1–7 Transport of Radionuclides in Depth Direction

— Investigation on Depth Distribution of Radionuclides in the Soil of Fukushima —

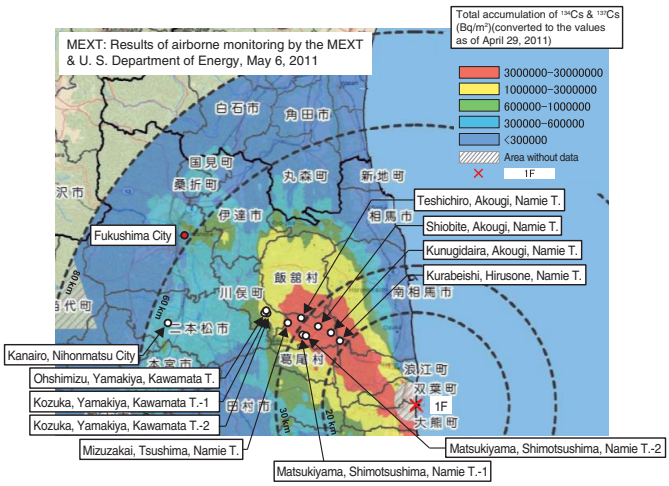

Fig.1-15 Locations investigated (although the distribution map was published on May 6, 2011, the values are those ones converted to as of April 29, 2011)

The investigation was conducted at 11 locations in Nihonmatsu City, where ^{131}I was detected from soil at that time, and Kawamata and Namie Towns, where R114 runs along the valley of Abukuma Highland. The sites are located northwest of 1F in an area through which a plume of RNs is considered to have passed.

Table 1-1 K_d values of ^{137}Cs and ^{131}I onto each soil sample

Sorption experiments by a batch method were conducted for soil samples taken at 11 locations (two different depths for each location).

Location	Soil	Depth (cm)	Distribution coefficient(K_d)					
			^{137}Cs(Cs^+ : cation)			^{131}I(I^- : anion)		
			pH	K_d(ml/g)	Error(±)	pH	K_d(ml/g)	Error(±)
Kanairo, Nihonmatsu City	Sandy	4–12	6.2	3.30E+03	2.38E+02	6.1	1.36E+00	1.34E−01
	Clayish	21–38	6.5	6.10E+04	9.75E+04	6.5	9.24E−00	1.31E−01
Kozuka, Yamakiya, Kawamata T.-1	Sandy	10–20	6.5	1.30E+04	5.15E+03	7.6	1.76E+01	1.85E−02
		32–43	6.2	4.24E+04	8.75E+04	6.1	2.37E+01	2.25E−01
Kozuka, Yamakiya, Kawamata T.-2	Sandy	15–20*1	5.8	1.87E+04	6.68E+03	5.8	4.44E+00	1.66E−01
		35–40*1	6.4	8.67E+03	1.63E+03	6.2	2.84E+01	2.92E−01
		5–15*2	6.1	2.88E+03	1.73E+02	6.2	1.84E+01	2.08E−01
		21–30*2	7.5	3.37E+03	2.40E+02	6.4	2.76E+01	2.58E−01
Ohshimizu, Yamakiya, Kawamata T.	Sandy	5–15	6.8	1.51E+04	6.52E+03	6.6	1.25E+00	8.78E−02
		33–41	7.3	4.31E+04	4.14E+04	7.1	5.52E−01	1.25E−01
Mizuzakai, Tsushima, Namie T.	Organic	8–18	5.8	2.24E+03	1.19E+02	5.8	3.08E+01	5.18E−01
		40–50	5.5	2.37E+03	1.26E+02	5.5	2.33E+01	4.12E−01
Matsukiyama, Shimotsushima, Namie T.-1	Sandy	8–19	6.7	4.01E+03	3.56E+02	6.6	1.20E+01	1.90E−01
		55–65	6.2	2.17E+04	1.60E+04	6.2	1.31E+01	1.54E−01
Matsukiyama, Shimotsushima, Namie T.-2	Organic	5–15	5.6	2.84E+03	1.86E+02	5.6	8.78E+00	1.35E−01
		20–30	5.6	2.97E+03	2.03E+02	5.6	1.30E+01	1.65E−01
Teshichiro, Akougi,Namie T.	Sandy	7–15	6.5	2.98E+03	1.92E+02	6.4	9.31E+01	6.58E−01
		29–36	6.1	7.43E+03	1.25E+03	6.2	5.99E+01	5.18E−01
Shiobite, Akougi, Namie T.	Sandy	10–23	5.8	2.16E+03	1.10E+02	5.7	1.42E+02	1.47E+00
		31–44	5.7	2.18E+03	1.07E+02	5.6	1.67E+01	3.08E−01
Kunugidaira, Akougi, Namie T.	Organic	10–15	6.0	2.08E+03	9.85E+01	6.1	1.19E+01	1.00E−01
		30–35	6.0	2.86E+03	1.85E+02	6.1	1.03E+01	1.36E−01
Kurabeishi, Hirusone, Namie T.	Sandy	10–25	6.5	2.16E+03	1.08E+02	6.6	2.08E+01	3.16E−01
	Clayish	33–46	6.5	3.53E+04	4.79E+04	6.5	2.58E+00	1.47E+01

Error: counting error, *1: soil core 1, *2: soil core 2

The accident at the TEPCO's Fukushima Daiichi NPS (1F), which was caused by the Great East Japan Earthquake in March 2011, led to the release of volatile radionuclides (RNs) that were deposited on the surrounding environment (e.g., soils, forests, residential land) around Fukushima Prefecture. The Ministry of Education, Culture, Sports and Technology (MEXT) initiated a project for making the distribution maps of dose rate, etc. in cooperation with Ministry of Agriculture, Forestry and Fisheries, JAEA, universities, etc. This work was conducted as part of the project described above.

The Geoslicer investigation examined the depth distribution of RNs in the soil as of about three months after the 1F accident. A total of 11 locations were selected in Nihonmatsu City, Kawamata Town, and Namie Town (Fig.1-15). Plate-shaped soil samples from a maximum depth of about 1 m (10 cm wide and 2 cm thick) were obtained, and soil samples for RN analysis were taken after the soil was observed and described. The γ decay nuclides were analyzed using a Ge semiconductor detector.

Both cesium-134 (^{134}Cs) and cesium-137 (^{137}Cs) were detected in all the locations investigated, and tellurium-129m (^{129m}Te) and silver-110m (^{110m}Ag) were detected only in locations where the dose rates were high. For the depth distribution of radiocesium (RC), at many of the locations investigated, RC more than 99% of the inventory distributed within depths of 10 cm and 14 cm in soil in the surface layer (mainly sandy soil) and in soil at locations that are supposed to have been used as farmland (mainly organic and clayish soils), respectively. The apparent diffusivities (D_a) derived from penetration profiles near the surface layer showed similar levels (10^{-11} m^2/s) for all the RNs detected, although the D_a values tended to be higher in the soil at locations that are supposed to have been used as farmland (D_a = 0.1~1.5 × 10^{-10} m^2/s) than in soil in the surface layer (D_a = 0.65~4.4 × 10^{-11} m^2/s). Because the distribution coefficients (K_d) of cations (Cs^+) and anions (I^-) differed significantly (Table 1-1), the respective D_a values were estimated to differ significantly. However, they were at similar levels for all the RNs; therefore, the D_a values were believed to be controlled by dispersion caused by rain water flow.

Thus, we can say that transport of RC in the soil is always quite slow because the K_d values onto soil are quite large. The transport of RNs in soil is strictly related to K_d, which depends on the minerals constituting the soil, their contents, the content of organic matter, and other factors. In particular, the clay mineral component affects the reversibility and irreversibility of sorption. For the long-term prediction of RC transport, it is essential to understand those details, and this remains as future work.

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Reference

Sato, H. et al., Investigation and Research on Depth Distribution in Soil of Radionuclides Released by the TEPCO Fukushima Dai-Ichi Nuclear Power Plant Accident, MRS Online Proceedings Library, vol.1518, 2013, 6p.