Sources and flow system of groundwater in and around eastern Fukushima Prefecture

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Great East Japan Earthquake on the 11th March 2011 impacted on the hydrosphere. Salinization by Tsunami and radiogenic isotopes caused by the Fukushima Daiichi nuclear disaster were the most serious for the groundwater of affected area. Tritium originated from the disaster was detected in the shallow groundwater near the nuclear power plant in Fukushima (Yabuzaki, 2015).
In this study, major and minor chemistry, radiogenic Cs, stable hydrogen and oxygen isotopes of water, and SF_6 and CFCs were analyzed to trace the groundwater flowing paths from the recharging zone to the sampling site. The samples were taken from the eastern half of Fukushima, southernmost part of Miyagi and northernmost part of Tochigi Prefectures; 37 riverwaters, 46 springwaters, 71 well waters <10 m depth (shallow groundwater hereafter), and 21 well waters >10 m depth (deep groundwater hereafter).
Dissolved components are generally low, i. e., EC<200 mS/cm. The most diluted waters were found in the mountainous area (Abukuma Mountains) and at foot of the high mountains (Ohu and Echigo Mountains) in the west, and the major chemistry were Na-Ca-HCO_3 type, reflecting silicic igneous rock compositions. The water chemistry changes through Ca-HCO_3 to Ca-Na-SO_4(+NO_3) types. Especially, the latter water chemistry was found in the low land and villages in the mountains, indicating vertical infiltration of surface water, plausibly containing wastewaters with anthropogenic origin of these anions. Na-Cl type water groundwater was found in the Tsunami affected area, however, the Cl concentrations are as low as 40 ppm, and the seawater rapidly removed from the reservoirs. Riverwaters collected from the foot of the high mountains occasionally gave Ca-SO_4 type water chemistry due to the large contribution of hot spring waters flew out from the volcanoes.
The relationship between d^{18}O and d ^{2}H gave the two different sources of precipitation; one was from Pacific Ocean Air masses and the other was from Sea of Japan Air masses. The former was plotted on the global meteoric water line, and the all of the waters from coastal plain and foot and inside of the Abukuma Mountains. Also, these waters were observed in the groundwaters from Fukushima basin and northernmost part of Kanto Plain (northernmost Tochigi). The latter was found in and foot of eastern Abukuma and western Ohu and Tochigi Mountains and low land intercalated by those mountains (Naka-dori). The smallest isotope values were observed for the waters originated from Ohu and Tochigi Mountains, and those were plotted on the local meteoric line of precipitation originated from Sea of Japan side. Most of the waters of this group were plotted between the two meteoric water lines, indicating mixing of two differently originated precipitations.
Recharging age of the groundwaters were from 7 to 51 years, and the many were between 20 and 30 years. The groundwaters recharged in these 10 years mainly distributed in the low land around the foot of mountains. Also, the recharging periods were shorter in the southern area than in the northern area, suggesting shorter paths of groundwater flow.
Cs of all analyzed waters was below detection limit (same as standard value 10 Bq/L). Five years passed after the earthquake, and tritium and/or soluble radiogenic isotopes would be found in the groundwaters having shorter recharging period widely in the studied area. We have to monitor the water to trace the fate of radiogenic isotopes in the whole hydrosphere.

