Behavior of Trace Elements on Leaf Surfaces of Crop Plants

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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 to other parts from the leaves. Some amount 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 and translocation are important processes involved in the radiation dose assessment of radionuclides from plants, site-specific parameters to describe those processes have not yet been elucidated. This work aims to establish site-specific parameters for those processes for Cs, Sr, and I using stable elements in a climate chamber in which meteorological conditions are controlled. The effect of rainfall or fog on the behaviors of I (I^-, IO_3^-) on leaf surfaces was studied in FY 2010. Compartment models were constructed for describing the behaviors of Cs, Sr and I by using results from the studies in FY 2007-2010, and the weathering half-lives by rainfall for the elements were obtained with the models.

After applying solid aerosols of NaCl containing NaI or $NaIO_3$ onto the leaf surfaces of radish, *Raphanus sativus*, the plants were treated at different rainfall intensities and rainfall durations using a rain simulator or at different atmospheric liquid water contents and fog durations using a fog simulator. After a plant sample was collected, its leaf surface was washed with a solution containing detergent. The resulting washing solution and the plant sample were analyzed for I. The proportion of I remaining on the leaf surface decreased as the rainfall intensity and duration increased, and in an experiment with a fixed rainfall intensity, the proportion of I remaining decreased according to a function with two exponential terms for rainfall duration. Exposure to fog with the atmospheric liquid water content of 3.5 mg m^{-3}, that is the geometric mean value for fog in Rokkasho, had no effect on removing I from the leaf surface. When the atmospheric liquid water content exceeded 3.5 mg m^{-3}, I was removed from the leaf surface depending on the liquid water content and duration of the fog. The proportion of I remaining on the leaf surface in an experiment with a fixed liquid water content exponentially decreased with the duration.

Compartment models of the target elements were constructed for describing foliar uptake, translocation and weathering by rainfall. Typical half-lives of the target elements were estimated by using the models and actual weather conditions. 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 20 d after the date. A half-life was obtained from the remaining proportion in the plant and on the leaf surface on the assumption of exponential decrease. The half-lives were calculated for each day from May to October in 2005 - 2010. The median values of 820 half-lives

obtained for Cs, Sr, I^- and IO_3^- were 10, 7.6, 25 and 6.0 d, respectively. Only the half-life for I^- in this study was longer than the weathering half-life (14 d) used in the safety review of the large-scale commercial spent nuclear fuel reprocessing plant located in Rokkasho, Aomori Prefecture, Japan.

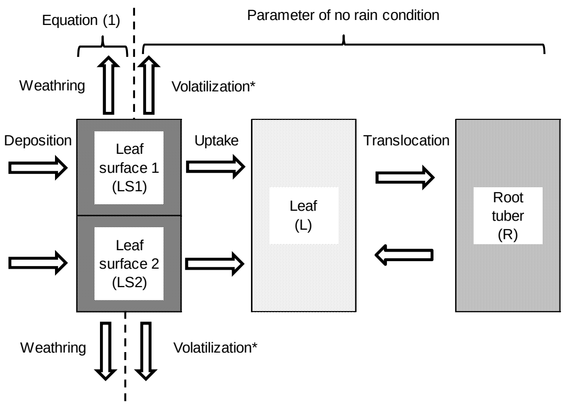

Fig. 1 Compartment model describing foliar uptake, translocation, volatilization and weathering by rainfall of Cs, Sr and I in plant.
* Only for I.

Table 1 Statistics of half-lives calculated for Cs, Sr, I^- and IO_3^- using the compartment model (Fig. 1).

Statistic	Half life (d)			
	Cs	Sr	I^-	IO_3^-
Arithmetic mean	9.7	7.3	23	5.7
Standard deviation	3.7	2.6	5.9	0.9
Geometric mean	8.7	6.7	21	5.6
Median	10.3	7.6	25	6.0
Minimum	0.32	0.32	0.67	0.41
Maximum	15.1	11.7	33	8.6
n=	820	820	820	820