium roots and branches were higher ranging 400–2000 Bq kg^{-1}. The concentrations of belowground and aboveground tree parts showed the same levels according to the size of organ. This indicated that ^{137}Cs-Fk went around the whole tree within these three years. We figured from the findings about ^{137}Cs-GFO and ^{137}Cs-Fk above that the contaminated roots of trees could be a source of ^{137}Cs transport from trees to soils. Distinguishing biological migration of ^{137}Cs between plants and soil from the secondary surface and vertical physical migration of ^{137}Cs in the soils is a clue to come closer to an important reliable prediction of future distribution of ^{137}Cs discharged from FNPP.