Is Coastal Groundwater Still a Viable Water Resource?

Many settlements have historically relied on fresh to brackish coastal groundwater sources. Some communities dug wells on coastal plains where groundwater level is close to sea level and the terrain allows water to be accessed from shallow pits. Others leaned on coastal springs where groundwater discharges to embayments, often protected from mixing with ocean by built rock walls. Groundwater from these coastal sources has been used for drinking and cooking as well as watering crops and providing drinking water for livestock. But with changes in land use and depletion of aquifers, groundwater levels have dropped almost globally, spring discharge has decreased and coastal springs became saltier. Climate change, especially decreased precipitation and increased evapotranspiration allow even less water to recharge into the aquifers. Imminent sea level rise will force more saline water to intrude into the coastal aquifer making it more salty. Considering these changes happening globally, **is coastal groundwater still a viable water resource**?

It turns out some communities still rely on coastal water sources, following practices of their ancestors. In Rapa Nui, some farmers still use coastal hand-dug wells called *puna*, mostly as drinking water for horses, cattle, and other livestock. But there is only a limited number of these preserved on the island. Perhaps coastal springs that discharge into semi-protected embayments have been used in the past as well. Any structures protecting these from mixing with ocean would now be washed away thanks to intense wave action.

"[RAD8's] rugged design and portability allowed us to access remote and hard to reach sites and perform in-situ measurements. RAD8's extended battery life allowed us to process numerous RAD-H2O and "Big bottle" analyses in the field by setting up the measurements in some challenging terrain. The instrument's ruggedness also helped with the highly variable weather conditions with high wind gusts, humidity, and frequent rain showers." - Professor Henrietta Dulai

Our project evaluated the viability of coastal groundwater resources focusing on locating coastal springs and quantifying their discharge rates. We relied on proven methods of using radon as submarine groundwater discharge (SGD) tracer through its coastal time series monitoring and spatial surveys (e.g. Burnett and Dulaiova, 2003 [1]; Dulaiova et al., 2005 [2]). For the coastal radon mass balance, we also needed to characterize groundwater, sediment, and air radon content.

All of these measurements were accomplished at each field site using the RAD8 instrument. Its rugged design and portability allowed us to access remote and hard to reach sites and perform in-situ measurements. RAD8's extended battery life allowed us to process numerous RAD-H2O and "Big bottle" analyses in the field by setting up the

measurements in some challenging terrain. The instrument's ruggedness also helped with the highly variable weather conditions with high wind gusts, humidity, and frequent rain showers. Due to high surf and swell events spatial radon distribution had to be assessed by the RAD-H2O Big bottle system.

Ultimately, in January 2023 we characterized SGD at 8 sites by collecting 30 discreet radon samples and performing 7 continuous tidal time series radon measurements. The measured radon concentrations ranged from 20 to 6,000 Bq/m^3. Our observations suggest that most of SGD manifests as discreet coastal springs and discharge rates from these vary between 400 and 20,000 m^3/day. Cattle and horses have been observed drinking from the ocean, obviously where springs provided lower salinity groundwater. But even the springs with the highest discharge rate experience changes in volumetric

discharge due to tidal fluctuation and mixing with ocean water at high tides. So how could people rely on springs that were accessible only for a few hours every day? Perhaps in the past the springs had protective rock wall structures built around them and were flowing at higher discharge rates and lower salinity than today. That would make the water from these coastal springs more accessible for human consumption. Nevertheless, even today, the coastline of the volcanic Rapa Nui is very leaky, discharging plenty of brackish water into the surrounding ocean and radon proved to be an excellent tracer to quantify SGD.

References

[1] Burnett, W. C., & Dulaiova, H. (2003). Estimating the dynamics of groundwater input into the coastal zone via continuous radon-222 measurements. Journal of Environmental Radioactivity, 69(1–2), 21–35. https://doi.org/10.1016/S0265-931X(03)00084-5

[2] Dulaiova, H., Peterson, R., Burnett, W. C., & Lane-Smith, D. (2005). A multi-detector continuous monitor for assessment of 222 Rn in the coastal ocean. Journal of Radioanalytical and Nuclear Chemistry, 263(2), 361–365. Retrieved from https://link-springer-com.sheffield.idm.oclc.org/article/10.1007/s10967-005-0595-y