Preferential infiltration of the Fukushima accident-derived radiocesium into soil in the vicinity of Japanese cedar trunk

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Stemflow takes important role on the hydrological and chemical cycling in the rhizosphere because it brings intensive rainwater input to forest soil and enhances downward infiltration of rainwater along tree root network to deep soil horizon. However, there are few studies about the effects of stemflow on rainwater infiltration mechanisms by collecting of soil water. In addition, the radiocesium derived from the Fukushima Dai-ichi Nuclear Power Plant accident is mostly intercepted by forest canopy, and transferred to forest soil by rainfall and stemflow. In particular, at the base of tree trunk, it is reported that the concentrations of radiocesium in soil increases due to contribution of stemflow with the high concentrations, and it is concerned that root uptake is promoted. However, there are studies limited to soil only, and few studies analyzed the concentrations of infiltration water that transports radiocesium.
In this study, stemflow from ceder tree, and soil water at the vicinity area of the tree roots (Rd : root downslope) and far from the trunk (Bt : between trees) are collected from a cedar forest in Namie Town, Fukushima Prefecture, Japan. Samples were collected from June 24 to December 11, 2019 with a total precipitation of 1100 mm during the period. Water volume and dissolved ^{137}Cs concentration drived from the Fukushima Dai-ichi Nuclear Power Plant accident were measured. As a result, stemflow flux per unit basal area was much larger than throughfall, and the average dissolved ^{137}Cs concentration weighted by volume was about 5.0 times larger than throughfall. Regarding to soil water, the Rd which is located in neighbor of the trunk showed greater water infiltration flux than that of the Bt, and the average amounts of infiltration water which were normalized for open rainfall depth during the whole sampling period were 1.4 times and 3.0 times larger at 5 cm and 20 cm depth for the Rd than the Bt. On the other hand, the average dissolved ^{137}Cs concentration weighted by depth was 1.6 times and 1.5 times larger at 5 cm and 20 cm depth for the Rd than the Bt, respectively. The average flux of dissolved ^{137}Cs into soil during the observation period was 1.15 kBq/m^2 and 0.73 kBq/m^2 at 5 cm depth, and 0.73 kBq/m^2 and 0.16 kBq/m^2 at 20 cm depth of Rd and Bt, respectively.
Therefore, this suggests that infiltration water flux can be increased due to contribution of stemflow input at the base of tree trunk. In particular, it was found that infiltration at the depth of 20 cm exceeded the depth of throughfall. Also, for dissolved ^{137}Cs, the concentration of soil infiltration water is higher at the base of tree trunk contributed by stemflow with the high concentration than between trees contributed by throughfall with the low concentration, and it was clarified that dissolved ^{137}Cs flux at the vicinity area of tree trunk was increased by the large amounts of infiltraion water. However, the observation data of this study alone cannot quantify the proportion of rainwater components derived from stemflow in infiltration water at the base of the trunk and the effect on radioactive cesium concentration of infiltration water. To determine the role of stemflow on rainwater infiltration flux and the concentration of dissolved elements in the rhizosphere, further analysis is required to clarify detailed infiltration mechanisms by using multiple tracer techniques such as stable isotopic composition of water and by collecting root oriented preferential flow.

Keywords: radioactive cesium, infiltration water, stemflow, forest soil, the Fukushima Dai-ichi Nuclear Power Plant accident

