Development of Dose Assessment Method for Black Pine Conifer

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Abstract

Since conifers are known to be more sensitive to radiation exposure 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 preparing for full operation in Aomori Prefecture, we selected a forest of Japanese black pine (*Pinus thunbergii*) trees, about 4 km 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.

In order to evaluate radiation dose rate to the pine tree by the radiation transport code using a Monte Carlo method (PHITS), we constructed the pine tree phantom which matches the tree midrange size in the target field. The phantom was produced from shapes, weights, and elemental compositions which we obtained from seven tree samples collected during 2016 to 2019. The phantom of stem and canopy had a geometrical shape. In addition, three lateral branches at different heights, a stump, a horizontal root, and a tap root were polygon type phantoms with resolution of 1×1×1 mm. In our target field, the crown of a pine tree in the midrange size had about 23 nodes at different heights with 3 to 4 lateral branches on average. Furthermore, these trees having the same size as the main structure of the phantom were evenly distributed surrounding the phantom. By using PHITS, the phantom and mean concentration of radionuclides analyzed in the trees and soils collected from 2017 to 2019, we estimated absorbed dose rate in the whole tree was 51 nGy h^{-1} including cosmic rays.

To study iodine dynamics in the forest, we measured stable iodine concentrations in plant, atmospheric and hydrological samples collected inside and outside the forest. Mean dry deposition rates of particulate, and organic and inorganic gaseous iodine from the atmosphere to the above-ground part of the tree were estimated to be 6.7E-3, 2.1E-3 and 1.7E-2 m s^{-1}, respectively, by using data obtained during the non-precipitation period. We established collecting methods of ^{129}I in atmospheric and hydrological samples inside and outside the forest in order to evaluate dry and wet deposition velocities to the above-ground part and washing out rate from the above-ground part of ^{129}I released by the reprocessing plant. Furthermore, we obtained the concentration of ^{129}I in the tree and soil samples collected in 2019 by the AMS method.

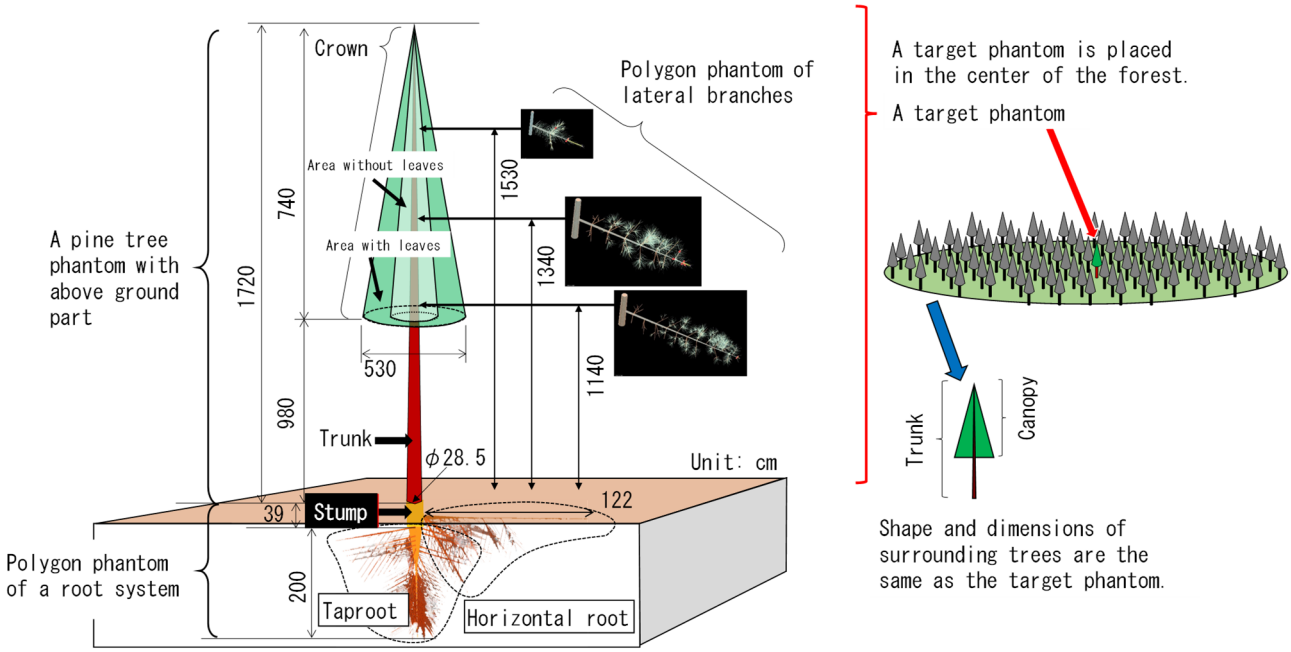

Fig. 1 Dimensions of a pine tree phantom centered in a black pine forest.