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Refining tropical island catchment models using water stable isotopes

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Pacific islands are among the regions most vulnerable to climate change, and are simultaneously experiencing rapid population growth [1,2]. Moreover, the geological settings—comprising karstified limestones, low-lying coral limestones, as well as volcanic and composite formations—are highly heterogeneous, leading to complex hydrogeological configurations, particularly in coastal aquifers affected by seawater intrusion. The remoteness of the islands and the scarcity of conventional hydrophysical data (e.g., water levels and hydraulic conductivity) further complicate the assessment of an already highly heterogeneous geological framework, making groundwater resource characterization and protection particularly challenging.

Stable isotopes ($\delta^{18}O$, $\delta^{2}H$) provide essential information on recharge dynamics, mixing processes, and seawater intrusion [3–6]. However, groundwater isotope signatures depend on the isotopic composition of precipitation, which remains poorly constrained across many Pacific islands due to a lack of monitoring [7–9].

To address this gap, monthly rainwater sampling for stable isotopes was conducted at multiple locations in Vanuatu's islands. These data are compared to groundwater sampled on five islands spanning all the Pacific geological contexts, different latitudes and topographic settings.

The results reveal a wide isotopic range and distinct patterns across the five investigated contexts. At one site, seasonal isotope variability is compared with local meteorological data and surface-water signatures to evaluate the groundwater recharge response to rainfall seasonality and extreme climatic events.

Different groundwater recharge areas have been delineated using stable isotopes and geochemical data. These findings refine conceptual models of island hydrology, strengthen groundwater resource management strategies, and establish a reference framework for future isotope-based monitoring under changing climatic conditions.

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