Transfer and Accumulation of Tritium and Radiocarbon in Terrestrial Ecosystems

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Abstract

Operation of the spent nuclear fuel reprocessing plant in Rokkasho, Japan, is accompanied by the discharge of a small amount of tritium (^{3}H, T) and ^{14}C mainly in the forms of HTO and $^{14}CO_2$, respectively. In terrestrial ecosystems around the reprocessing plant, both radionuclides are incorporated into organic compounds in plants mainly due to photosynthesis, followed by their supply to soil such as via dead leaves and roots. This raises a concern about accumulation of those radionuclides in soil, because soil organic matter is recognized as the largest carbon pool in terrestrial ecosystems. In order to predict the accumulation of those radionuclides in terrestrial ecosystems, simulation models to describe the dynamics of ^{3}H and ^{14}C in organic matter and HTO concentration in soil and plant are required. We selected a Japanese radish field, a meadow, and a forest of Japanese black pine (*Pinus thunbergii*), which are common around the reprocessing plant, as our targets. To construct those models, we are measuring many parameters, which will be used in the models, through field observations and laboratory experiments.

We established an experimental Japanese radish (*Raphanus sativus*) field in FY 2017 in our institute for determining the parameters of the soil moisture model. Temporal changes of the soil water content have been continuously measured in several soil layers during the crop cultivation period since FY 2017. Obtained data were used to construct soil water dynamics model mentioned below.

In a 50 × 50 m quadrat in a black pine forest established ~5 km east of the reprocessing plant in FY 2015, the growth rate of fine roots was measured by root-ingrowth cores installed in FY 2016. Monthly fallout rates of above-ground litter have been continuously measured from July 2015, for obtaining input rate of dead plant matter to the forest floor. For getting parameters affecting water dynamics in the forest, soil water content and soil properties affecting water percolation were measured.

In the experimental meadow established in FY 2015 in our institute, the growth data of timothy (*Phleum pratense*) germinated in autumn of 2015 have been continuously obtained in FY 2018. To clarify the long-term retention of photosynthate translocated to perennial plant parts (i.e., stem base and root), timothy was labelled with ^{13}C before the first harvest in FY 2018, and the concentration of ^{13}C in the stem base and root at the second and third harvest was determined. Since significant retention of ^{13}C in the perennial parts in the third-harvest plant was found, we decided that the cultivation of ^{13}C-labelled timothy should be continued in FY 2019 to establish the long-term retention of photosynthate in the parts.

Hydrological models to predict soil water dynamics in each of our targets, the Japanese radish field, meadow and forest, were constructed by using water content data in several soil layers. The model in the meadow was validated with an experiment spraying HDO on the ground surface. Although the estimated HDO concentrations agreed fairly well with the measured ones, further tuning of model parameters may improve the results.

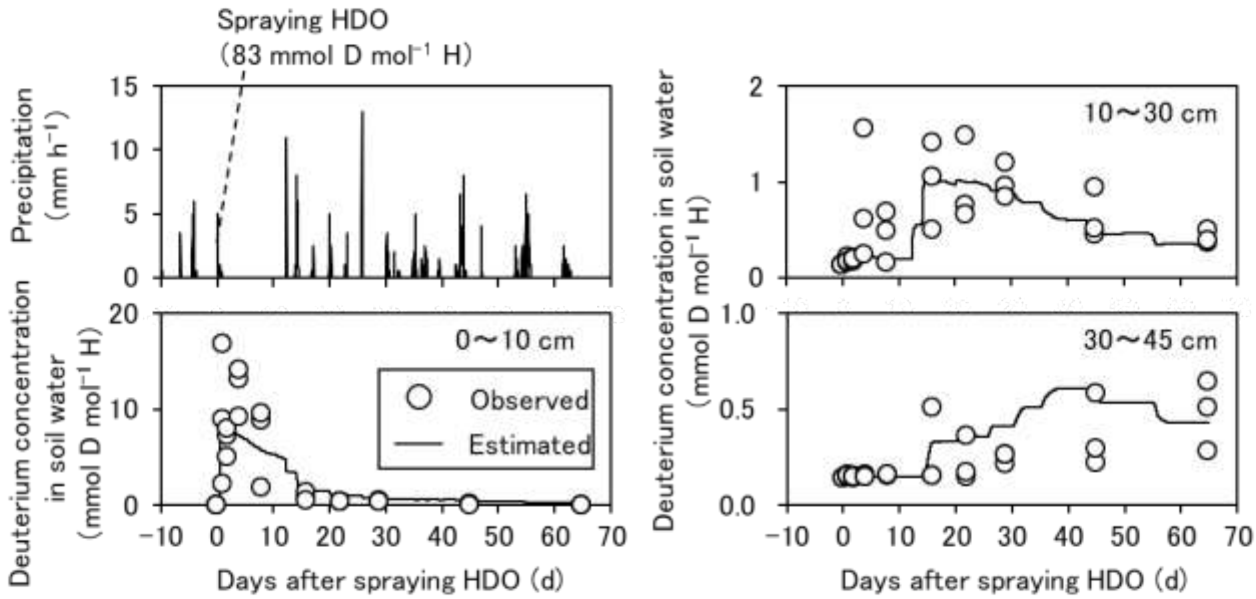

Fig. 1 Observed and estimated concentrations of deuterium in soil water of the 1-yr meadow where deuterium-enriched water (HDO) was sprayed to the soil surface. Replicated data are separately presented for each soil layer.