Transfer and Accumulation of Tritium and Radiocarbon in Terrestrial Ecosystems

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Abstract

The operation of the spent nuclear fuel reprocessing plant in Rokkasho, Japan, is accompanied by the discharge of a small amount of tritium (^3H, T) and ^{14}C mainly in the form of HTO and $^{14}CO_2$. 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 the 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 ^3H 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 target. To construct those models, we are measuring many parameters, which will be used in the models, through field observations and laboratory experiments.

After we established an experimental Japanese radish (*Raphanus sativus*) field in FY 2017 in our institute for determining the parameters of the soil moisture model, the growth data of leaves and roots and soil moisture were measured, followed by estimation of the water percolation parameters.

In a 50 × 50 m quadrat in a black pine forest established ~5 km east of the reprocessing plant in FY 2015, trunk circumference and tree height of all trees were measured for determination of growth rate of all trees during 2 years. 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 contentiously 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, water equivalent of snow 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 were obtained. The contribution of carbohydrates accumulated in stem base to newly produced shoot (leaf and stem) was found to be ~1% by analyzing the ^{13}C concentration in the first-harvested grasses after labeling with ^{13}C during the final growing period in the year before. To clarify the retention of ^3H photosynthesized during growth of the third-harvested timothy, timothy were sequentially exposed to deuterium-enriched water (HDO) vapor, followed by analyzing non-exchangeable organically bound deuterium (NxOBD) concentrations in the shoot at harvest. High NxOBD retention was observed in shoot exposed at 20-40 days after second-harvesting. A hydrological model to predict water dynamics in the meadow was constructed by using water content data in several soil layers in 2017 and validated with an experiment spraying HDO on the meadow. The results showed that further improvement of the model was necessary, though the values estimated by the model agreed fairly well with the measured results.

Finally, the basic models of ^3H and ^{14}C dynamics in the meadow and forest were constructed by using

provisional parameters and they were confirmed to run during 50 y without unreasonable outputs.

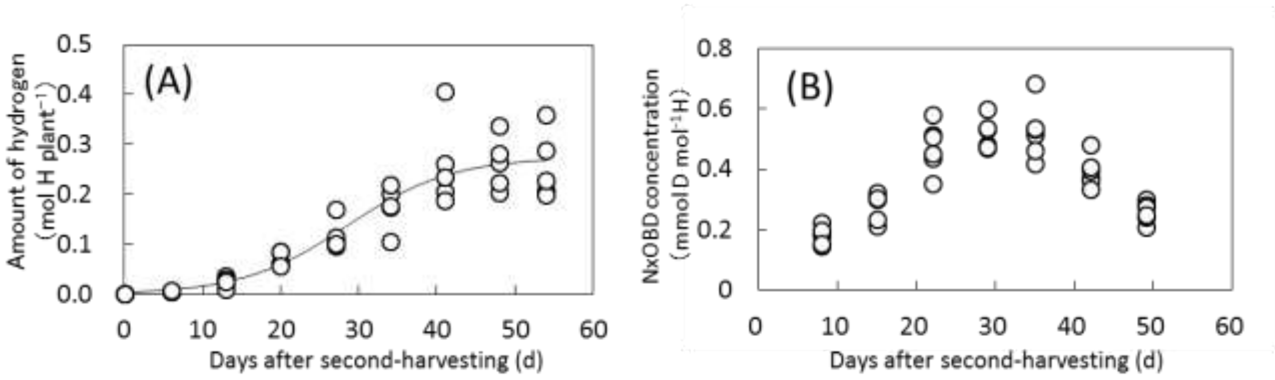

Fig. 1 Changes in hydrogen amount (A) and non-exchangeable organically bound deuterium (NxOBD) concentrations (B) in shoot (leaf and stem) harvested at 54 days after second-harvesting.