Tritium Transfer from the Atmosphere to Crops

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Abstract

Estimation of the specific activity of tritium in edible parts of crops is necessary to assess the local radiological impact of tritium released from the spent nuclear fuel reprocessing plant in Rokkasho, Japan. Chemical forms of tritium in plant are thought to be tritiated water (HTO) and organically bound tritium (OBT). In this study, tritium transfer from the environment to a leafy vegetable plant was described in a three-compartment model consisting of 2 compartments of free water in leaf associated (FW1) and not associated with transpiration (FW2) and organically bound hydrogen compartment in leaf (OBH). Tritium in the environment moves as free water into the FW1 compartment, and a part of the free water accumulated there is released into the atmosphere by transpiration and evaporation. The other part of free water in the FW1 relates to OBH synthesis and decomposition. The FW2 compartment exchanges free water only with the FW1 compartment. Leafy vegetable plants were experimentally exposed to deuterium (D)-enriched water under artificial illumination for 14 hours, and temporal changes in D concentrations of free water in leaf were determined. The model estimates of D concentrations of free water in leaf agreed relatively well with the experimental observation. In order to optimize the values of model parameters, the concentration of organically bound deuterium (OBD) in leafy vegetable plant needs to be determined using a newly developed experimental system.

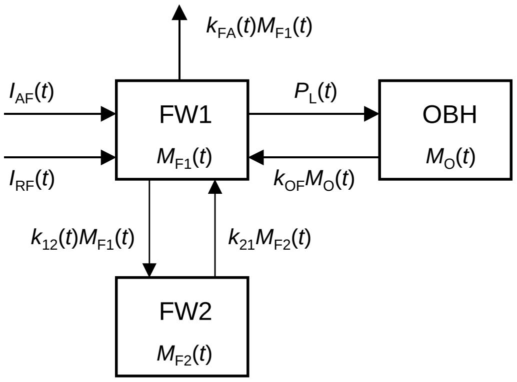

Fig. 1 Conceptual diagram of a dynamic three-compartment model.

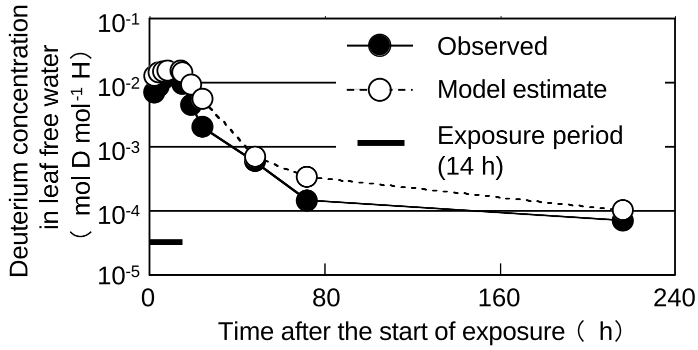

Fig. 2 Temporal changes in the observed and estimated deuterium concentrations of free water in leaf.

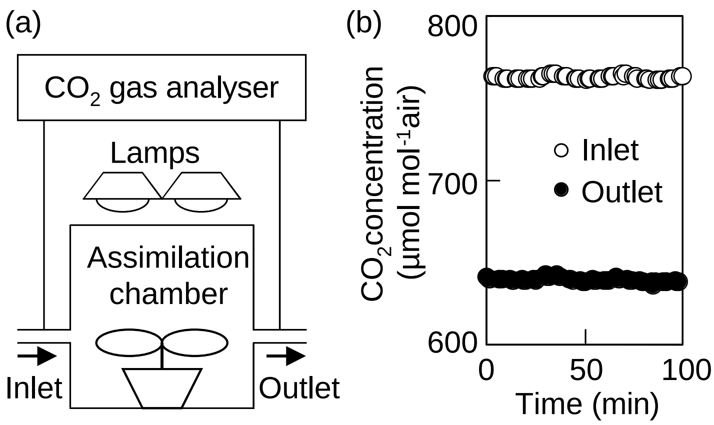

Fig. 3 (a) Schematic illustration of an assimilation chamber. (b) Changes in CO_2 concentrations measured at the inlet and outlet of the assimilation chamber containing a leafy vegetable plant. Photosynthetically active radiation at the top of the plant was 200 μmol m^{-2} s^{-1} during the measurement.

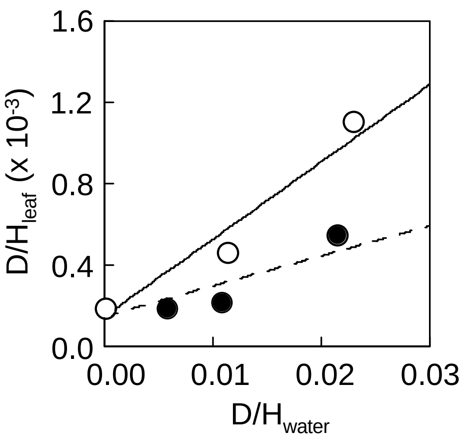

Fig. 4 Deuterium isotopic ratios (D/H) in dried leaf samples equilibrated separately with water vapor (open circle) and liquid water (closed circle) with different D concentrations. The gradient obtained by the linear regression method, which indicated the ratio of exchangeable OBH to the total OBH, was larger in the case of water vapor than in the case of liquid water.