Exploring groundwater dynamics in Kikaijima, southwest Japan, using radiocarbon, oxygen isotopes, and hydro-chemical data

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Groundwater, the world's largest freshwater resource, faces a great challenge in aquifer exploitation and depletion in the 21st century. Increased reliance on aquifers has led to declining groundwater resources and deteriorating water quality, and the demand for scientifically understanding the behavior of subsurface water systems is vital.
Kikaijima, a southern island in the Amami archipelago, Japan, is an ideal site to evaluate the recharge and discharge relationships of groundwater because of its geological features and the small size of the island. It is also a unique study site as an underground dam is built to support the water supply on the island. Combined research using radiocarbon, stable oxygen isotopes, and hydro-chemical data of Ca, Mg, Na, and K was carried out monthly from Jan 2022 to Dec 2022. Twenty points around the island were measured using groundwater from wells and springs, and seawater from the coast.
Radiocarbon is the most used and effective tracer to determine groundwater residence times. Moreover, it covers long-time scales in the range of 2,000 to 30,000 years, and those covering a similar age range as ^{14}C remain unavailable today.
Radiocarbon results show that spatial rather than seasonal variations were substantial, uncovering the residence times and groundwater flow inside the island. Results also show the mixing of seawater and groundwater on the coast is large in the southwest of the island while the northeast has small mixing with groundwater. Such trend could not be demonstrated clearly from stable oxygen isotope or hydro-chemical data, a common tracer used for detecting groundwater dynamics.
The data generated in this study shows the validity and effectiveness of using radiocarbon for groundwater research and concurrently provides valuable information for long-term sustainable water resource management in Kikaijima.

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