

Geochemical characteristics of groundwater and its flow system in Miyagi Prefecture

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Major and minor element chemistry, stable isotopes (H, O, S), and radiogenic Cs (134 and 137) were analyzed for of ca. 200 groundwaters and 30 river waters taken from Miyagi Prefecture from the March to November 2012 to evaluate the groundwater quality at present and draw groundwater flow system in and around Sendai Plain, which was surrounded by high mountains in the northern and western end and facing to the Pacific Ocean at the east. Sendai Plain can be divided into northern and southern plains by Matsushima hill, and two large rivers run in the basins of each plain; Kitakami and Naruse rivers in the northern plain, and Natori and Abukuma rivers in the southern plain.

Groundwater chemistry is different in between the northern and southern plains. In the northern plain, diluted Na-Cl type shallow groundwater (spring water and groundwater from <10 m depth) and riverwater are found in the high mountainous and hilly areas, indicating that the groundwaters of this area are not chemically immature and residence time would be short to react with the soils and sediments to dissolve the salts. Dilute Ca-HCO₃ type shallow groundwaters are found in the plain basin as results of evolution of the water chemistry. In the southern plain, Ca-HCO₃ type water appears in the high mountain area, and Ca and HCO₃ concentrations become higher in the hill and inland basins. The groundwaters in the southern plain seem to be more mature than those in the northern plain. Along the coast, where Tsunami covered the ground in the 11th, March, 2011, seawater contaminated into the shallow Ca-HCO₃ type groundwaters. The highest Cl concentration was 14000 mg/L, however, most of the seawater contaminated groundwaters contained ~500 mg/L Cl. S isotope of sulfate ions also suggests the contamination of seawater. Deep groundwater (>10 m depth) occasionally gives Na-HCO₃ type chemistry. Also, high Na-Cl type chemistry occurs in the deep groundwaters in Sendai of the southern Plain and Ishinomaki in the northern plain. Those would be results of salinization due to excess use or fossil seawater. Thus, the groundwater aquifers >10 m depth from the surface are commonly at stagnant condition in the studied area.

Hydrogen and oxygen isotopes of groundwater become smaller from east to west along NS direction, parallel to the coast and mountains, in the southern plain, however, such a variation is not prominent for the groundwaters in the northern plain. The isotope ratios of groundwater change corresponding to the sampling sites but not depths, indicating small catchments of the deep groundwater in the studied area.

Contamination of toxic elements such as As is found from shallow and deep groundwaters. Some of them are presumed to originate the oxidation of As-bearing pyrite in the Neogene aquifer sediments. As contaminated groundwater can be found in the groundwaters from Tsunami affected area, although the relationship of seawater and/or sediments carried by Tsunami to As contamination is not clear at present.

Radiogenic Cs was not detected from the all samples analyzed here, thus, the accident at Fukushima Daiichi nuclear power plant would not cause contamination of radionuclides in the studied groundwater at present.

Keywords: groundwater contamination, aquifer, Tsunami, radiogenic Cs, O, H, S stable isotopes, As