Development of Dose Assessment Method for a Conifer

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Abstract

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 preparing for full operation, 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.

To obtain basic data (shape, weight, elemental composition and radionuclide concentration) for a Japanese black pine tree of midrange size, one black pine tree of midrange size in the target field was collected each year from 2017 to 2019. Wet weights of the above-ground and root-system parts in the pine tree collected in July 2019 were found to be 378 kg and 80 kg, respectively. Litter and soil samples in 0 – 2 m depths around the pine tree were also collected and analyzed for apparent density, and stable element and radionuclide concentrations for radiation dose evaluation.

In order to evaluate radiation dose to the tree by the radiation transport code using a Monte Carlo method (NCNPX and PHITS), a pine tree phantom of the above-ground part had been constructed in FY 2018 and the root-system part was produced from results for two sample trees collected in FYs 2017 and 2018. The phantom consisted of a geometrically shaped main structure with voxel phantoms consisting of 1×1×1 mm voxels for a lateral branch at each of three height levels, and a below-ground part including a stump, a lateral root and a taproot. In our target field, the crown of a pine tree in the midrange size has about 23 nodes at different heights with 3 to 4 lateral branches on average. By using NCNPX and PHITS and the phantom, we estimated absorbed dose rate in the whole tree was 55 – 72 nGy h^{-1} including cosmic rays.

To study iodine dynamics in the forest, stable iodine concentrations in plant, atmospheric and hydrological samples collected inside and outside the forest were measured. Mean dry deposition rates of particulate, and organic and inorganic gaseous iodine from the atmosphere to the tree canopy were estimated to be 4.8E-3, 6.7E-3 and 1.2E-3 m s^{-1}, respectively, by using data during the non-precipitation period. The apparent removal rate of iodine by a 1-mm precipitation was estimated to be 4.8E-6 g m^{-2} during March – October 2019.

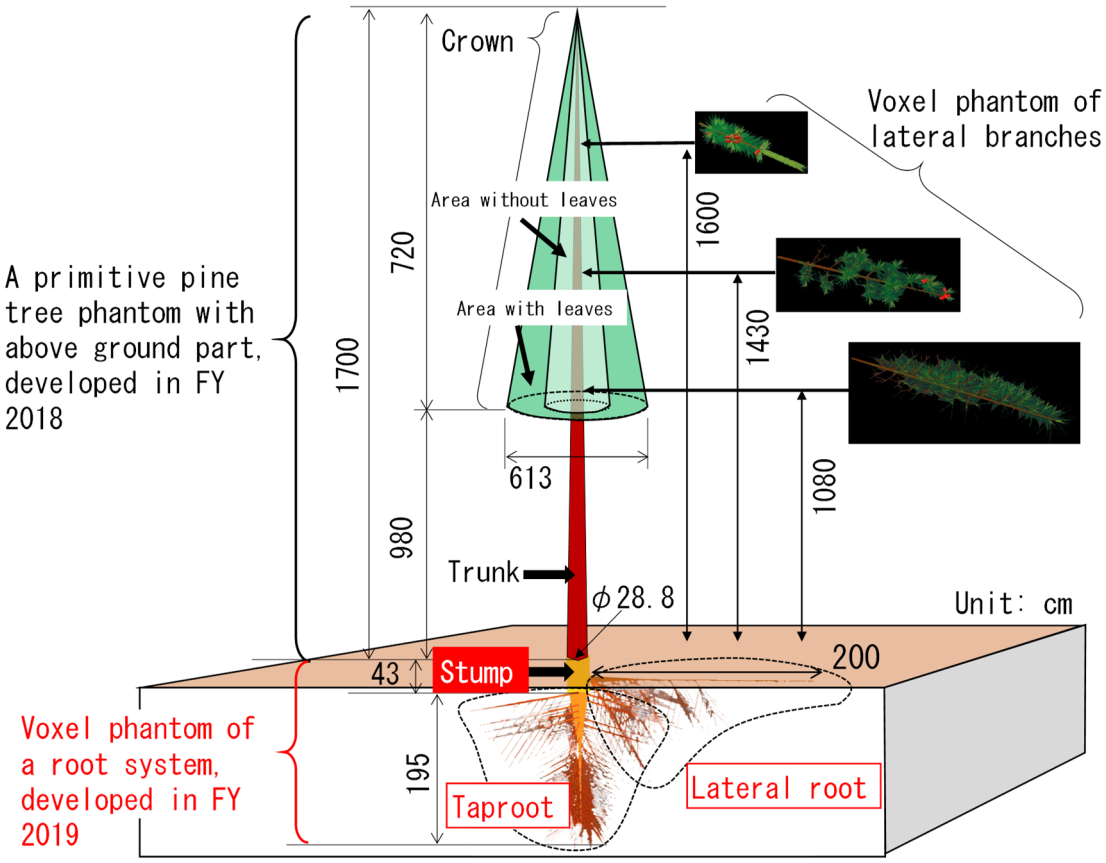

Fig. 1 Dimensions of a pine tree phantom with above and below ground parts.