

Groundwater isoscapes in Japan and in the world - utility of bottled waters

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The importance of "isoscapes", that is, the mapping of large-scale spatiotemporal distributions of stable isotope compositions in various environments, is being recognized as providing a framework for fundamental and applied research questions at large scales. In the field of hydrological science, groundwater isoscapes are potentially important, for example, as a background data for observation studies and as a validation data for modeling studies. Bottled waters, many of them are from natural groundwater sources and contain the information of sampling location, are easily available in many countries. Here, we present a dataset of stable isotope ratios for bottled waters collected from worldwide, and consider potential applications of such data for groundwater isoscape studies. We collected 378 bottles from Japan and 216 bottles from 42 nations except Japan. We successfully present the isoscape of the Japanese bottled waters based on this dataset. There is a clear linear relationship between $\delta^{18}\text{O}$ and δD for the Japanese bottled water. Generally, these values decrease from south to north. The correlations of $\delta^{18}\text{O}$ with the latitude and with the ground surface elevation are negative. Thus, the latitude and altitude effects, which are commonly observed in precipitation, are also reflected to the bottled waters. The large part of the world samples are from the Northern Hemisphere. The weak latitude effect for $\delta^{18}\text{O}$ is found in the Northern Hemisphere. On the other hand, the effect is unclear in the Southern Hemisphere. These patterns are similarly found in the global maps of $\delta^{18}\text{O}$ in precipitation derived from the Global Network for Isotopes in Precipitation (GNIP). Moreover, the spatial distributions in Europe and in East Asia are similar to the published groundwater isoscapes in some European and Asian Countries. Our findings suggest that the commercial bottled waters will be a good proxy of natural environmental water on average, and a potential tool for the global isoscape studies and for the database of isotope values of groundwater if samples are available from all over the world.

Keywords: Bottled water, stable isotope of water, isoscape, Japan;, the World