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 that must be considered 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 2013, we studied 1) the downward migration rate of $^{125}I^-$ and $^{125}IO_3^-$ in core samples of surface soil, 2) the effect of soil water condition on the chemical form of stable I in soil solution, and 3) the effect of rice plant root activity on the chemical form of stable I in cultivated soil solution.

Undisturbed soil core samples were collected at a forest in Rokkasho to study the downward migration rate of I. The distribution coefficient (Kd) values of $^{125}I^-$ and $^{125}IO_3^-$, as well as ^{85}Sr and ^{137}Cs, in the soil samples fractionated from different depths (0–50 cm) of the soil core samples 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. The downward migration rate of ^{125}I in the two forms examined ranged from 0.1 to 69 mm y^{-1}, where higher values were observed within 3 cm in depth. The downward migration rates of ^{85}Sr and ^{137}Cs were 0.9–7.5 mm y^{-1} and 0.03–2.2 mm y^{-1}, respectively. Undistributed soil columns were prepared from the core samples, and the solution of ^{125}I was added on the soil surface of each column. Vertical distribution of the nuclides was investigated after passing simulated rainwater through it. The vertical distribution was not different between $^{125}I^-$ and $^{125}IO_3^-$ in the 0–20 cm soil column while the distribution in a soil column deeper than 20 cm suggested that the downward migration rate of $^{125}IO_3^-$ was higher than that of $^{125}I^-$.

Surface soil samples were incubated during 28 d under different water conditions: 30, 60, 100, 200 and 300% of the maximum water holding capacity. Concentrations of I^-, IO_3^- and total I in the soil solution collected at pre-determined periods after starting the incubation were analyzed. The concentration of the total I in the soil solution was remarkably high under the soil reducing condition at higher water content, in which I^- was the main form of iodine in the solution. No IO_3^- was detected in any soil solution samples.

The chemical forms of stable I in the cultivation solution of different rice cultivars with different root activities were examined to study the effect of plants on I. Concentrations of I^-, IO_3^- and organic-I in the soil solution were analyzed 4 d after adding I^- or IO_3^- solutions to the cultivated soil surface. Concentrations of I^- in all soil solution samples were not different from that in the soil solution without plants, so independent of the rice cultivars, while organic-I concentrations were increased for the plant cultivation, showing dependence on the rice cultivars. No IO_3^- was detected in any soil solution samples.

To investigate the effect of plant root activity on iodine speciation, rice plant cultivars were cultivated by sand-hydroponics using the cultivation solution with added I^- and IO_3^-. The concentrations of both I^- and IO_3^- in the solution decreased in the cultivation period. The I^- concentration depended on the rice plant cultivars, while the IO_3^- concentration did not.