Parameters of Iodine Migration in Soil

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Abstract

Iodine-129 (half-life, 1.6×10^7 y) is one of the important radionuclides discharged from the first commercial nuclear fuel reprocessing plant in Rokkasho, Japan for the assessment of radiation dose to the public. A part of the ^{129}I discharged to the atmosphere from the plant is deposited on the land surface and retained in surface soil. Downward migration of ^{129}I in soil is important for the prediction of its concentration in both ground water and surface soil during and after long-term operation of the reprocessing plant. The aims of this study are to evaluate the rate of downward migration of ^{129}I in soil around the reprocessing plant and to clarify physico-chemical and biological factors affecting the migration rate. In FY 2014, we studied: 1) the downward migration rate of ^{125}I in core samples of subsurface soil (0.5–3 m); 2) chemical form of stable I in surface soil in grassland and forest; and 3) the effect of pasture grassed and wild plants on the chemical form of stable I in soil solution by an experiment with cultivation pots.

A core sample in subsurface soil (0.5–3 m) was collected from grassland in Rokkasho to study the downward migration rate of I. The distribution coefficient (Kd) values of ^{125}I, as well as ^{85}Sr and ^{137}Cs, in the soil samples fractionated from different depths of the soil core sample were measured by the batch sorption method. Downward migration rate of the nuclides in a soil was estimated by using a retardation factor, which was obtained by the measured Kd value, under the assumption that half of the precipitation in Rokkasho permeates in the soil. The downward migration rate of ^{125}I, ^{85}Sr and ^{137}Cs ranged from 0.04 to 41 mm y^{-1}, 0.02–0.16 mm y^{-1} and 0.005–0.022 mm y^{-1}, respectively. The downward migration rate of ^{125}I significantly increased in soil under 2 m depth, while that of ^{137}Cs and ^{85}Sr in 0.5-3.0 m depth showed gradually increasing and decreasing trends with soil depth, respectively.

To study the chemical forms of stable I in soil, surface soil samples were collected at four points in each grassland area and forest around the nuclear fuel reprocessing plant at 5 cm depth intervals up to 20 cm. The organic layer including the root mat and O-horizon were also collected at each point. Soil solution of the surface soil sample was obtained by a centrifugation method and analyzed for I^-, IO_3^- and total I separately. The concentration of the total I in the soil solution ranged from 2.8 to 46 μg-I L^{-1}. The major form of I in the soil solutions was I^- (61%), whereas IO_3^- was not detected in any of the soil solution samples. Organic-I, which is assumed to be the difference between the total I and the sum of I^- and IO_3^-, was also a significant form of I in the soil solution. Water-soluble I, which was extracted at 1:10 (w/v) ratio with deionized water, occupied 0.03-1.2% of the total I in the organic layer and subjacent soil (0–5 cm) samples. The concentration of the water-soluble I positively correlated with that of water-soluble organic carbon, suggesting that migration of I would be affected by behavior of the organic carbon in the surface soils.

The chemical forms of stable I in the soil solution in cultivation pots of pasture grasses and wild plants were examined to study the effect of plant cultivation on I in soil. Concentrations of I^-, IO_3^- and organic-I in the soil solution were analyzed 1 d after adding I^- or IO_3^- solutions to the cultivated soil surface.

Concentrations of both I^- and organic-I in the soil solution samples were increased by the plant cultivation. The increasing ratio of cultivated soil to non-cultivated control depended on the cultivated plants. No IO_3^- was detected in any soil solution samples.

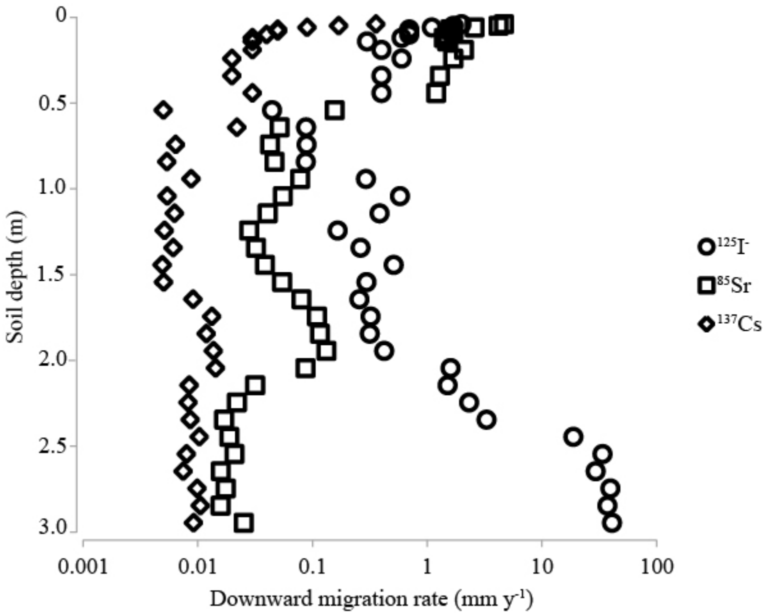

Fig. 1 Vertical profiles of downward migration rate.
Open circles, $^{125}I^-$; Open squares, ^{85}Sr; Small open rhombuses, ^{137}Cs. Migration rates of 0 to 0.5 m were adapted from the previous report in FY