Determining the ages, sources, and connections between groundwater and surface waters in the upper Babocomari watershed

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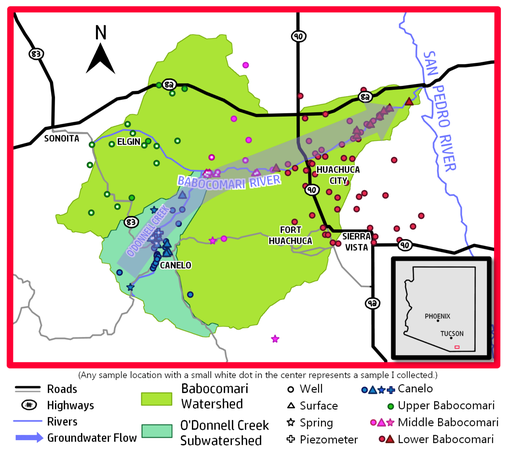
INTRO

- Groundwater and surface water are two intimately connected water storage regimes whose interactions impact the health of the regions they sustain.
- Many growing communities with evolving land use lack comprehensive hydrologic studies characterizing their water resources.
- The Babocomari Watershed of southeastern Arizona is home to the winery communities of Elgin and Sonoita, whose citizens recently pushed back against a county initiative to promote tourism in the area for reasons including concerns over limited water resources (Vendituoli, 2024).
- The watershed also contains the Babocomari Cienega, a critical habitat for endangered flora and fauna which is sensitive to changes local groundwater conditions.
- This study builds upon previous research in select parts of the watershed through analyzing solute chemistry, stable water isotopes (SWIs), and age tracer data of groundwaters and surface waters in Elgin, Canelo and the Babocomari Cienega.

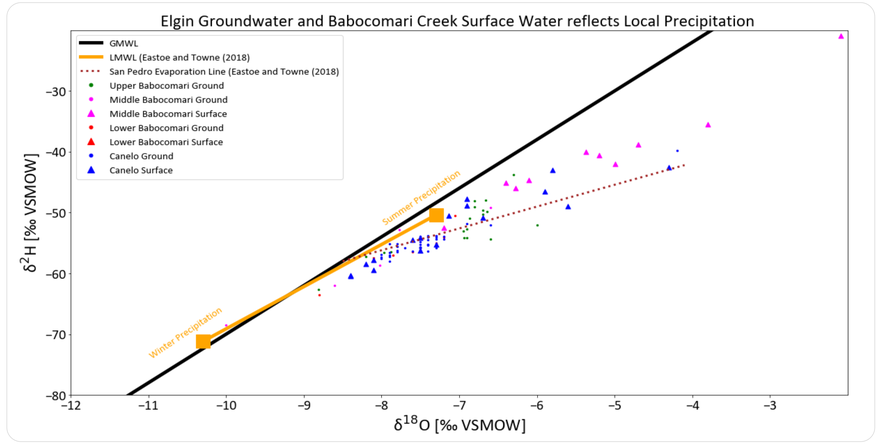
METHODS

- Roughly twenty groundwater samples were collected from private wells within Elgin, Canelo, and the Babocomari Cienega. Three piezometer samples and fifteen surface water samples were also collected within the Babocomari Cienega and O'Donnell Creek in Canelo.
- Sample pH, electroconductivity (EC), and dissolved oxygen (DO) were analyzed in-field, with major ion chemistry, stable water isotopes, etc. analyzed in labs.

STUDY AREA



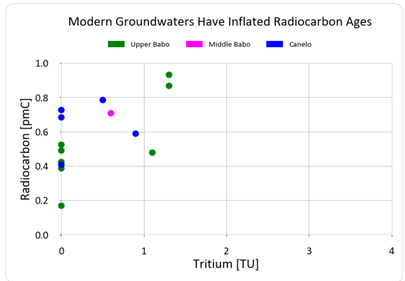
RESULTS

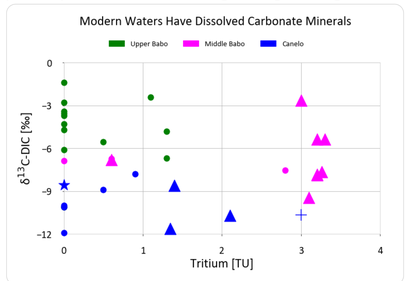


Groundwater from Elgin (upper Babocomari, green circles) appears to come from local winter and summer precipitation, while surface waters in the Cienega (middle Babocomari, pink triangles) reflect evaporated local summer precipitation. This seasonality can be affected by climate change, which shifts precipitation patterns and thus recharge timing and magnitude.

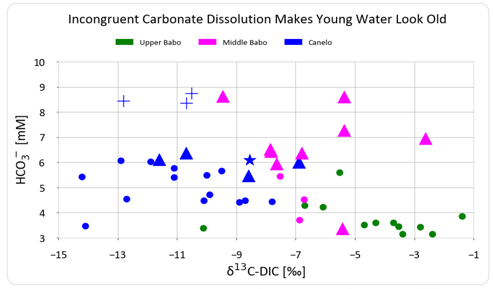
Well water being collected from a private well spigot for sampling.

Surface water being collected from a standing pond in the Babocomari Cienega.

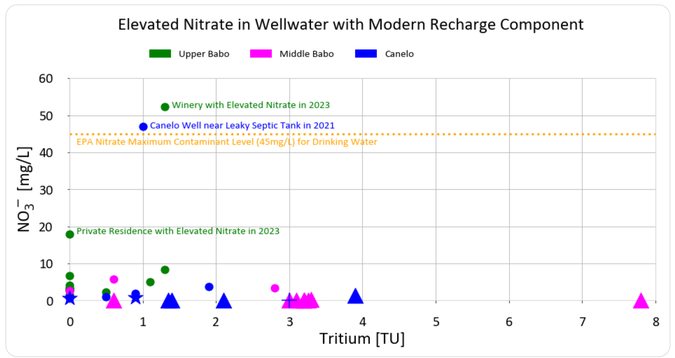




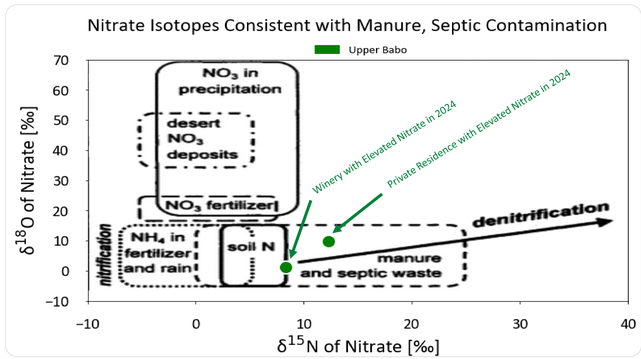
Seven groundwater samples from the upper and middle Babocomari had "modern" corrected radiocarbon ages, implying recharge from less than 500 years ago. However, this disagrees with signs that older water should be present, like how these groundwaters had a lower radiocarbon pmC (percent modern carbon) and higher δ^{13}C-DIC values, normally caused by older water spending more time interacting with carbonate minerals. Nonzero tritium also implies mixing with younger water.



The counterintuitive old-age signature of young groundwater could be caused by incongruent carbonate dissolution, which artificially lowers the pmC and raises the δ^{13}C-DIC of young water, making it appear older; decreasing alkalinity with increasing δ13C-DIC implies this is occurring (Han et al., 2012).



Water with a modern recharge component is vulnerable to modern sources of contamination. Three wells sampled in the Babocomari were found to have elevated nitrate concentrations, with two of these wells also having a tritium signature, implying a recharge component from after the 1950s. One of these wells from Canelo was later found to be near a leaky septic tank.



Isotopic analysis of the two Upper Babocomari samples with elevated nitrate revealed they also had nitrate isotope signatures consistent with manure and septic waste contamination. Leaky septic tanks are a common problem in rural areas lacking central sewage infrastructure. The original nitrate isotope graph above is from Kendall (1998).

DISCUSSION AND CONCLUSIONS

- Elgin groundwater reflects evaporated local summer and winter precipitation, while surface waters in the Cienega reflect evaporated local summer precipitation.
- Initial radiocarbon and dissolved inorganic carbon (DIC) analyses implied groundwater samples from Elgin were recharged more than 1000 years ago; however, correction factors later revealed these waters were modern, being recharged less than 500 years ago. Samples with a tritium signature contain even younger water that was recharged after the 1950s.
- A trend of decreasing alkalinity with increasing δ13C-DIC is evidence of incongruent carbonate dissolution occurring in the area, which could have caused the initially inflated apparent groundwater ages.
- Groundwater with a modern recharge component is susceptible to modern sources of contamination. Two groundwater samples from Elgin had elevated nitrate levels, with the higher-concentration one also having a tritium signature, implying post-1950s recharge. Both samples had nitrate isotope signatures consistent with manure and septic waste contamination. This agrees with a previous Canelo sample with elevated nitrate, which was located near a leaky septic tank.

FUTURE RESEARCH

- Determine cause in divergence of δ13C-DIC values between Canelo and Upper Babocomari.
- Plot water chemistry along length of Babocomari river to determine sources of water feeding the Cienega (e.g., surface water flow from Upper Babocomari river, shallow soil water flow from O'Donnell Creek, or deeper regional groundwater flow).
- Analyze relationships between groundwater ages, well depths, and areal groundwater withdrawal rates.

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DESERT BOTANICAL garden