



Arsenic concentrations in harvested rainwater from four Arizona communities

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Introduction

- Rainwater harvesting reduces water consumption and combats water scarcity due to climate change.
- Harvested rainwater is federally unregulated in the US and potential risks to human health are unknown.
- Arsenic is known to have detrimental human health impacts and, in harvested rainwater, may pose a human health risk depending on water usage.
- This work focuses on understanding spatial and temporal arsenic dynamics in citizen scientist harvested rainwater to inform community use of the water.

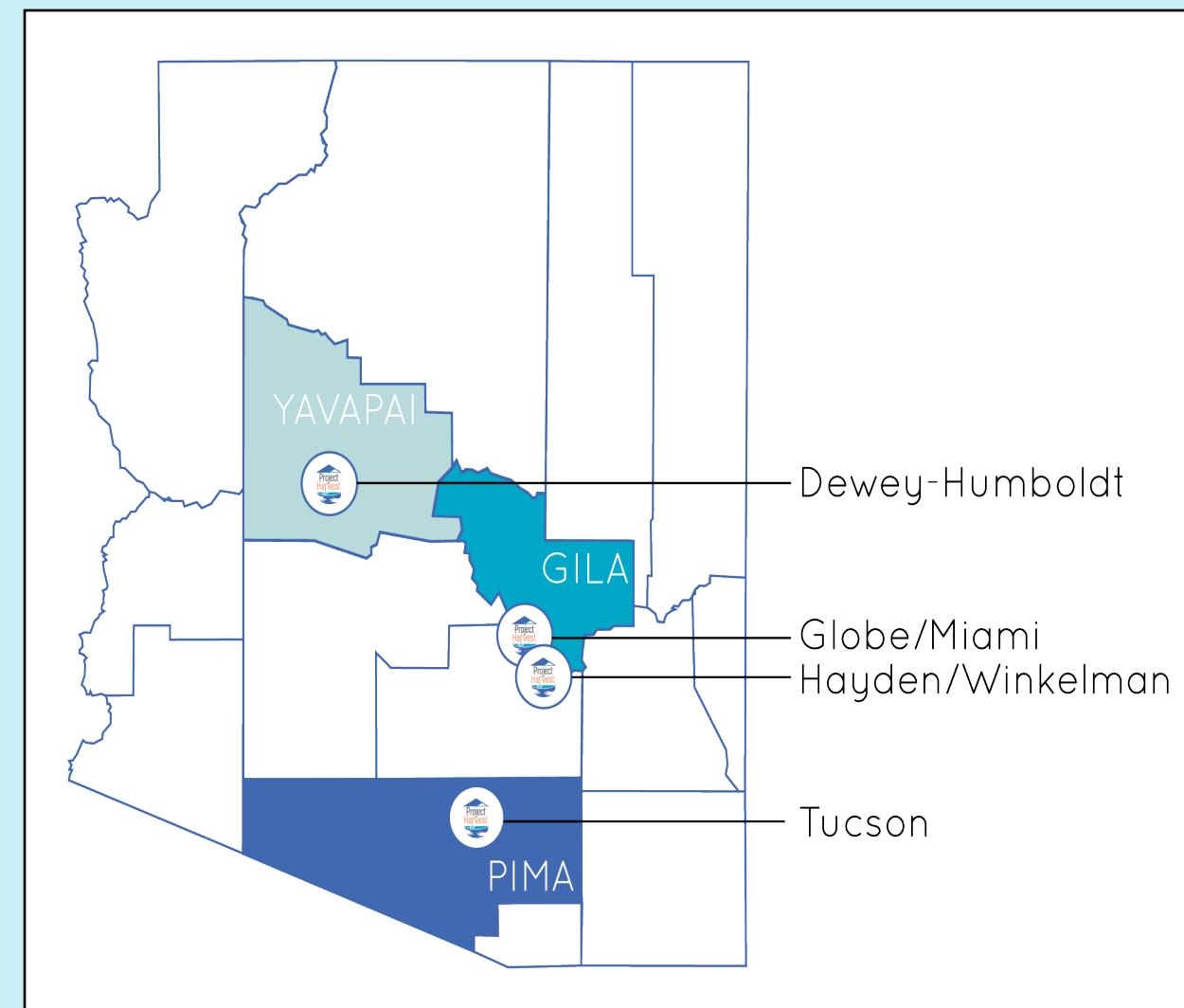


Figure 1. Map displaying locations of Project Harvest communities.

Methods

Sampling

- Trained citizen scientists harvested rainwater from cisterns at their homes – hereafter called site – four times throughout the sampling year, first winter (FW), last winter (LW), first monsoon (FM), and last monsoon (LM).
- Samples were analyzed via inductively coupled plasma – mass spectrometry (ICP-MS) for dissolved metal(loid)s by the Arizona Laboratory for Emerging Contaminants (ALEC).

Data Analysis

- A linear mixed model was built – using the maximum likelihood method – due to variability of data, number of parameters, and lack of true independence. Spatial auto-correlation and incomplete sampling was accounted for by adding site as a random effect (Lark and Cullis 2004).
- The R packages *nlme* (Pinheiro et al. 2019), *ggplot2* (Wickham 2016), and *effects* (Fox and Weisberg 2019) were used in R Project software (R Core Team 2019).

Results

Table 1. Arsenic exceedances of various water quality standards by community

Community	n	PB (%)	FB (%)	DW (%)	AI (%)	LDW (%)
Dewey	25	0	0	8.00	0	8.00
Globe	44	0	0	0	0	0
Hayden	28	0	3.57	17.9	3.57	17.9
Tucson	102	0	0	1.96	0	1.96

PB = ADEQ Surface Water Standard - Partial Body Contact.

FB = ADEQ Surface Water Standard - Full Body Contact.

DW = USEPA Drinking Water Standard.

AI = USDA Agricultural Irrigation Standard.

LDW = USDA Livestock Drinking Water Standard.



Most harvested rainwater samples do not exceed water quality standards for arsenic.

Arsenic concentrations in harvested rainwater differ significantly by community and season.

Results (cont.)

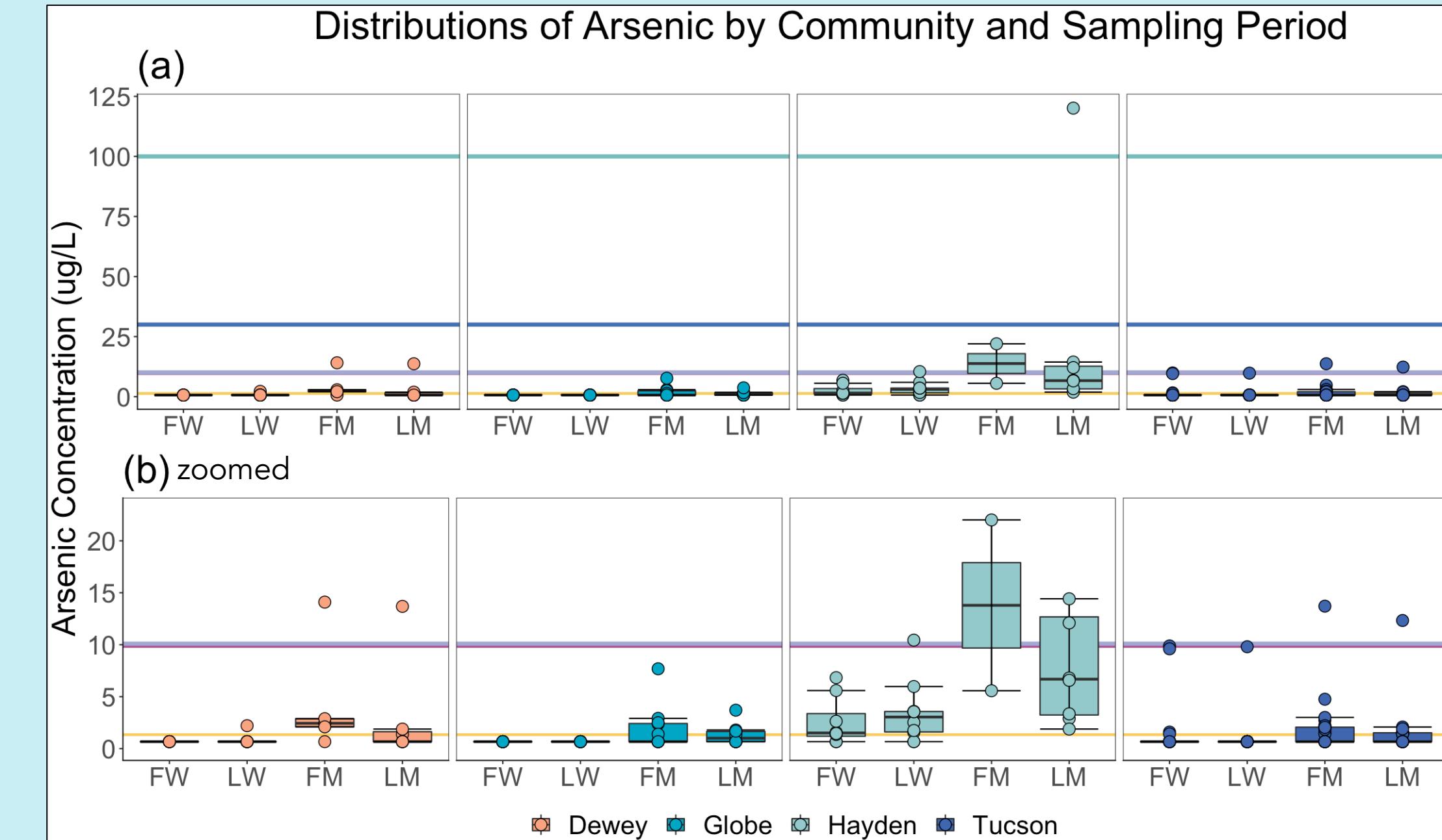


Figure 2. Boxplots showing the distribution of arsenic concentrations in harvested rainwater collected four times throughout the sampling year. Graph (a) shows the entire distribution; graph (b) displays up to 25 ug/L. Dark blue line indicates the ADEQ Surface Water Standard - Full Body Contact. Light blue line indicates USEPA Drinking Water Standard. Green indicates USDA Agricultural Irrigation Standard. Purple indicates USDA Livestock Drinking Water Standard.

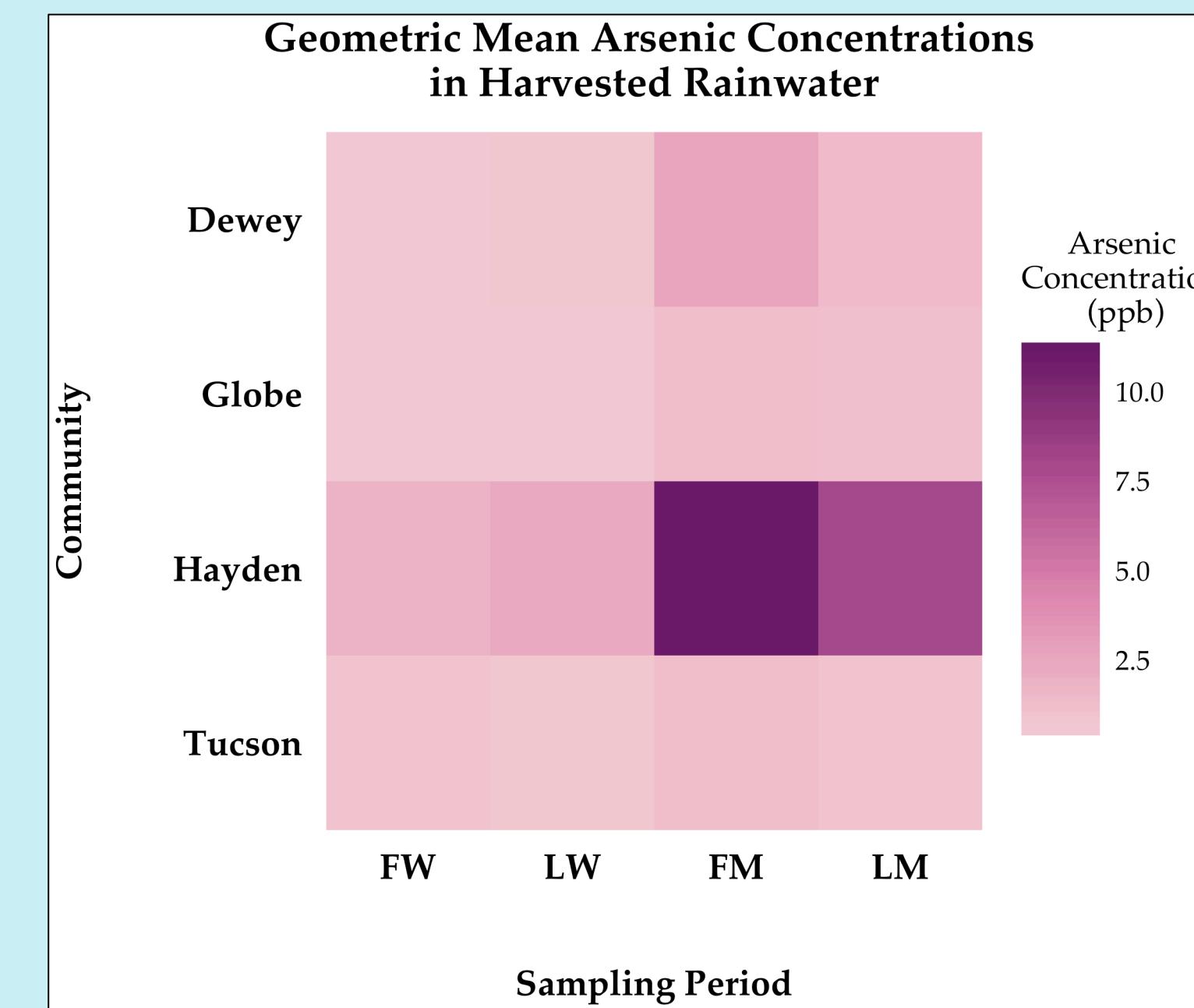


Figure 3. Heatmap showing the geometric mean of arsenic concentrations in harvested rainwater by community and sampling period. Dewey has 25 samples, Globe has 44, Hayden has 28, and Tucson has 102.

$\log(\text{As concentration}) = \beta_0 + \beta_1 \text{Season} + \beta_2 \text{Community} + \beta_3 \text{Community} \times \text{Season} + \gamma \text{Site}$

Figure 4. A linear mixed model of log transformed arsenic concentrations. Season, community, and a season:community interaction are fixed effects. Site is a random effect.

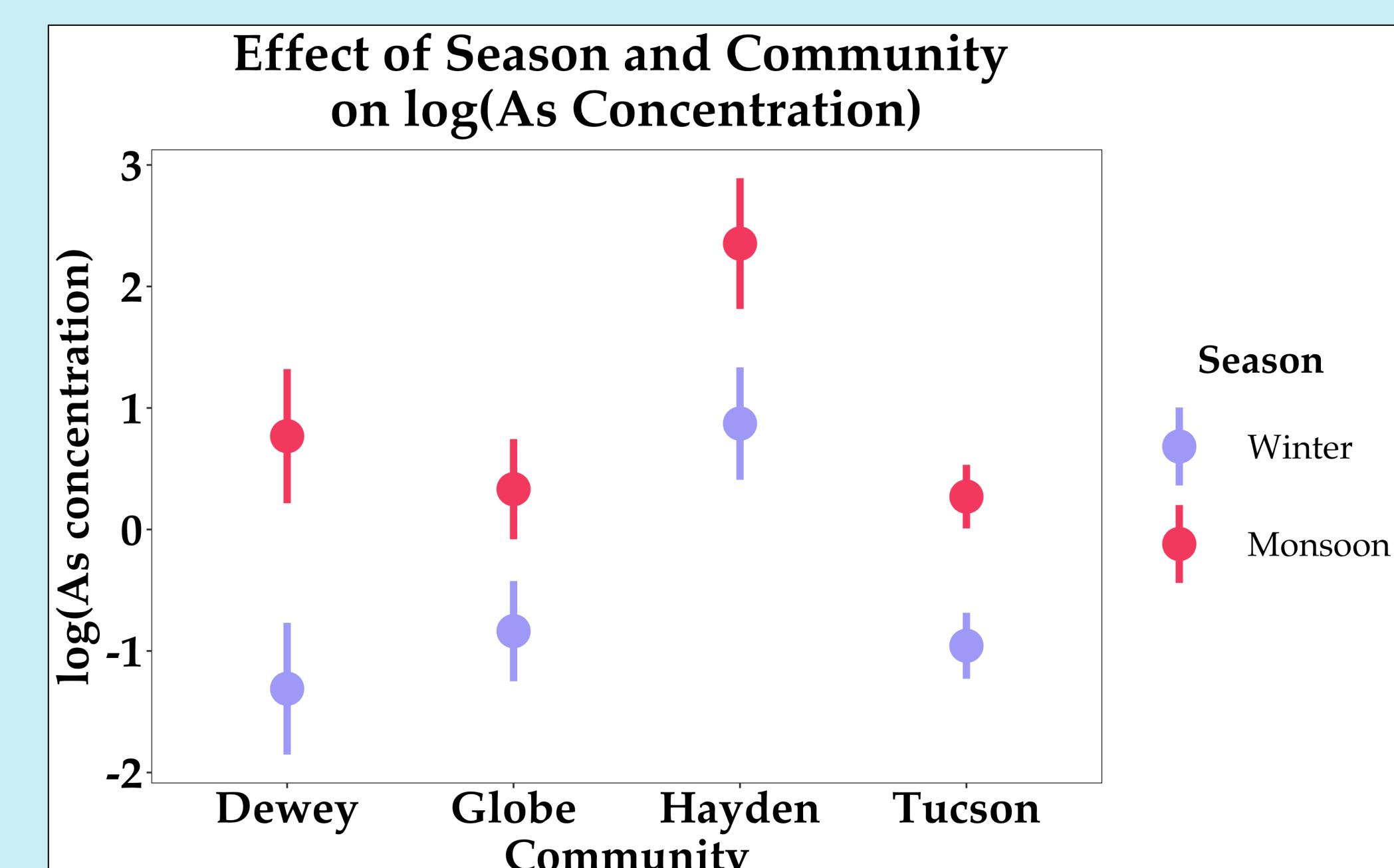


Figure 5. Effect plot showing the impact of season and community on $\log(\text{As concentration})$. Values and error bars are estimates based on the linear mixed model in Figure 4.

Discussion

- Most participants use harvested rainwater for irrigation and only one sample exceeded the As agricultural irrigation standard.
- Future work focuses on identifying pollution sources and building predictive arsenic models.
- Citizen science datasets have the potential to inform regulatory authorities and contribute to the creation of health-based contaminant standards.

References

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