

Pollution sources of groundwater contamination diagnosed by boron isotope composition in Okinawa, Yoron, and Tarama Islands, southern Japan

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Groundwater is very important resources at the Ryukyu Limestone area of Ryukyu islands, southern Japan. On these islands, groundwater pollution such as an increase in the concentration of nitrate nitrogen has become apparent due to the increased human activity. In this study, Boron (B) concentration and B isotope composition are utilized as a tracer to demonstrate the pollution source in the agricultural environment. Manure and chemical fertilizer contain significant amount of B; it is leached by rainfall and migrate through the soil to contaminate the groundwater. In this study, we utilized the characteristic of B to reveal the pollution processes in the southern part of Okinawa Island, Tarama Island, and Yoron Island. We also collected precipitations at Ginowan City and fertilizers in the local areas as endmembers of mixing curves.

The B concentrations and $\delta^{11}\text{B}$ values are 12-168 ppb and 19.5-38.1 ‰ in the southern part of Okinawa Island; 25-4247 ppb and 32.8-41.3 ‰ in Tarama Island; 20-26 ppb and 25.2-33.7 ‰ in Yoron Island. The mixing curve of precipitation and seawater represents the influence of seawater. In Tarama Island, the boundary of freshwater lens is clearly defined by sharp increases in B concentration in groundwater with $\delta^{11}\text{B}$ values approaching to those of seawater. According to the characteristic of B, the groundwater of the southern part of Okinawa Island, Tarama Island, and Yoron Island can be reproduced by mixing precipitation with 0.6%, 0.8%, and 0.3% seawater. Two mixing curves between the least polluted groundwater and average $\delta^{11}\text{B}$ values of manure (20 ‰) and chemical fertilizer (-5 ‰) in the southern part of Okinawa Island and Tarama Island are applicable to quantitative evaluation of contamination. In Yoron Island, the average $\delta^{11}\text{B}$ values of manure and chemical fertilizer are 31 ‰ and -3 ‰, respectively, and our data indicate that Yoron groundwater is influenced by 0.1% of chemical fertilizers. These results demonstrate that B concentration and its isotope composition of groundwater can be useful tracers for contamination processes in the Ryukyu Limestone area.

Keywords: Boron, Tracer, Groundwater contamination, Ryukyu Limestone