Carbon Transfer and Accumulation in Forests, Wetlands and Farmlands

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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 ^{14}C mainly in the form of $^{14}CO_2$, which is transferred into terrestrial ecosystems and accumulated in them. In order to predict the fate of ^{14}C discharged from the reprocessing plant, it is necessary to develop a transfer and accumulation model of carbon in terrestrial ecosystems, including the processes of photosynthetic fixation of carbon and the decomposition of organic matter in soil. Various ecosystems, such as forests, wetlands, paddy fields, farmlands and pastures are found around the reprocessing plant. In FY 2012, we investigated: 1) the net primary productivity (NPP) in forests and tree plantations, 2) the gross primary productivities (GPPs) of carrot using the Closed Plant Experiment Facility, and 3) the decomposition rates of organic matter in soils by field and room experiments.

We selected the following as target forests and plantations in the study: a forest co-dominated by beech (*Fagus crenata*) and hiba (*Thujopsis dolabrata*) trees, a deciduous broad-leaved forest dominated by oak (*Quercus crispula*) trees, and two tree plantations of 20-y-old and 66-y-old Japanese cedar (*Cryptomeria japonica*) trees. The NPPs at the target fields were obtained as the sum of growth rate of the ground part biomass from 2010 to 2012, annual fine litter fall rate in 2012, and fine root growth rate in 2012. Although the obtained results were in the range reported in the literature, the estimation errors were large in the forests, and further study was required for getting precise results.

The GPPs of carrot were measured at three growth stages of the plants by pot cultivation experiments using soil from actual farmland. The air and soil temperatures, soil moisture, and light intensity were controlled to simulate conditions of the actual farmland. Both maximum GPPs and the initial slopes for photosynthesis capability of carrot decreased with the increasing number of days after sowing.

To investigate the decomposition rate of soil organic matter in forests, wetlands, paddy fields, farmlands and pastures, mixtures of ^{13}C-labelled plant powder and soil of each study field were packed into glass-fiber filter bags, and buried in each study field in FY 2011. Concentrations of ^{13}C in the bags were measured several times during the period to ~200 d after burying. The decomposition rates of soil organic matter were calculated using the measurement results; however, the obtained values were generally higher than those in the literature. Since coarsely cut plant matter was generally used in the previous studies, which differed from the present buried plant shape, this may be one of the reasons for the higher values of the present study.

To obtain temperature dependency of the decomposition rate of organic matter in soil, soil samples from forests, wetlands, paddy fields, farmlands and pastures were incubated in the laboratory at different temperatures (10, 20, and 30°C), and respired CO_2 amounts from the soil samples were measured to obtain the decomposition rates. The organic carbon decomposition was approximated by an exponential decay function with a constant term representing the hardly decomposed fraction. The rate constant of the decay function was fitted to the Arrehenius equation to obtain the rate constant at any temperature around the examined temperatures.

Table 1 NPPs of tree plantations and forests from field observations

Vegetation type	NPP (kg-dry m^{-2} y^{-1})
C. japonica tree plantations	
20-y-old tree plantation	1.6 ± 0.6
66-y-old tree plantation	1.4 ± 0.2
F. crenata- T. dolabrata co-dominated forest	1.3 ± 2.2
Q. crispula-dominated forest	0.8 ± 1.0

NPP: net primary productivity

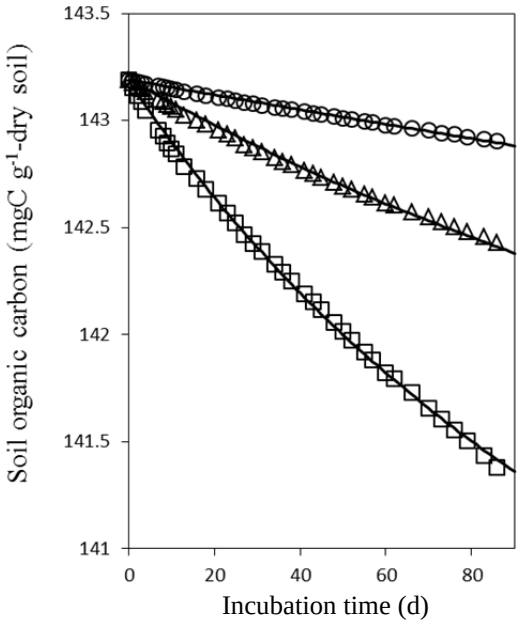

Fig. 1 Decrease in soil organic carbon incubated in oak (*Q. crispula*) tree-dominated forest soil at 10°C (○), 20°C (△), and 30°C (□).
Lines show estimated amounts of soil organic carbon by the model equation obtained in this study.