Groundwater flow system in Fukushima Prefecture traced by tritium-^{3}He and ^{129}I dating methods

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For developing and effective utilizing of groundwater resources, it is necessary to understand the large circulation of water from precipitation to use by residents (Mahara *et al.*, 1993). In particular, studying the residence time and source (recharge area) of the water is important in evaluating the groundwater flow system. In Fukushima Prefecture, although environmental behaviors of various radionuclides released by the accident of Fukushima Daiichi Nuclear Power Plant have been analyzed, there are few reports on the behavior and contamination status of groundwater by radionuclides, which are necessary to be assessed for safety use of groundwater resources in the future.

In this study, we investigated the groundwater flow system in Fukushima Prefecture and the anthropogenic contamination of groundwater caused by the nuclear accident using ^{3}H-^{3}He dating method, which is possible to acquire not only the age of groundwater but also the information on the water source based on the initial ^{3}H concentration, and ^{129}I, one of the radionuclides released by the nuclear accident.

Sampling was conducted in September 2016 and January 2017 mainly on groundwater and spring water at the Hama-dori region, Fukushima Prefecture. The water samples for ^{3}H-^{3}He dating method were collected and sealed in copper tubes with special care to atmospheric contamination and analyzed using a noble gas mass spectrometer at Department of Basic Science, University of Tokyo. After the first extraction of originally dissolved helium, the sample water was sealed in the copper tube again and stored for about a month, and then the amount of ^{3}He produced by the decay of ^{3}H was extracted by the second degassing and analyzed to obtain the initial ^{3}H concentration and the residence time. Water samples for iodine analysis were sampled in 1-L plastic bottles. Iodine in the sample water was extracted and back-extracted to yield silver iodide pellet, and then $^{129}I/^{127}I$ ratios and concentration of stable isotope ^{127}I was measured using an accelerator mass spectrometer and ICP-MS at Micro Analysis Laboratory, Tandem accelerator, University of Tokyo.

For example, in Minami Soma Sports Park located about 30 km north of the nuclear plant, the concentration of tritium-derived ^{3}He was approximately 2.2×10^{-18} mol/g. The current ^{3}H concentration has been determined by liquid scintillation counter to be 9.3 TU for a sample collected from the same locality (Yabusaki *et al.*, 2015). These values give the initial ^{3}H concentration of 10.1 TU and the residence time of about 1.5 years. This suggests the groundwater system in this region has already been almost completely refreshed since March 2011 due to the short residence time.

For $^{129}I/^{127}I$ ratios, most of the samples measured so far showed values below 1.0×10^{-11}, which is the lower limit of the isotope ratio including radioactive iodine of anthropogenic origin (Fehn, 2012). The low $^{129}I/^{127}I$ ratio of water from Minami Soma Sports Park is in the range of natural background, which is consistent with the short residence time obtained with the ^{3}H-^{3}He method.

Up to the present, it is not possible to confirm the apparent contamination due to the nuclear accident, but depending on the residence time of the groundwater, the possibility that polluted water will discharge in the future cannot be ruled out. We are planning to carry out further sampling to estimate the residence time and water source by the ^{3}H-^{3}He method and combine it with the ^{129}I results to investigate the environmental impact.

References

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