Precipitation-Mediated Fluctuations of Well Water Arsenic in Hancock County, ME

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Introduction

With over half of Maine residents and ~80% of Hancock County residents relying on private wells for drinking water, well water quality is a first-order public health concern for this region. Known toxins such as arsenic and uranium are prominent in the groundwater of this region (Ayotte et al., 2003; Moroz et al., 2021).

- Monthly well water samples collected during 2020-2021 from Hancock County private wells reveal monthly fluctuations in arsenic and other elemental concentrations.
- Droughts and intense precipitation events are both projected to become more frequent in coming decades throughout coastal Maine due to climate change (Birkel and Mayewski, 2018), likely impacting groundwater resources.

GOAL: To identify potential fluctuations related to rain events, a set of 32 wells from the monthly program were tested before and after four rain events occurring at different rain events throughout the wet (February and May 2021) and dry seasons (October 2020 and August 2021).

Methods

This dataset includes water from different well types and wells with varying substrates, elevations, positions within the watershed, well types, and pre-rain arsenic concentrations (Fig 1 and Fig 2).
In addition to As, samples were analyzed by ICP-MS for 13 other elements (Sb, Ba, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Se, and U) at the Trace Element Analysis Laboratory of Dartmouth College.

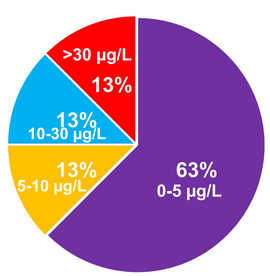

Fig. 1: Median monthly arsenic concentrations for the 32 wells in this study. These concentrations range from 0 to 50.6 µg/L.

32 total wells with both monthly and rain event samples:

- 5 dug wells with unfiltered samples
- 6 drilled wells with particulate-only samples
- 21 drilled wells with unfiltered samples
- 6 drilled unfiltered wells and 2 dug unfiltered wells have samples for all 4 rain events, others were sampled during 1-3 rain events.

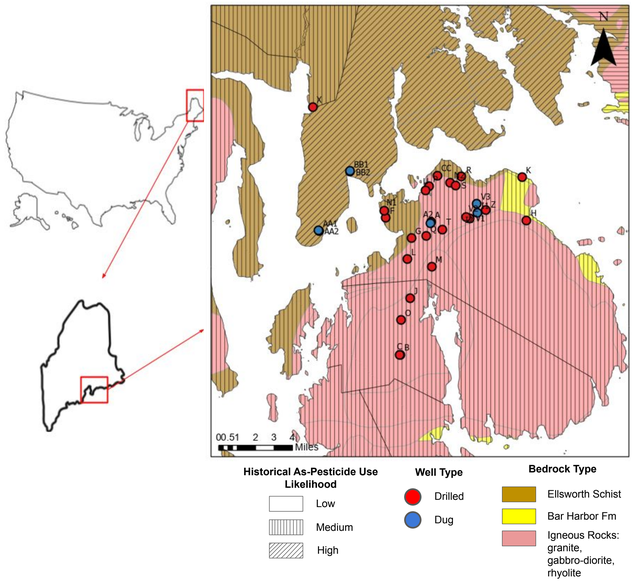

Fig. 2: Map of the study area, Mount Desert Island and Trenton, ME. 32 drilled and dug wells span different bedrock units (Osberg et al., 1985) and different scenarios for likelihood of prior arsenical pesticide use (Robinson and Ayotte, 2006).

Results: Individual Wells

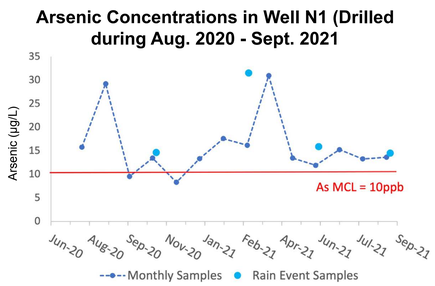

Fig. 3: Arsenic concentrations in Well N1 during 2020-2021. Samples were collected monthly (dark blue) as well as post 4 rain events (light blue dots). The maximum post-rain As concentration is similar to the maximum annual concentration. All post-rain samples are a higher concentration than the pre-rain samples for a given rain event.

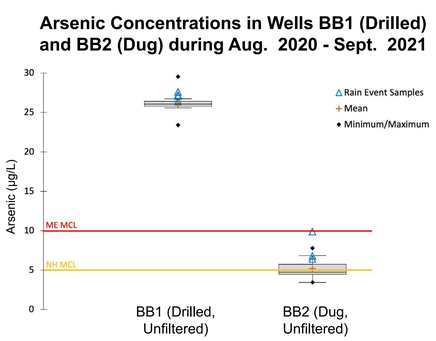

Fig. 4: Box plot showing monthly arsenic concentrations in a drilled and dug well pair. Both wells have a fairly narrow range of arsenic fluctuations through the year compared to other wells in the study. Note that one rain event sample (blue triangle) in BB2 was higher than the highest monthly sample (black diamond) and at the ME MCL (red line).

Results: Rain Events

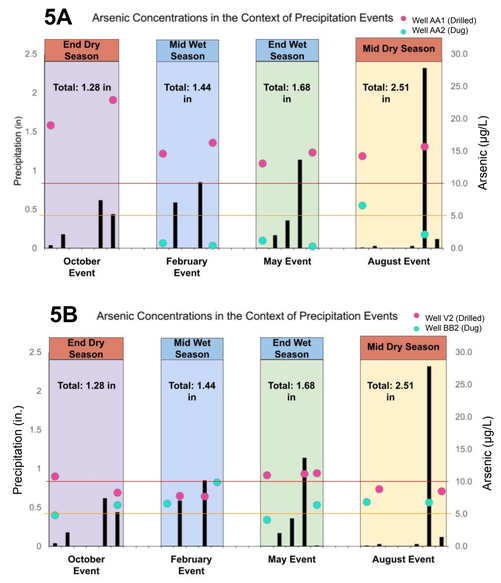

Fig. 5 - Changes in arsenic concentrations between pre and post-rain samples in select individual wells. Black bars are daily precipitation values:

5A) Wells AA1 and AA2: This drilled (pink) and dug (blue) well pair changed in opposite directions with respect to their post-rain As concentrations. Another drilled and dug well pair, BB1 and BB2 both increase in arsenic post-rain event.

5B) Wells V2 and BB2: As concentrations moved above or below the Maine and New Hampshire As MCL post-rain in drilled well V2 (blue) and dug well BB2 (pink) (see also Fig. 4).

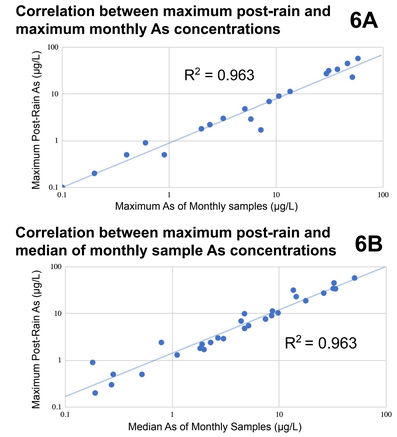

Fig. 6: Correlations between arsenic values of monthly samples and post-rain samples for a given drilled well. Both the maximum measured arsenic values from the ~13 monthly samples (6A) and the median of the monthly arsenic values correlate with the measured maximum post-rain arsenic values for a given well.

Discussion and Conclusions

- Preliminary results suggest that most wells only fluctuate within ~1 µg/L of the pre-rain As concentration during rain events.
- The largest fluctuations in arsenic post-rain are observed in drilled wells during the February and May rain events.
- The largest increases in arsenic post rain samples (~15 to 21 µg/L) are larger than the largest decreases in arsenic post rain samples (~4 to ~5 µg/L).
- Some individual wells fluctuated above or below the Maine As MCL of 10 µg/L in the days around a rain event (see Fig. 5B).
- 59% of wells have similar maximum monthly As concentrations and maximum post-rain As concentrations (<1 µg/L of difference).
- Maximum post-rain As concentrations correlate with the median concentrations of monthly samples and highest-As samples collected during monthly testing.
- There were no consistent pre and post-rain event trends in As concentration across all 32 wells sampled due to the unique characteristics and environmental conditions of each well.

Take Home Message: Well owners should understand that their well water chemistry may vary throughout the year (monthly or daily) to levels above the Maine MCL.

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