Parameters of Iodine Migration in Soil

Hirofumi TSUKADA, Mutsumi YAMAGAMI, Akira TAKEDA,
Yuichi TAKAKU, Shun'ichi HISAMATSU
Department of Radioecology

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 2012, 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 temperature 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 cultivation solution.

Undisturbed soil core samples were collected from a grassland area 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 the soil was estimated by using a retardation factor that was obtained from the measured Kd value. The downward migration rate of ^{125}I in the two forms examined ranged from 0.3 to 2.3 mm y^{-1}, which was lower than the rate for ^{85}Sr and higher than that for ^{137}Cs. Undistributed soil columns were prepared from the core samples, and the solution of ^{125}I ($^{125}I^-$ or $^{125}IO_3^-$), ^{85}Sr or ^{137}Cs was added onto the surface of each column. The vertical distribution of the nuclides in the column was investigated after passing the artificial rainwater through it. Since the fraction of $^{125}IO_3^-$ at a depth to 20 cm was larger than that of $^{125}I^-$, it was suggested that the downward migration rate of $^{125}IO_3^-$ was higher than that of $^{125}I^-$.

Surface soil samples collected from three sites in Rokkasho were used in the soil incubation experiment under different temperatures: 4, 15, 30 and 45°C. Soil solution samples were obtained by high-speed centrifugation after the incubation within 18 d, and concentrations of I^-, IO_3^- and total I in the samples were analyzed. The IO_3^- concentrations in all soil solution samples were under the detection limit. While the concentrations of total I and I^- did not change in the samples incubated at 4, 15 and 30°C, the total I concentration for the 45°C incubation was significantly higher than that in the lower temperatures. Dissolved organic iodine was the main form of iodine solubilized under the highest temperature, though the I^- concentration in the soil solutions was also increased.

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.