Development of Dose Assessment Method for a Conifer

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Abstract

Protection of an ecosystem itself from radiation has become an important theme in the research field of radiation safety. Since conifers are known to be more sensitive than other organisms in the general environment, we planned to establish the radiation dose assessment method for one type of conifer and get its natural background radiation dose rate. After considering that the first commercial spent nuclear fuel reprocessing plant is now under construction in Rokkasho, Japan, we selected a forest of Japanese black pine (*Pinus thunbergii*), about 4 km away from the main stack of the plant, as our target field. In addition, we studied the iodine dynamics in the forest for possible radioiodine release from the plant.

Four black pine trees in midrange size were felled as pilot samples in the target forest in 2016 for preparing a phantom of the tree type. Samples of different-age leaves, branches and trunks were collected, followed by measuring their dimensions, weights, and water contents. From the relation of the trunk diameters at several heights above the ground, heights and lengths of every branch, the shape of the trunk, the outer shape of the crown and the space inside the crown without leaves were found to be represented by cone shapes. Mean wet-weight and the standard deviation were 399 ± 176 kg of the above-ground parts of those samples. The wet-weight of their trunks, branches and leaves contributed about 89%, 8% and 3%, respectively, to the total weight on average.

For deciding the phantom composition, we measured stable elements in the plant parts, while we determined natural radioactive nuclide concentrations for calculating internal dose. For getting background external dose rate, the horizontal distribution of environmental γ-ray dose rates in the forest were measured with glass dosimeters. The dose rates at five or ten points in the forest were at a similar level with the mean dose rate of 22±0.4 nGy h^{-1}.

To study iodine dynamics in the forest, we made preliminary measurements of iodine concentrations in the tree samples, dry deposition fluxes onto the tree and removal rates by rainfall and litter fall. Mean inventories of stable iodine in the crown and trunk were evaluated to be 3.8E-3 and 1.7E-3 g $individual^{-1}$, respectively. The iodine dry deposition rate of 1.9E-4 to 9.6E-4 m s^{-1} to the forest crown was evaluated from the difference of dry depositions inside and outside the forest and gaseous iodine concentration outside the forest. The estimated deposition rate was comparable to that for methyl iodine reported in the literature. A mean removal rate of iodine from the crown by 1 mm rainfall was estimated to be 3.3E-6 g m^{-2} by the difference of wet iodine deposition inside and outside the forest. Litter fall including deciduous tree leaves contributed to the iodine removal of 3.5E-6 g m^{-2} d^{-1} in the forest during April 2017 – January 2018.

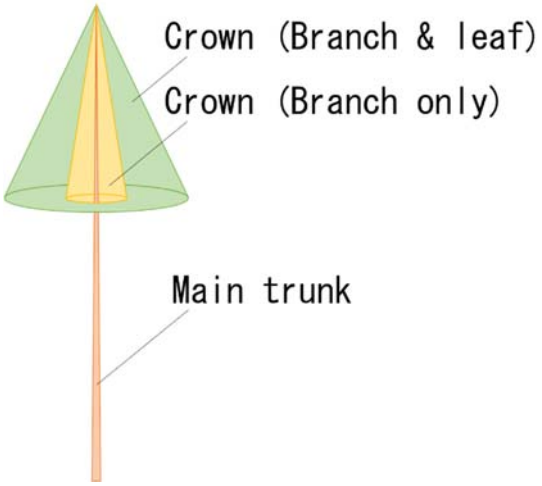

Fig. 1 The external form of Japanese black pine constructed based on the test trees in a Rokkasho forest.

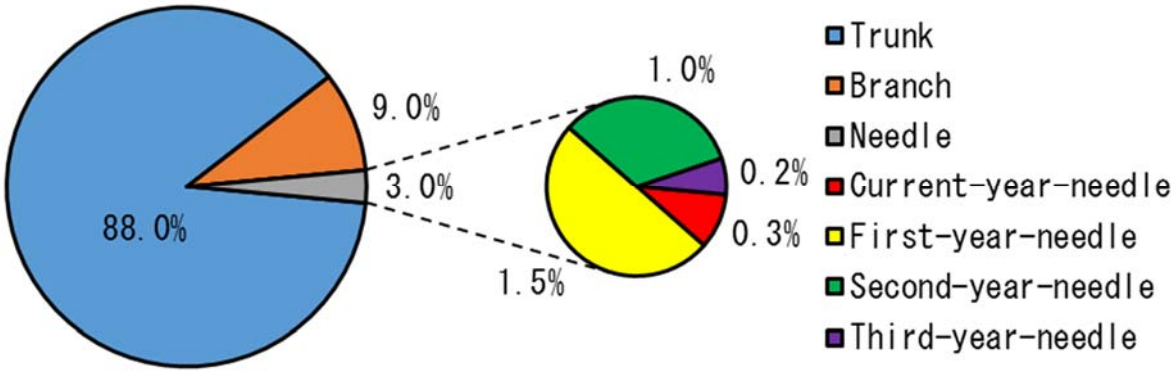

Fig. 2 The average percentage of wet-weight of each part in the above-ground part of four pine trees.