Age dating of groundwater using tritium and CFCs in headwater catchments, Fukushima after the Fukushima Dai-ichi Nuclear Power Plant accident

*Koichi Sakakibara[1], Sho Iwagami[2], Maki Tsujimura[3], Yutaka Abe[4], Manami Hada[5], Ishwar Pun[6], Yuichi Onda[3,7]

1. Faculty of Science, Shinshu University, 2. Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, 3. Faculty of Life and Environmental Sciences, University of Tsukuba, 4. Natural Environment Conservation Center, Kanagawa, 5. Graduate School of Life and Environmental Sciences, University of Tsukuba, 6. Organization for the Strategic Coordination of Research and Intellectual Property, Meiji University, 7. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba

Groundwater age is crucial information for understanding the continuum groundwater flow system from mountain to ocean. Headwaters are origins of the terrestrial hydrological cycle and therefore important areas to understand the water resources management, material cycle, and disaster prevention. After the Fukushima Dai-ichi Nuclear Power Plant accident, concerns of radionuclide contamination of water resources have been elevated. However, the groundwater flow system including age information in radionuclide-contaminated headwaters in Japan has not been well clarified. Therefore, the objective of this study is to investigate the groundwater age and related radionuclide effect on the water resources by using multi-tracer approach in headwater catchments approximately 30 km north-west apart from the Fukushima Dai-ichi Nuclear Power Plant. Periodical field surveys were conducted from May 2011 (2 months after the disaster) to November 2012. Tritium, chlorofluorocarbon (CFCs), and stable isotopes (oxygen and hydrogen) were used as environmental tracers.
Mean groundwater age in the study areas was estimated to be ranging from 10 to 26 years by combined use of multiple CFCs concentrations. The tritium concentration in groundwater was between 1.3 TU and 6.0 TU, which supported the estimated CFCs-based groundwater age. In addition, the governing groundwater flow system was approximated by a piston flow model; however, a modern water fraction was also suggested based on the relationship between CFC-11 and CFC-12. The estimated water age and isotopic signals among the stream water, spring water, and groundwater suggested an indication of the radionuclide intrusion into the groundwater. This is consistent with the monitored ^{137}Cs concentration in the groundwater (Iwagami et al., 2017). Modern water fractions with relatively high radionuclide concentrations into groundwater possibly cause the prolonged contamination of water resources.

Keywords: tritium, CFCs, groundwater age, headwater catchment

