Weathering of Iodine Deposited on Grass Leaf Surfaces

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Abstract

Radionuclides released into the atmosphere are deposited on the leaf surfaces of crop plants, taken up by the plants, and translocated from the leaves to other parts. Part of the radionuclides deposited onto the leaves is removed from the surface by the environmental process called weathering, i.e. removal by rain, wind, etc. Although weathering, foliar uptake and translocation are important processes involved in the radiation dose assessment of radionuclides in crops, parameters to describe those processes for ^{129}I, which is an important radionuclide for the safety assessment of the nuclear fuel reprocessing plant in Rokkasho, have not yet been elucidated. Since grasses are cultivated for livestock farming which is one of the important industries in Rokkasho, a research project to determine the behavior of iodine (I) on the surface of grasses was launched in FY 2011. In FY 2015, we studied the following subjects: 1) the effect of the growth stage of grasses on the foliar uptake and volatilization of I applied as inorganic vapor (I_2) onto leaf surfaces, and 2) the weathering of I deposited on leaf surfaces as I_2, dry aerosol or solution by simultaneous exposure to fog and wind.

After exposing Orchard grass (*Dactylis glomerata* L. var. Akimidori II) to I_2 vapor at 39 d or 49 d after sowing, the plants were cultivated for 7 d in an artificial climate chamber. The plant leaves were periodically collected, and the leaf surfaces were washed with solution containing detergent. The foliar uptake of I was measured by analyzing the leaves and the solution samples obtained by washing the surfaces. The I volatilized from the plant was collected on activated carbon paper filters. Immediately after exposing to I_2, more than 98% of the I in the plants was found in the leaves, then I in the leaves gradually decreased with increasing volatilized I. The behavior of I was almost the same at the two growth stages of the plant.

After applying 1) I_2 vapor, 2) liquid droplets containing NaI or $NaIO_3$, or 3) dry aerosol containing NaI or $NaIO_3$, onto the leaf surfaces of Orchard grass, the plants were simultaneously exposed to fog and wind. The exposure was carried out in a combination of fog with several atmospheric liquid water contents and wind of different wind speeds. The exposed plant leaves were collected and treated in the same manner as mentioned for the first study. For I applied as liquid droplets or dry aerosol, I retention in and on leaves in a fog with 47 mg m^{-3} liquid water content for 2 h exponentially decreased with wind speed. The I applied as I_2 was removed from the plants by the exposure to the fog and wind of 2 m s^{-1} for 24 h in contrast to the previous result showing no removal under the same fog condition without wind.

To summarize the weathering of I applied as iodate in liquid droplets by rainfall in the previous studies, compartment models of the I were constructed for describing foliar uptake, volatilization and weathering, and typical weathering half-life was obtained. A unit amount of radionuclide was assumed to deposit onto the leaf surface at noon of a given date, and then the behavior of the radionuclide was simulated with the model and actual weather condition during 60 d after the date. A half-life was calculated from the remaining proportion in the plant and on the leaf surface on the assumption of exponential decrease. The half-lives were obtained for each day from May to October in 2014 and from May to October in 2015. The median values of 250 half-lives obtained for iodate of liquid droplets was 38 d. The half-life in this study was longer than the weathering half-life (14 d) used in the safety review of the reprocessing plant.

Table 1 Statistics of half-lives calculated for IO_3^- using the compartment model

Statistic	Half life (d)
Arithmetic mean	36.9
Standard deviation	3.2
Geometric mean	36.7
Median	38.0
Minimum	17.3
Maximum	38.1
n=	250