# 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 ($^3H$, 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 $^3H$ 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 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 the soil HTO dynamics model.

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 their growth rate. 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. The dead plant matter can be divided into decomposable and resistant materials, and the division ratio was determined by litter-bag experiments using $^{13}C$-labelled leaves of Japanese black pine. For getting parameters affecting HTO 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 2019. To clarify the long-term retention of photosynthate translocated to perennial plant parts (i.e., stem base and root), timothy labelled with $^{13}C$ before the first harvest in FY 2018 was continuously cultivated, and the concentration of $^{13}C$ in the stem base and root was determined in FYs 2018 and 2019.

Simulation models to predict the accumulation of $^3H$ and $^{14}C$ as organic matter in soils of the Japanese radish field, meadow and forest were constructed. We simulated the accumulation of $^3H$ and $^{14}C$ as organic matter in soils of the Japanese radish field, meadow and forest using our newly constructed model. In this simulation, temporal changes in the concentrations of $^3H$ and $^{14}C$ in soils during 40 years were calculated under the condition that the concentrations of $^3H$ and $^{14}C$ in air were constantly elevated. The concentrations

of $^{3}H$ and $^{14}C$ in soils increased, and only the concentration of $^{3}H$ reached the plateau level during 40 years because of its shorter physical half-life than $^{14}C$.

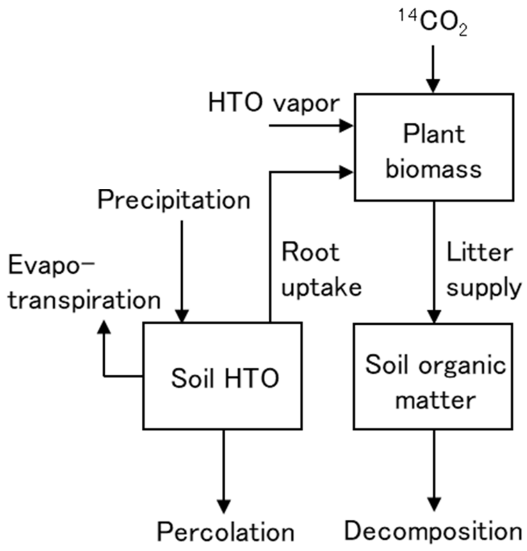


Fig. 1 Scheme of the simulation model to describe the dynamics of $^{3}H$ and $^{14}C$ in terrestrial ecosystems.

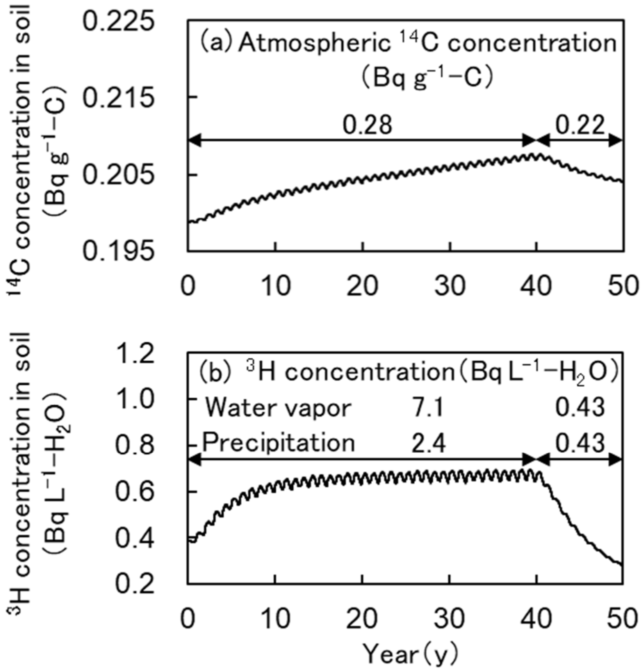


Fig. 2 Simulation results for the concentrations of soil organic $^{3}H$ and $^{14}C$ in a forest of Japanese black pine.