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Data Article

Dissolved arsenic and lead concentrations in rooftop harvested rainwater: Community generated dataset

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A R T I C L E I N F O

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A B S T R A C T

Here, we detail arsenic (As) and lead (Pb) concentrations in community science generated rooftop harvested rainwater data from Project Harvest (PH), a co-created community science study, and National Atmospheric Deposition Program (NADP) National Trends Network wet-deposition AZ samples as analyzed by Palawat et al. [1]. 577 field samples were collected in PH and 78 field samples were collected by NADP. All samples were analyzed via inductively coupled plasma mass spectrometry (ICP-MS) for dissolved metal(loid)s including As and Pb by the Arizona Laboratory for Emerging Contaminants after 0.45 um filtration and acidification. Method limits of detection (MLOD) were assessed and sample concentrations above MLODs were considered detects. Summary statistics and box and whisker plots were generated to assess variables of interest such as community and sampling window. Finally, As and Pb data is provided for potential reuse; the data can be used to assess contamination of harvested rainwater in AZ and to inform community use of natural resources.

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Specifications Table

Subject	Environmental Science
Specific subject area	Pollution science, community science
Type of data	Table Figure
How the data were acquired	Trained community scientists collected harvested rainwater samples and field blanks from their homes from four communities in Arizona, using materials provided by Project Harvest (PH) at the University of Arizona (UA) in partnership with the Sonora Environmental Research Institute, Inc. (SERI) according to a pre-determined sampling schedule and method from Dec 2017 till Feb 2020. The National Atmospheric Deposition Program (NADP) also provided wet-only deposition rainwater samples from July 2019 – Sept 2021. Samples were submitted to the UA for dissolved metal(loid) analysis via inductively coupled plasma mass spectrometry (ICP-MS, Agilent 7700). All data were corrected and visualized using R software in RStudio [2]
Data format	Raw Corrected
Description of data collection	Harvested rainwater, field blank, and NADP samples were stored at 4°C and analyzed for dissolved metal(loid)s via ICP-MS using a modified EPA method SW-846 3005A, 200.8, and 200.9. Duplicate samples and those collected outside of the determined schedule were analyzed, but excluded from this data article and associated research.
Data source location	City/Town/Region PH: Dewey-Humboldt, AZ; Hayden/Winkelman, AZ; Globe/Miami, AZ; Tucson, AZ; Arizona Trail System near Superior, AZ NADP: Grand Canyon National Park Hopi Point, AZ; Petrified Forest National Park Rainbow Forest, AZ; Oliver Knoll, AZ; Chiricahua National Monument, AZ; Organ Pipe Cactus National Monument, AZ Country: USA
Data accessibility	Repository name: GitHub, Zenodo Data identification number: 10.5281/zenodo.7375319 Direct URL to data: https://doi.org/10.5281/zenodo.7823551 To protect participant privacy and respect data ethics guidelines, all samples were anonymized by deidentifying sample IDs and sites. Based on survey responses, 12 participants did not feel comfortable with their data shared publicly. To further protect participant privacy and respect their data ethics, a total of 99 samples were excluded from this database.
Related research article	Palawat K, Root R, Cortez LI, Foley T, Carella V, Beck C, Ramírez-Andreotta MD. 2023. Patterns of contamination and burden of lead and arsenic in rooftop harvested rainwater collected in Arizona environmental justice communities. Environmental Management, 337, 117747. https://doi.org/10.1016/j.jenvman.2023.117747.

Value of the Data

- The data provide site-specific, household-scale, community-generated dissolved metal(loid) concentrations in rooftop harvested rainwater from environmental justice communities in AZ as well as wet-only deposition concentrations from natural areas in AZ.
- These data can be used by non-academic, academic, government, non-profit, and industry stakeholders to better understand harvested rainwater pollution and potential management/best practices in the US desert southwest.

- These data can be used to assess contamination relative to natural sites, be compared to other sites around the world, and be analyzed for spatiotemporal variation.
- Data is compared to US federal and AZ state standards and maximum recommended limits for water quality.
- The data can inform community members' knowledge about local environmental quality to help make decisions about community use of harvested rainwater.

1. Objective

Urban and rural community members are gardening locally and conserving water by installing systems to harvest rainwater. Communities seeking to adopt these practices want information on the quality of harvested rainwater and guidance on how to use it. In response, The University of Arizona in partnership with SERI designed Project Harvest, a co-created community science project focused on evaluating potential pollutants in harvested rainwater, soil, and garden plants irrigated with harvested rainwater, learning outcomes, and social action [1,3-8]. The objective of Project Harvest is to answer the community-generated question regarding the quality of rooftop harvested rainwater in Arizona. This dataset expands upon the associated article [1] by providing graphical and tabular summaries of the data and comparisons to relevant federal/state standards and recommendations. It also allows Project Harvest community scientists and others to use and analyze the rooftop harvested rainwater data themselves. We provide sample code to ensure our methods and interpretation are more accessible and transparent.

2. Data Description

Supplemental file 1 in the repository [9] provides As and Pb raw and corrected concentration data for 577 PH field samples, 588 PH field blanks, and 78 NADP field samples. Field blanks were not tabulated or visualized. Supplemental file 1 also details all method limits of detection (MLOD) for As and Pb. Supplemental file 2 [9] provides R code used for MLOD corrections to generate usable, corrected concentration data.

Detection frequencies by community for As and Pb are reported in Table 1. The detection percentages shown indicate how many of the samples had As and Pb concentrations above MLODs. Table 1 also compares the sample concentrations to regulatory standards/recommended maximum concentrations/recommended upper limits. These include the U.S. Environmental Protection Agency (USEPA) primary and secondary drinking water standards [10], Arizona Department of Environmental Quality (ADEQ) surface water (full and partial) standards [11], the U.S. Department of Agriculture (USDA) recommended maximum irrigation concentration for continuous use on all soils, and USDA livestock and poultry drinking water recommended upper limit [12].

Tables 2 and 3 describe summary statistics for As and Pb in rainwater respectively by PH and NADP community and sampling window. Geometric means and geometric standard deviations (GSD) were calculated instead of arithmetic means and standard deviations in order to better represent the non-normal data with multiple outliers.

Table 4 describe As and Pb concentrations for four harvested rainwater samples collected by the Arizona Trail System (ATS).

Box and whisker plot representations of As and Pb data by community and sampling window are visualized in Figs. 1 and 2.

Supplemental File 3 in the repository [9] provides code to load data from Supplemental File 1 and run linear mixed models on As and Pb concentrations.

Table 1
Harvested rainwater sample percent detection and exceedances of various water quality standards, recommended maximum concentrations, or recommended upper limits for arsenic and lead by community.

Contaminant	Community	n	Percent Detection	USEPA Drinking Water	USDA Livestock and Poultry Drinking Water Recommended Upper Limit	ADEQ Surface Water Full Body Contact	ADEQ Surface Water Partial Body Contact	USDA Recommended Maximum Irrigation Concentration For Continuous Use On All Soils
As	*Standard Value (μg L⁻¹)*			*10*	*10*	*30*	*280*	*100*
	Project Harvest							
	Dewey-Humboldt	53	77%	3.8%	3.8%	0.0%	0.0%	0.0%
	Globe/Miami	124	70%	0.0%	0.0%	0.0%	0.0%	0.0%
	Hayden/Winkelman	93	97%	17.2%	17.2%	3.2%	0.0%	1.1%
	Tucson	307	75%	0.7%	0.7%	0.0%	0.0%	0.0%
	Total	577	78%	3.5%	3.5%	0.5%	0.0%	0.2%
	National Atmospheric Deposition Program							
	Chiricahua	24	33%	0.0%	0.0%	0.0%	0.0%	0.0%
	Grand Canyon	17	6%	0.0%	0.0%	0.0%	0.0%	0.0%
	Oliver Knoll	15	40%	0.0%	0.0%	0.0%	0.0%	0.0%
	Organ Pipe	10	60%	0.0%	0.0%	0.0%	0.0%	0.0%
	Petrified Forest	12	33%	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	78	32%	0.0%	0.0%	0.0%	0.0%	0.0%
Pb	*Standard Value (μg L⁻¹)*			*15*	*100*	*15*	*15*	*5000*
	Project Harvest							
	Dewey-Humboldt	53	100%	0.0%	0.0%	0.0%	0.0%	0.0%
	Globe/Miami	124	100%	2.4%	0.0%	2.4%	2.4%	0.0%
	Hayden/Winkelman	93	100%	5.4%	0.0%	5.4%	5.4%	0.0%
	Tucson	307	99.7%	3.6%	0.7%	3.6%	3.6%	0.0%
	Total	577	99.8%	3.3%	0.3%	3.3%	3.3%	0.0%
	National Atmospheric Deposition Program							
	Chiricahua	24	100%	0.0%	0.0%	0.0%	0.0%	0.0%
	Grand Canyon	17	100%	0.0%	0.0%	0.0%	0.0%	0.0%
	Oliver Knoll	15	100%	0.0%	0.0%	0.0%	0.0%	0.0%
	Organ Pipe	10	100%	0.0%	0.0%	0.0%	0.0%	0.0%
	Petrified Forest	12	100%	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	78	100%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 2
As summary statistics by sampling window and community in μg L^{-1}.

Community	First Winter	Last Winter	First Monsoon	Last Monsoon	Total
Project Harvest					
Dewey-Humboldt					
n	14	20	11	8	53
Geometric Mean (GSD)	0.5604 (2.1)	0.8572 (2.2)	2.325 (2.3)	1.44 (2.7)	1.019 (2.6)
Median [Min-Max]	0.99 [0.154-1.1]	0.9286 [0.28-3.494]	2.435 [0.8125-14.1]	1.1855 [0.4978-13.71]	0.99 [0.154-14.1]
Globe/Miami					
N	34	45	24	21	124
Geometric Mean (GSD)	0.6004 (2.3)	0.6549 (1.9)	1.477 (1.8)	1.334 (1.8)	0.8444 (2.2)
Median [Min-Max]	0.66905 [0.16-3.837]	0.6889 [0.28-3.813]	1.3525 [0.5866-7.681]	1.191 [0.4587-7.42]	0.92 [0.16-7.681]
Hayden/Winkelman					
n	31	36	12	14	93
Geometric Mean (GSD)	2.01 (2.2)	2.224 (3)	9.682 (3)	6.423 (3.5)	3.05 (3.2)
Median [Min-Max]	2.023 [0.4622-14.83]	2.49 [0.1387-22.05]	13.65 [1.843-40.33]	6.688 [1.167-120.2]	2.632 [0.1387-120.2]
Tucson					
N	104	116	53	34	307
Geometric Mean (GSD)	0.9484 (2.3)	0.7125 (2.1)	1.457 (2.1)	1.092 (1.9)	0.9312 (2.2)
Median [Min-Max]	1.1 [0.108-9.604]	0.6294 [0.28-9.804]	1.308 [0.34-13.71]	1.045 [0.3717-12.34]	0.9634 [0.108-13.71]
National Atmospheric Deposition Program					
Chiricahua					
N	6	6	5	7	24
Geometric Mean (GSD)	0.9782 (1.5)	0.61 (1)	0.1207 (2.4)	0.197 (2.9)	0.3523 (2.9)
Median [Min-Max]	0.8747 [0.61-1.799]	0.61 [0.61-0.61]	0.066 [0.066-0.45]	0.263 [0.066-0.7514]	0.61 [0.066-1.799]
Grand Canyon					
N	3	7	4	3	17
Geometric Mean (GSD)	0.45 (1)	0.61 (1)	0.3499 (3)	0.2785 (3.6)	0.4417 (2.1)
Median [Min-Max]	0.45 [0.45-0.45]	0.61 [0.61-0.61]	0.61 [0.066-0.61]	0.45 [0.066-0.7275]	0.61 [0.066-0.7275]
Oliver Knoll					
N	4	3	2	6	15
Geometric Mean (GSD)	0.8319 (1.1)	0.61 (1)	0.066 (1)	0.2062 (3)	0.3192 (3)
Median [Min-Max]	0.8196 [0.7766-0.9184]	0.61 [0.61-0.61]	0.066 [0.066-0.066]	0.2796 [0.066-0.7981]	0.61 [0.066-0.9184]
Organ Pipe					
N	4	3	0	3	10
Geometric Mean (GSD)	0.8098 (1.1)	0.61 (1)	–	0.3598 (4.4)	0.5831 (2.2)
Median [Min-Max]	0.8434 [0.6894-0.8774]	0.61 [0.61-0.61]	–	0.7805 [0.066-0.9042]	0.73495 [0.066-0.9042]
Petrified Forest					
n	3	5	1	3	12
Geometric Mean (GSD)	0.8563 (1.1)	0.61 (1)	0.066	0.1382 (3.6)	0.3806 (2.9)
Median [Min-Max]	0.9003 [0.7728-0.9024]	0.61 [0.61-0.61]	0.066 [0.066-0.066]	0.066 [0.066-0.6059]	0.61 [0.066-0.9024]

Table 3
Pb summary statistics by sampling window and community in µg L^{-1}.

Community	First Winter	Last Winter	First Monsoon	Last Monsoon	Total
Project Harvest					
Dewey-Humboldt					
n	14	20	11	8	53
Geometric Mean (GSD)	0.3051 (4.5)	0.3411 (3.8)	0.5237 (2.7)	0.1526 (3.8)	0.3207 (3.8)
Median [Min-Max]	0.1891 [0.02628-3.742]	0.19835 [0.03943-2.506]	0.5828 [0.1138-3.182]	0.1559 [0.01424-1.728]	0.2116 [0.01424-3.742]
Globe/Miami					
n	34	45	24	21	124
Geometric Mean (GSD)	0.6101 (2.8)	0.5082 (3.1)	0.9917 (5.2)	0.9617 (5.6)	0.6775 (3.8)
Median [Min-Max]	0.53885 [0.07847-5.101]	0.4974 [0.07796-4.291]	0.8172 [0.03554-15.07]	1.094 [0.07672-27.22]	0.61985 [0.03554-27.22]
Hayden/Winkelman					
n	31	36	12	14	93
Geometric Mean (GSD)	0.6442 (2.9)	0.7158 (3.9)	2.652 (5)	1.84 (6)	0.9433 (4.3)
Median [Min-Max]	0.6232 [0.07212-13.4]	0.6541 [0.03188-19.34]	3.7955 [0.261-23.64]	1.7015 [0.193-23.63]	0.7323 [0.03188-23.64]
Tucson					
n	104	116	53	34	307
Geometric Mean (GSD)	0.6821 (4.3)	0.652 (4.2)	1.163 (3.5)	0.7622 (6.6)	0.7444 (4.4)
Median [Min-Max]	0.56185 [0.013-25.37]	0.55265 [0.06074-350.2]	1.16 [0.0712-18]	0.489 [0.04841-264.2]	0.625 [0.013-350.2]
National Atmospheric Deposition Program					
Chiricahua					
n	6	6	5	7	24
Geometric Mean (GSD)	0.3266 (1.7)	0.3497 (2.6)	0.4965 (1.3)	0.3458 (1.6)	0.3686 (1.8)
Median [Min-Max]	0.28625 [0.1789-0.6755]	0.3185 [0.103-1.781]	0.4848 [0.3426-0.7528]	0.3234 [0.1446-0.6682]	0.35105 [0.103-1.781]
Grand Canyon					
n	3	7	4	3	17
Geometric Mean (GSD)	0.35 (3.5)	0.175 (1.6)	0.2881 (1.8)	0.4529 (1.4)	0.263 (2)
Median [Min-Max]	0.2782 [0.113-1.364]	0.1496 [0.1162-0.4156]	0.2934 [0.1393-0.5776]	0.4287 [0.3265-0.6638]	0.2712 [0.113-1.364]
Oliver Knoll					
n	4	3	2	6	15
Geometric Mean (GSD)	0.2391 (1.3)	0.2855 (1.4)	0.3602 (3.5)	0.452 (1.8)	0.3376 (1.8)
Median [Min-Max]	0.2342 [0.1894-0.3172]	0.2894 [0.1966-0.4091]	0.5123 [0.148-0.8766]	0.5037 [0.1572-0.7394]	0.3172 [0.148-0.8766]
Organ Pipe					
n	4	3	0	3	10
Geometric Mean (GSD)	0.2473 (1.5)	0.2064 (1.2)	–	0.2518 (1.5)	0.2355 (1.4)
Median [Min-Max]	0.2367 [0.1625-0.4146]	0.1904 [0.188-0.2456]	–	0.2442 [0.1738-0.3762]	0.2293 [0.1625-0.4146]
Petrified Forest					
n	3	5	1	3	12
Geometric Mean (GSD)	0.2957 (2.8)	0.1451 (1.3)	0.6344	0.9542 (2.7)	0.3139 (2.8)
Median [Min-Max]	0.1934 [0.1416-0.944]	0.1496 [0.1085-0.1866]	0.6344 [0.6344-0.6344]	0.5636 [0.5163-2.986]	0.19 [0.1085-2.986]

Table 4
Arsenic and lead concentrations in harvested rainwater from the Arizona Trail System.

Contaminant	First Winter (n=1)	Last Winter (n=1)	First Monsoon (n=1)	Last Monsoon (n=1)
As (µg L^{-1})	0.259	1.01	0.18*	0.18*
Pb (µg L^{-1})	0.189	0.118	0.166	0.695

* These values were non-detects with an As MLOD of 0.25 µg L^{-1}. The Pb MLOD was 0.0082 µg L^{-1}.

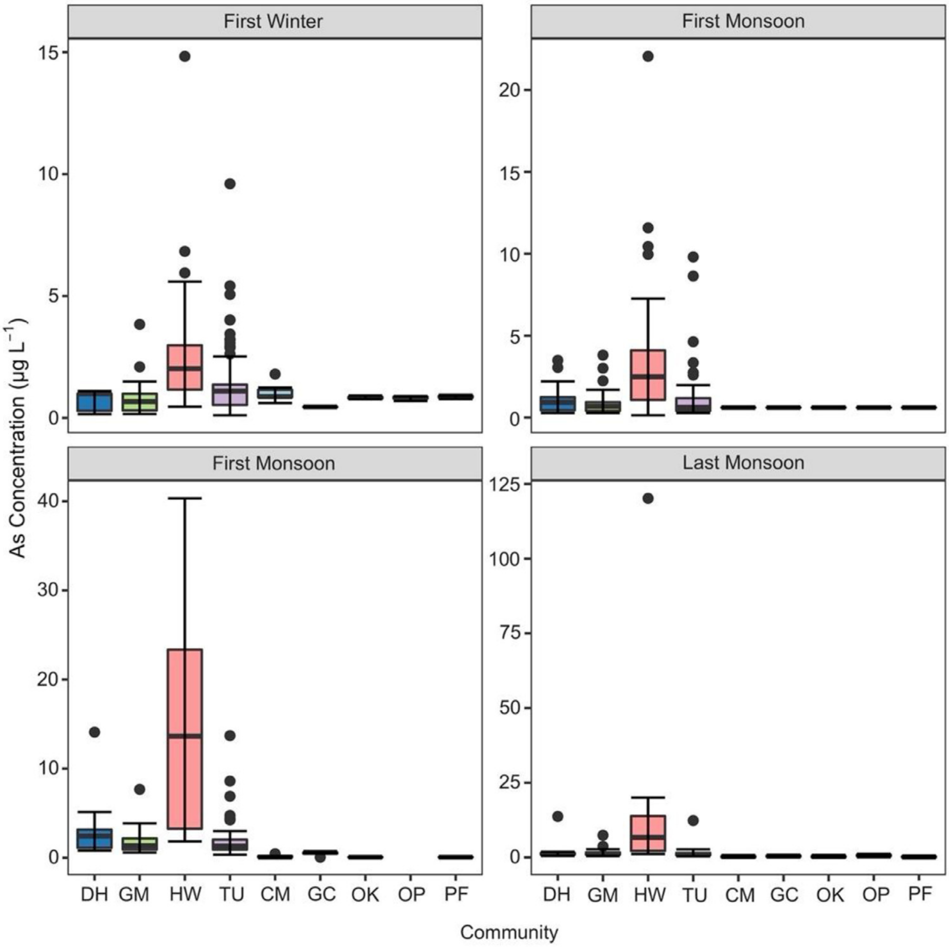

Fig. 1. Box plots of As concentrations (µg L^{-1}) by sampling window and community. Note different y-axis scales for each sampling window. Community abbreviations are as follows: DH, Dewey-Humboldt; GM, Globe/Miami; HW, Hayden/Winkelman, TU, Tucson; CM, Chiricahua National Monument; GC, Grand Canyon National Park Hopi Point; OK, Oliver Knoll; OP, Organ Pipe Cactus National Monument; PF, Petrified Forest National Park Rainbow Forest.

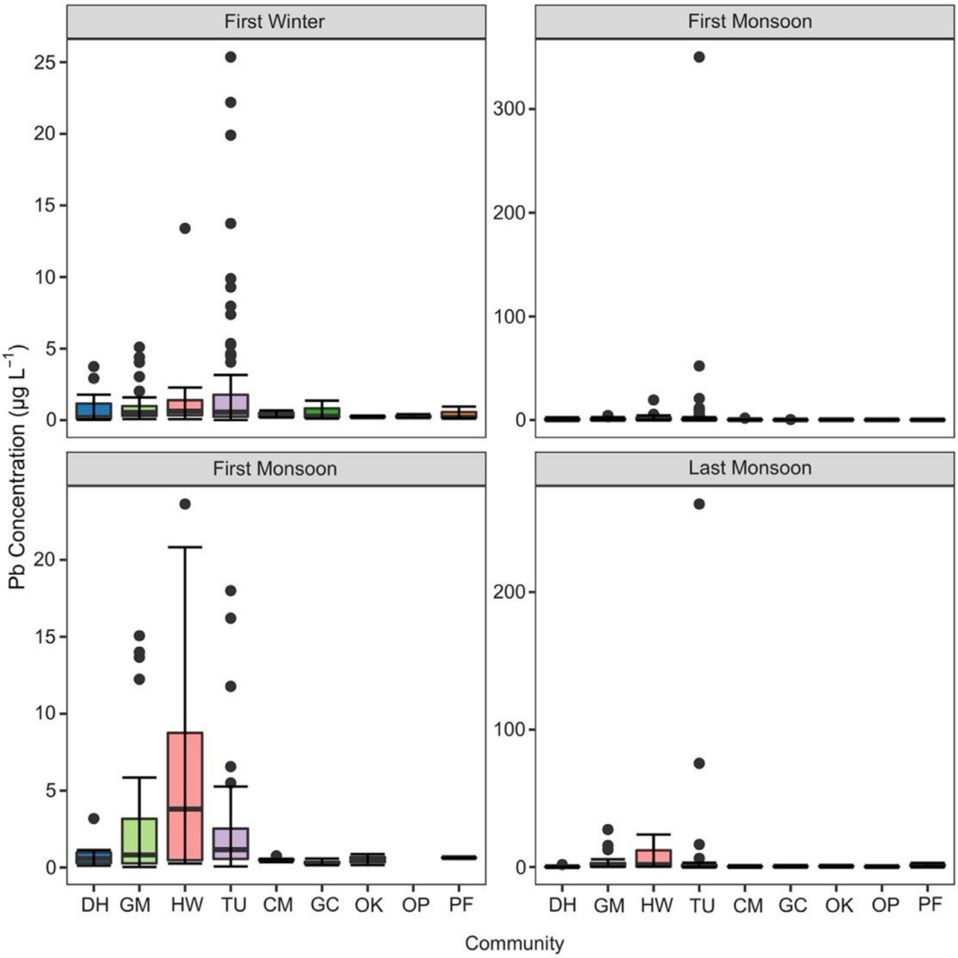

Fig. 2. Box plots of Pb concentrations (μg L^{-1}) by sampling window and community. Note different y-axis scales for each sampling window. Community abbreviations are as follows: DH, Dewey-Humboldt; GM, Globe/Miami; HW, Hayden/Winkelman, TU, Tucson; CM, Chiricahua National Monument; GC, Grand Canyon National Park Hopi Point; OK, Oliver Knoll; OP, Organ Pipe Cactus National Monument; PF, Petrified Forest National Park Rainbow Forest.

3. Experimental Design, Materials and Methods

3.1. Sample Collection

Trained community scientists, as part of The University of Arizona's (UA) transdisciplinary co-created community-based science program, PH, in partnership with SERI [1,3-8], collected a total of 577 harvested rainwater samples and field blanks during four sampling windows each water year from December 2017 to February 2020. Sample collection dates, hereafter, sampling window, were the first winter (December to January), last winter (February), first monsoon (June to July), and last monsoon (September). PH partnered with the NADP National Trends Network to obtain 78 wet-only deposition rainwater samples from five NADP locations in AZ. All samples were recorded on a chain of custody, labeled, sealed, and delivered to the UA and stored at 4° C prior to analyses. See Palawat et al. [1] and project website [7] for further details on sampling methods and project design.

3.2. Sample Analysis

Water samples were processed and analyzed for dissolved metal(loid) concentration via inductively coupled plasma mass spectrometry (ICP-MS, Agilent 7700). Briefly, a 20 mL aliquot of rooftop harvested rainwater was filtered to 0.45 µm, and acidified with 0.2 mL of 5% nitric acid (1.1 M). Acidified samples were analyzed for dissolved metal(loid)s of interest in the Arizona Laboratory for Emerging Contaminants (ALEC). NADP samples were analyzed in duplicate, when there was substantial volume for analysis, and averaged for future analysis. See Palawat et al. [1] and project website [7] for further details on sampling methods and project design.

3.3. Data Preparation

ALEC has shifting limits of detection (LOD) for all analytes, further varied by preparation factors (concentration factor, dilution factor, or combination) and multiple batches of samples. ALEC applies their preparation factor(s) to the instrument values and LODs, creating method limits of detection (MLOD) and reports all information back to PH researchers. Through PH sample preparation, we utilize 0.20 mL 5% nitric acid for dissolved metal(loid) analyses. This means samples are slightly diluted; thus, preparation factors must be applied to all values provided by ALEC including ALEC MLODs. After MLOD calculations, sample concentrations below the specific final MLOD were substituted using Eq. (1) as a conservative estimate of the real concentration. After MLOD assessment, these data were considered raw and ready for further analysis. See Supplemental File 2 in the repository for the R script used to conduct MLOD analysis [9].

$$\frac{MLOD}{\sqrt{2}} = \text{substitution} \tag{1}$$

Ethics Statement

This Data in Brief does not include any human subjects research. Project Harvest participants were consented under the University of Arizona Institutional Review Board (IRB) as an approved project. Informed consent was obtained from all participants and/or their legal guardians; materials and consent forms were administered in the participant's primary language.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

kpalawat223/AsPbRainwaterPatterns: As_Pb data and code (Original data) (Zenodo).

CRediT Author Statement

Kunal Palawat: Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Validation, Visualization; **Robert A. Root:** Conceptualization, Writing – review

& editing, Supervision, Funding acquisition; **Luz Imelda Cruz:** Investigation, Writing – review & editing; **Theresa Foley:** Investigation, Writing – review & editing; **Victoria Carella:** Investigation, Writing – review & editing; **Charles Beck:** Investigation, Writing – review & editing; **Mónica Ramírez-Andreotta:** Conceptualization, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition.

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