Filtration Impacts: Assessing Water Quality in Varied-Age Buildings

[1]

[2]

5/6/2024
Group 4
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[1] Bhattacharyya, Amrita, and Alex Chang. "New Campus Instructional Facility Opens for Fall Semester." *The Daily Illini*, 31 Aug. 2021, dailyillini.com/news-stories/2021/08/31/campus-instructional-facility/.

[2]Catalystadmin. "A Brief History of UIUC." *Burnham 310*, 9 June 2023, burnham310.com/a-brief-history-of-uiuc/.
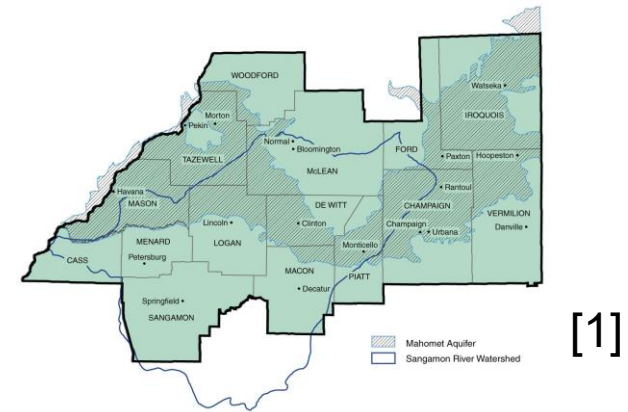
Overview

- Problem Statement

- Research Questions

- Methodology

- Sample Results

- Design Results

- Conclusions

- Future Investigations

- Q & A

Problem Statement – Background

[1]

Mahomet Aquifer

o Source of drinking water for over 500,000 residents in Illinois, serving Champaign, Urbana, Savoy, and other communities

o As of 2021,18 PFAS were tested and all were non-detect

o High hardness contributes to higher alkalinity; PH resilient

o Excellent quality despite certain areas with high ammonia, arsenic, and organics

Table 9. (concluded)

Well	Cu	Pb	Ni	Zn	Co
93-24B	<0.002	<0.014	<0.008	0.039	<0.004
92-3A	<0.002	<0.014	<0.008	0.040	<0.004
93-18A	<0.002	<0.014	<0.008	0.355	<0.004

[2]

[1] *Mahomet aquifer*. City of Champaign. (2019, January 23). https://champaignil.gov/public-works/find-a-service/mahomet-aquifer/

[2] Holm, T. R. (1995, February). *Ground-water quality in the Mahomet aquifer, McLean, Logan, and Tazewell counties*. GROUND-WATER QUALITY IN THE MAHOMET AQUTFER, McLEAN, LOGAN, AND TAZEWELL COUNTIES. https://www.isws.illinois.edu/pubdoc/cr/iswscr-579.pdf

Problem Statement – Motivation

Metals Commonly Found in Drinking Water

o Lead and Copper commonly found in US drinking water
  o Especially in pre-1986 plumbing systems
o UIUC drinking water could have unchecked amounts
  o Check new and old construction for water quality
  o Filtered and unfiltered
  o Look for correlation between building age and metal levels
  o Look for effectiveness of filter use
o EPA guidelines:
  o Copper MCLG: 1.3 mg/L
  o Lead MCLG: 0 mg/L

Problem Statement – Design Challenge

Point of use water quality sampling and treatment

- Primary goal
  - variations in water quality in different age campus buildings?
  - improved drinking water quality?

- End goal
  - Inform campus of finding

Client – iSEE

Mission & Purpose

- Established in 2013 under Research & Innovation office
  - Provides research on worldly sustainability efforts
  - Applies new practices to campus
- Sustainability in agriculture, energy, air, water, infrastructure
- Includes research sector in drinking water
  - Mostly treatment & microorganism elimination
  - No specific focus in presence of metals
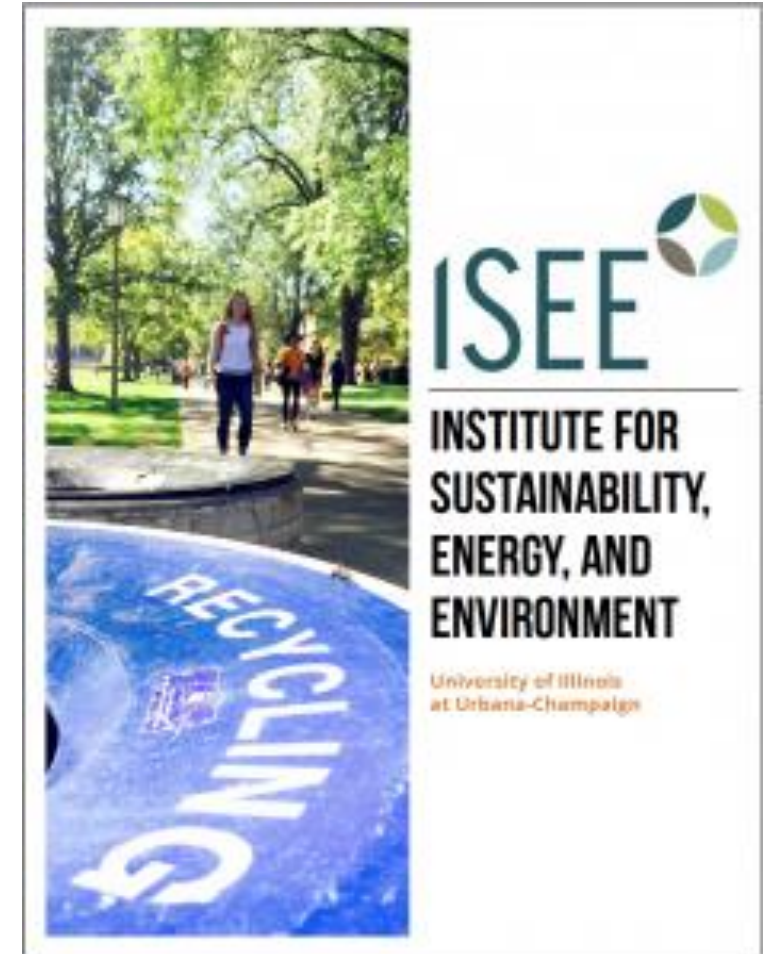
Research Questions

Null hypothesis 1:

There is no significant difference between lead/copper concentration based on presence of POU filter

Alternate hypothesis 1:

There is a significant difference between lead/copper concentration based on presence of POU filter

Null hypothesis 2:

There is no significant difference between lead/copper concentration based on building

Alternate hypothesis 2:

There is a significant difference between lead/copper concentration based on building

Sampling

Scope

- Campus Instructional Facility (CIF), completed 2021[1]
- Illini Union, completed 1941[2]
- Samples from high traffic areas
- 11-4pm

Overview

- 48 Samples
- 24 per building
- Blanks incorporated in ICP-MS (DI water)[3]
- Individual Sampling Event: 1st & 2nd (1L) flush taken consecutively from the same station
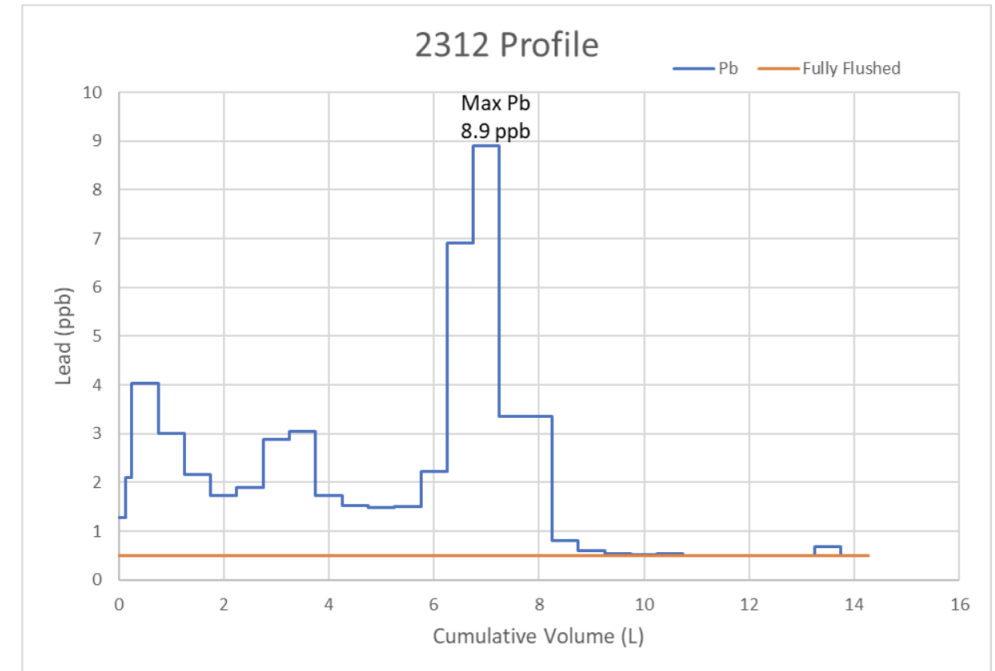
EPA Benton Harbor data report flushing illustration. [4]

[1] Campus Instructional Facility, University of Illinois Urbana-Champaign , cif.illinois.edu/. Accessed 29 Feb. 2024.

[2] Leetaru, Kalev. "Illini Union." Illini Union: UIHistories Project Virtual Tour at the University of Illinois, uihistories.library.illinois.edu/virtualtour/landmarks/union/. Accessed 29 Feb. 2024.

[3] "Quick Guide to Drinking Water Sample Collection." EPA, United States Environmental Protection Agency, Sept. 2016, www.epa.gov/sites/default/files/2015-11/documents/drinking_water_sample_collection.pdf.

Sampling Matrix

Building	Sample Type	Sampling Locations	Samples Collected per Location	Total 1L Samples
CIF	Filtered	3	4	12 Filtered, 12 Unfiltered
	Unfiltered	3	4	
Union	Filtered	2	6	12 Filtered, 12 Unfiltered
	Unfiltered	3	4	

Note: 24 of 48 measurements were performed on an instrument that lacked the sensitivity to measure samples at such low concentrations.
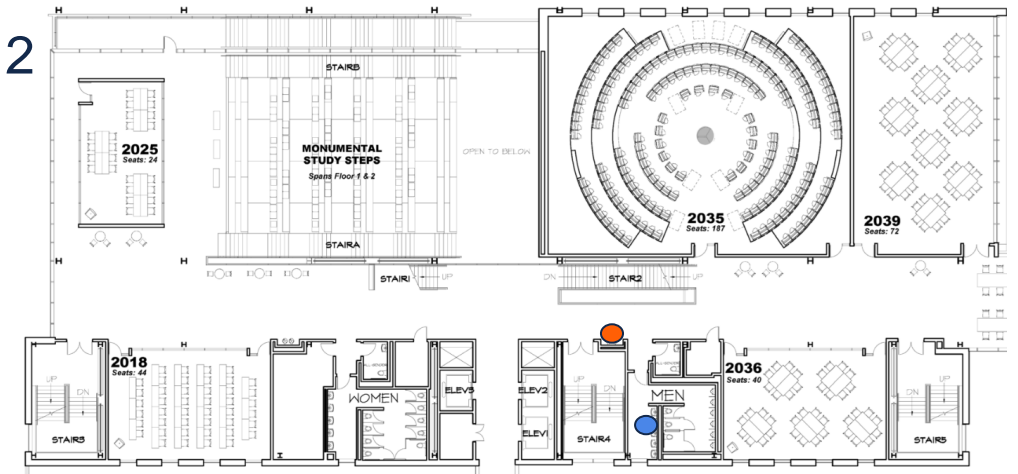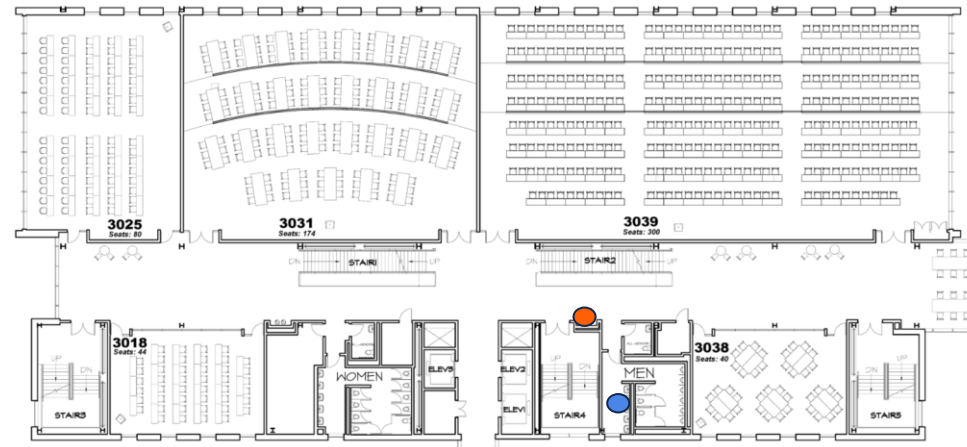
CIF Map

Floor 1

Floor 2

Floor 3

Key:
Orange: filtered
Blue: unfiltered
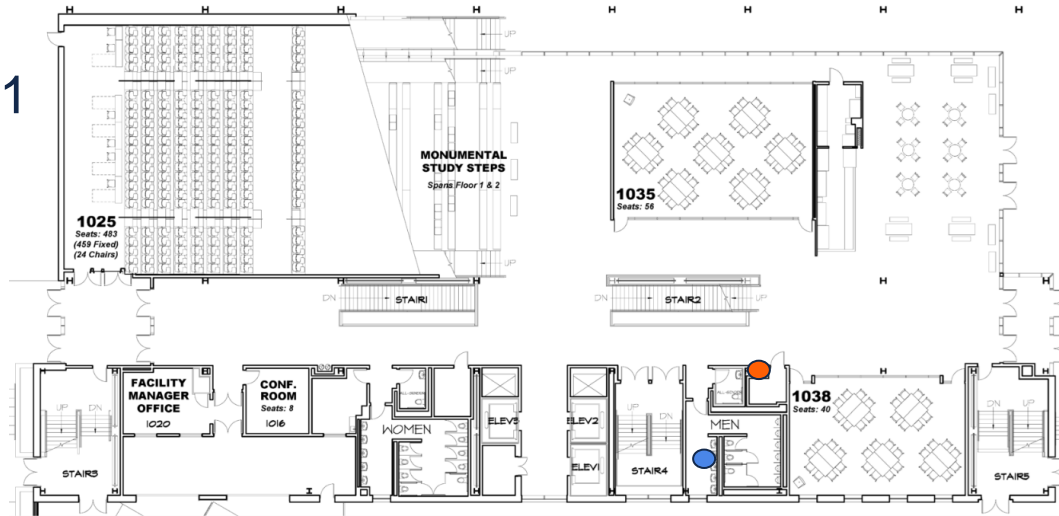
Union Map

Basement
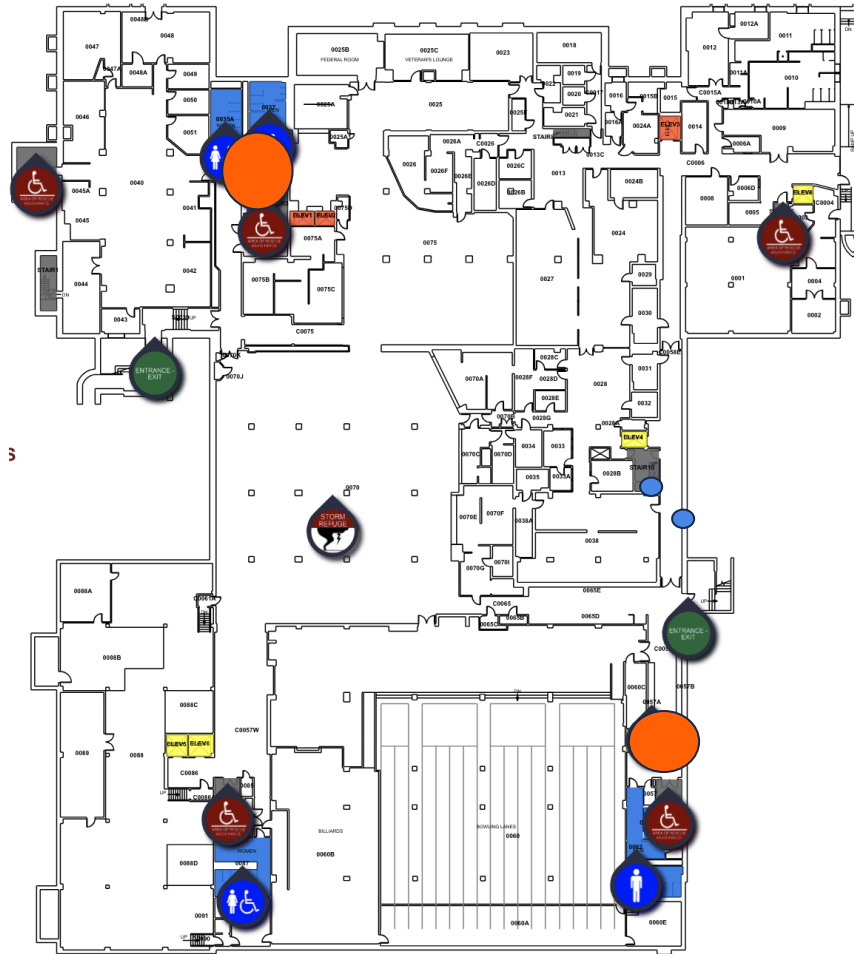
Floor 1

Key:
Orange: filtered
Blue: unfiltered

F&S Filtered Sample Locations

Building	Asset Label	Change Frequency	Last Change
Union	0023-EWC-001	Semi-Annual	8/21/2023
Union	0023-EWC-002	Semi-Annual	8/21/2023
CIF	1545-EWC-004	Annual	4/17/2023
CIF	1545-EWC-006	Annual	4/17/2023
CIF	1545-EWC-008	Annual	4/17/2023

Preliminary Free Chlorine Sampling

- Samples taken from Union (5) and CIF (6)
  - 3 filtered, 3 unfiltered at CIF
  - 2 filtered, 3 unfiltered at Union
  - Free chlorine tests done on all
    - DPD free chlorine powder pillow added
    - DR 890 colorimeter detects Cl_2 by magnitude of color change
  - Verifies that filter is actually present at locations
- Results: filter presence confirmed
  - Filtered range: 0.06-0.21 mg/L as Cl_2
  - Unfiltered range: 1.69-2.16 mg/L as Cl_2
- 3/19 lab comparison
  - Filtered range: 0.00-0.61 mg/L as Cl_2
  - Unfiltered & treated range: 1.31-2.00 mg/L as Cl_2

Preliminary Free Chlorine Sampling

Key

Blue: unfiltered

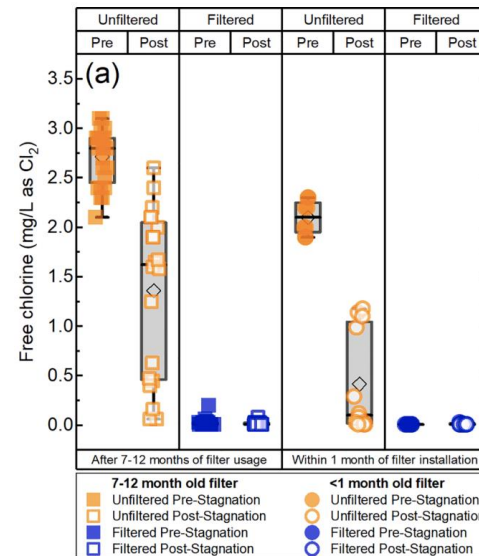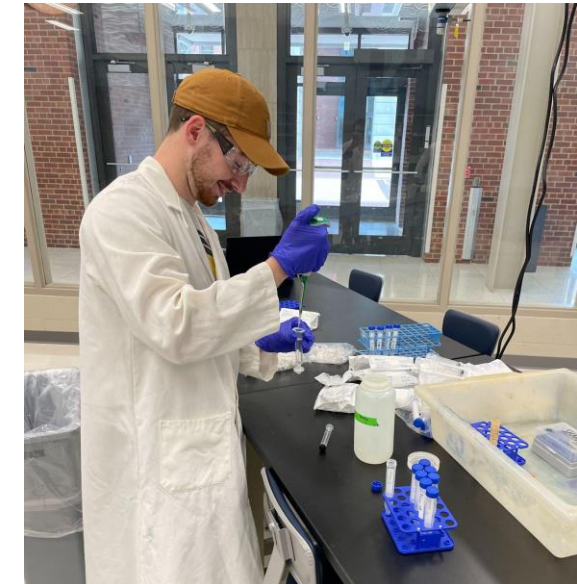Orange: filtered

Hatch: CIF

Solid: Union

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Analysis

- Group preparation of samples for ICP-MS
- TA assistance with standards and calibration curve
- Compare concentrations of Pb and Cu from different sources
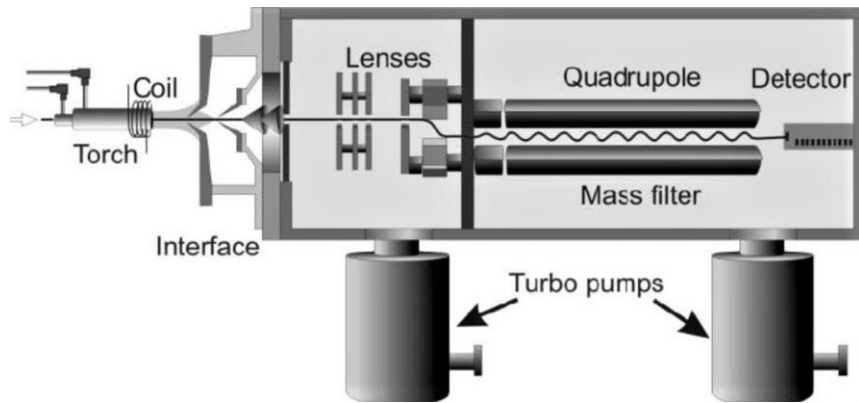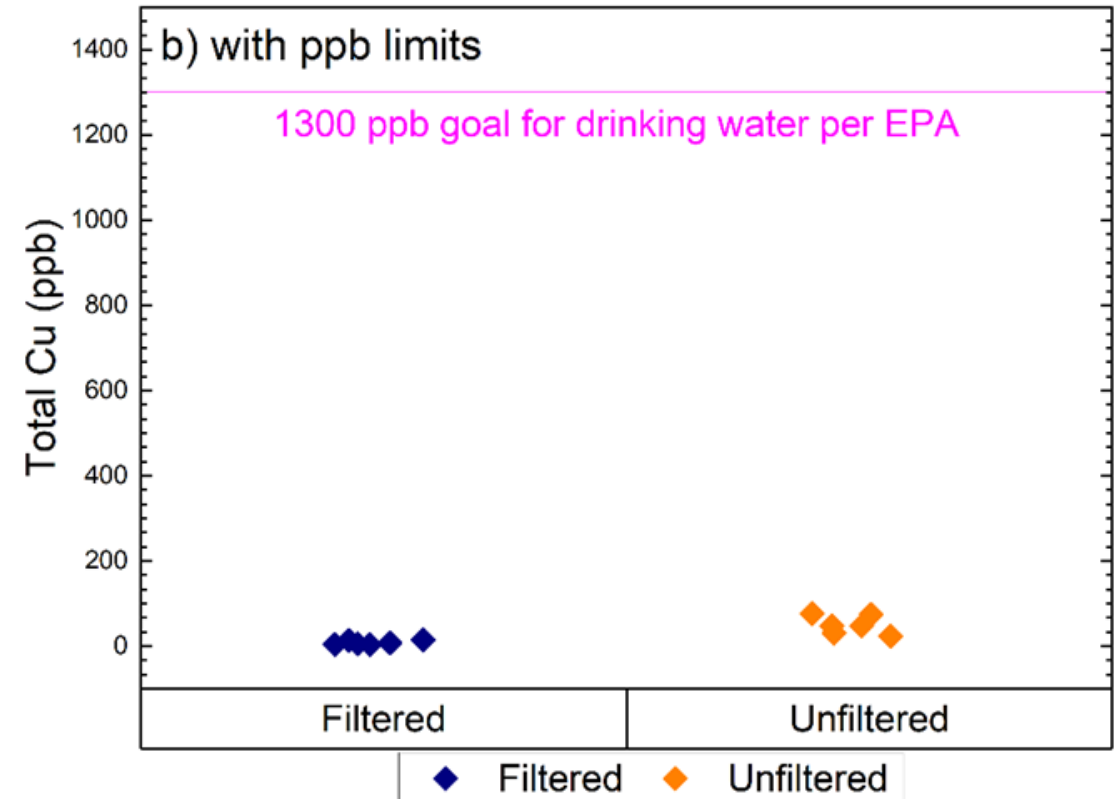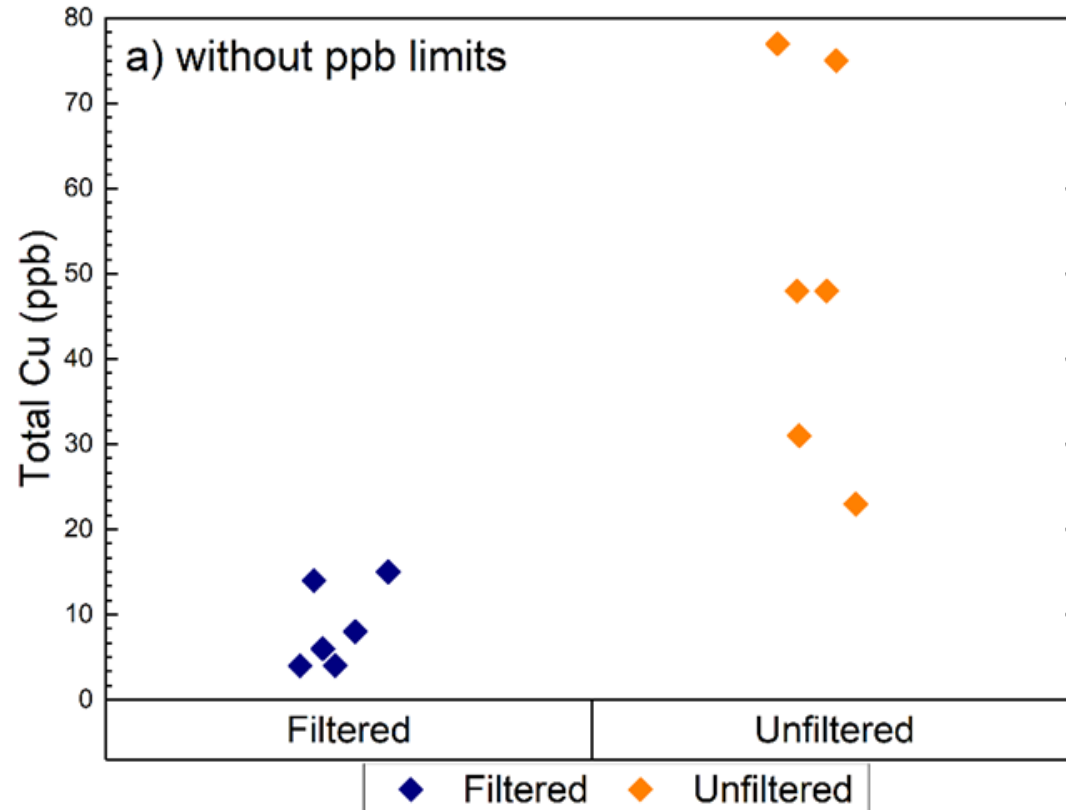

Cross section schematic of an ICP-MS. [1]

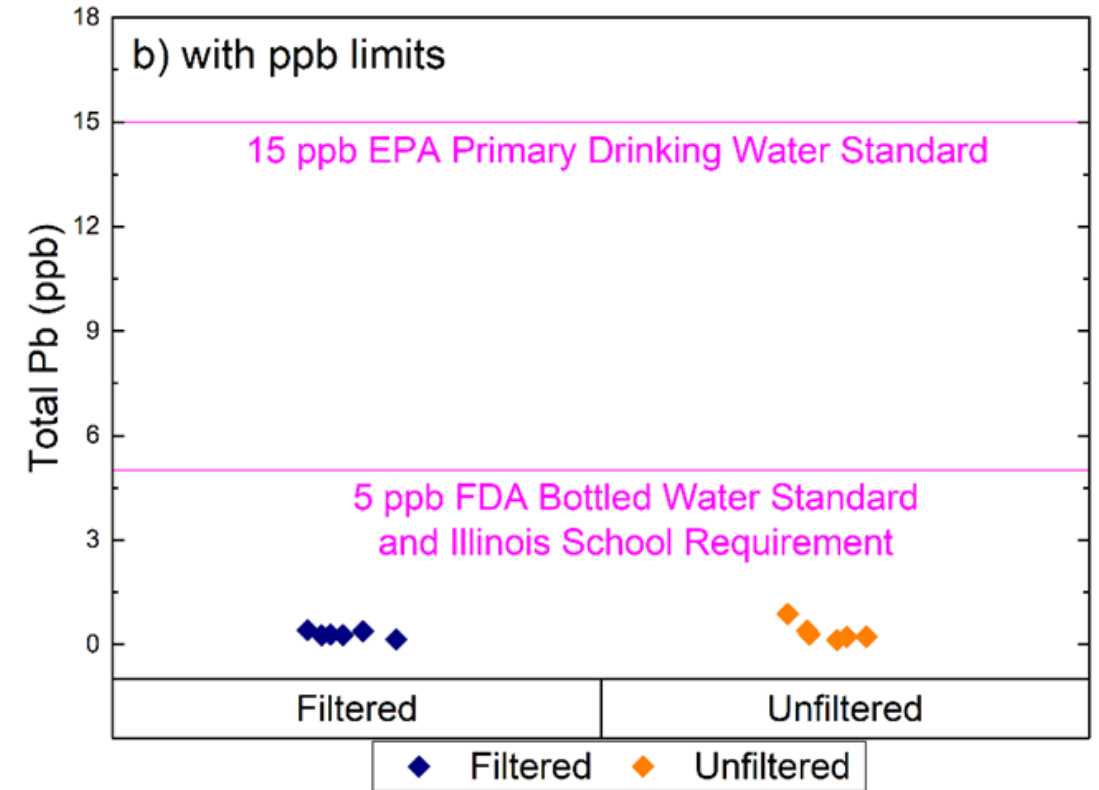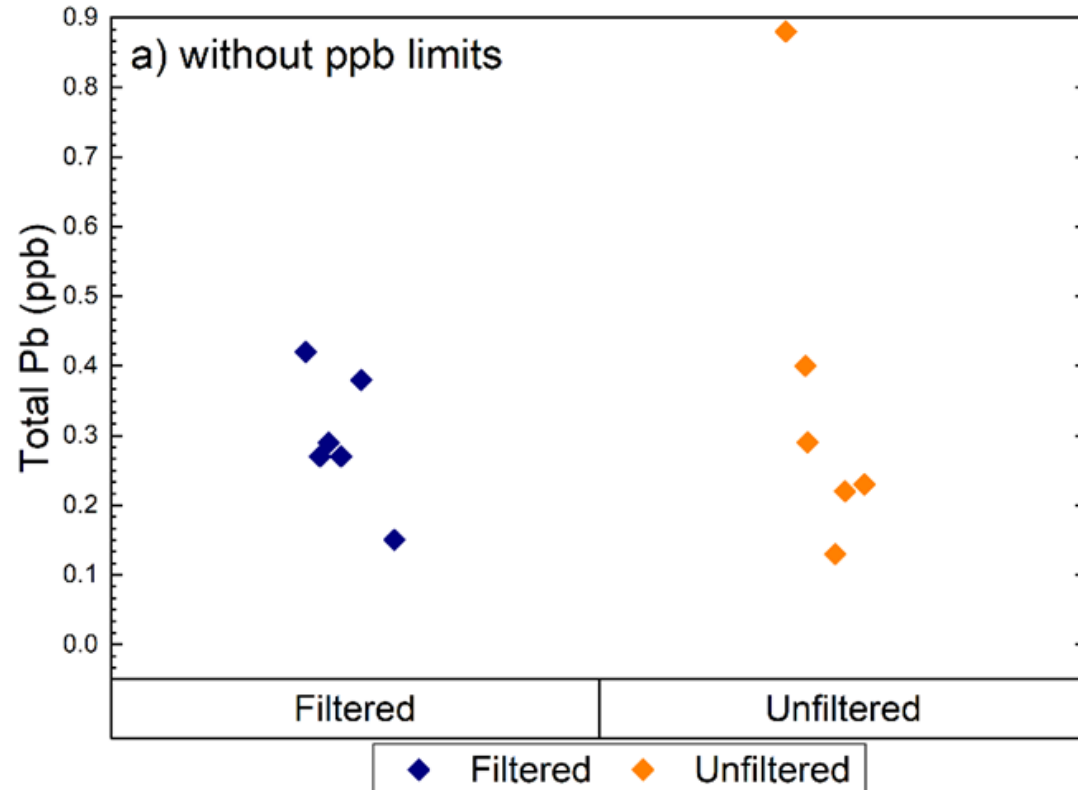Filtered vs unfiltered free chlorine concentrations. [2]

[1] Wilschefski, Scott C, and Matthew R Baxter. "Inductively Coupled Plasma Mass Spectrometry: Introduction to Analytical Aspects." The Clinical Biochemist. Reviews, U.S. National Library of Medicine, Aug. 2019, www.ncbi.nlm.nih.gov/pmc/articles/PMC6719745/#:~:text=Inductively%20coupled%20plasma%20mass%20spectrometry%20(ICP%2DMS)%20is%20an,trace%20levels%20in%20biological%20fluids.

[2] Clark, Gemma G., et al. "Influence of point-of-use filters and stagnation on water quality at a preschool and under laboratory conditions." Water Research, vol. 211, Mar. 2022, p. 118034, https://doi.org/10.1016/j.watres.2021.118034.
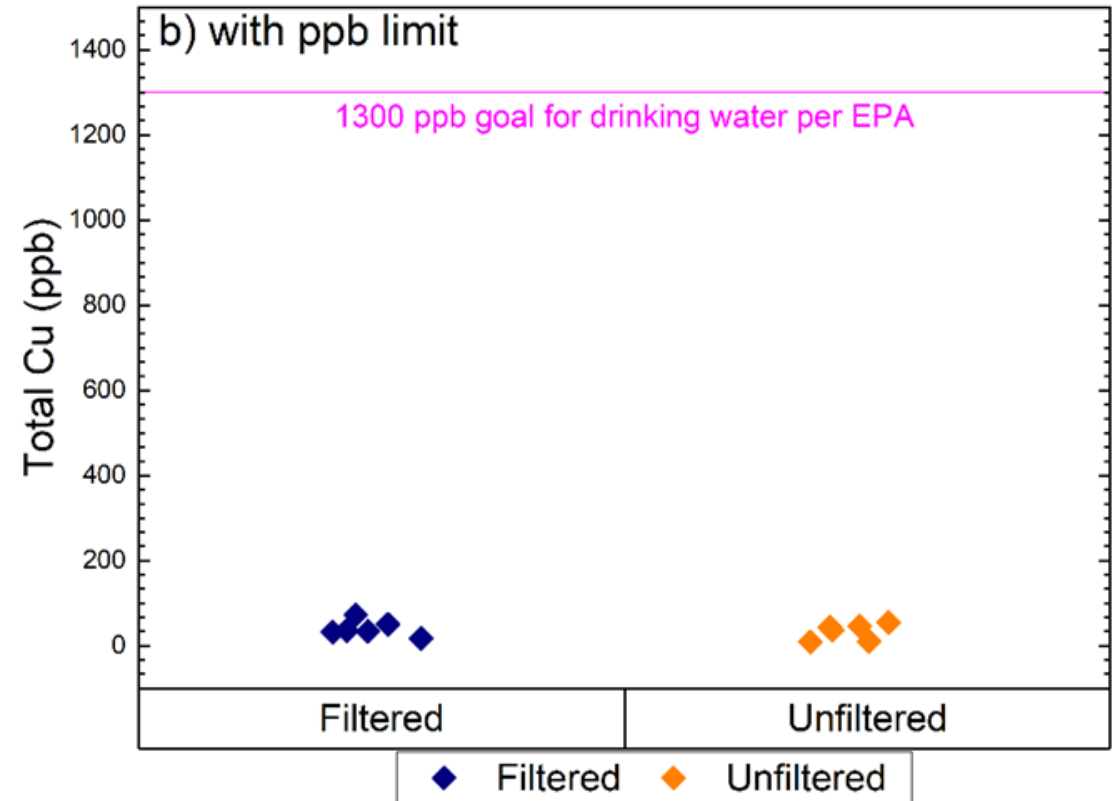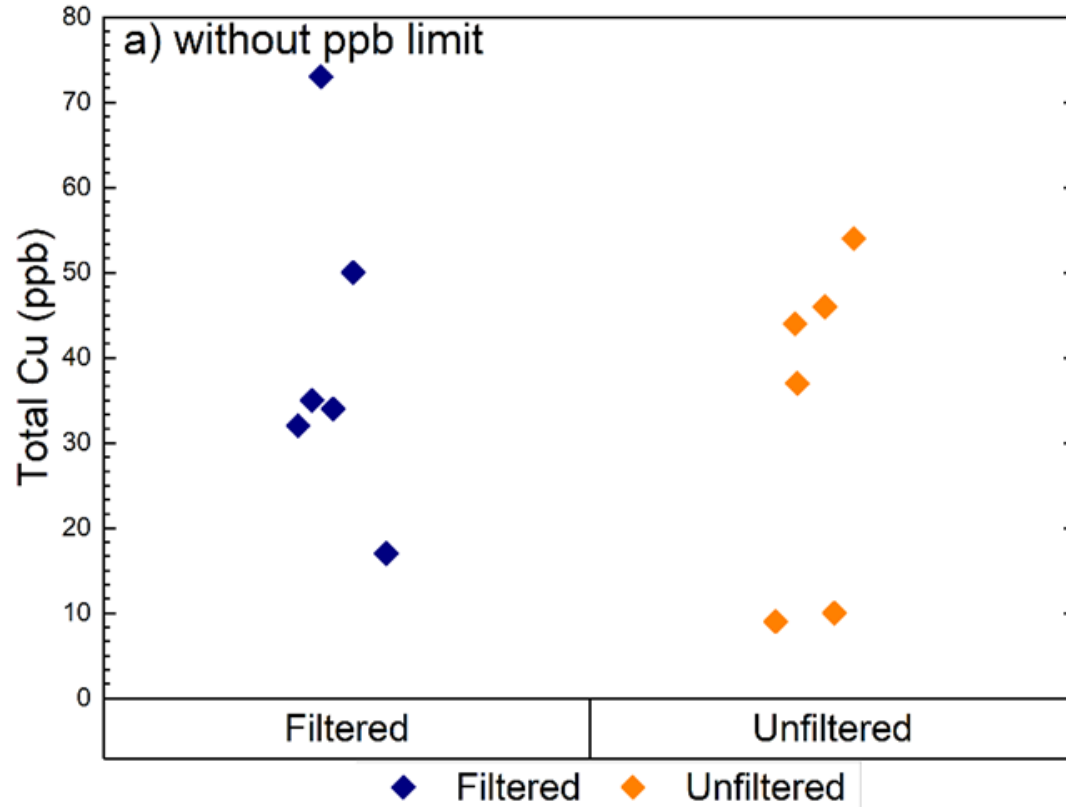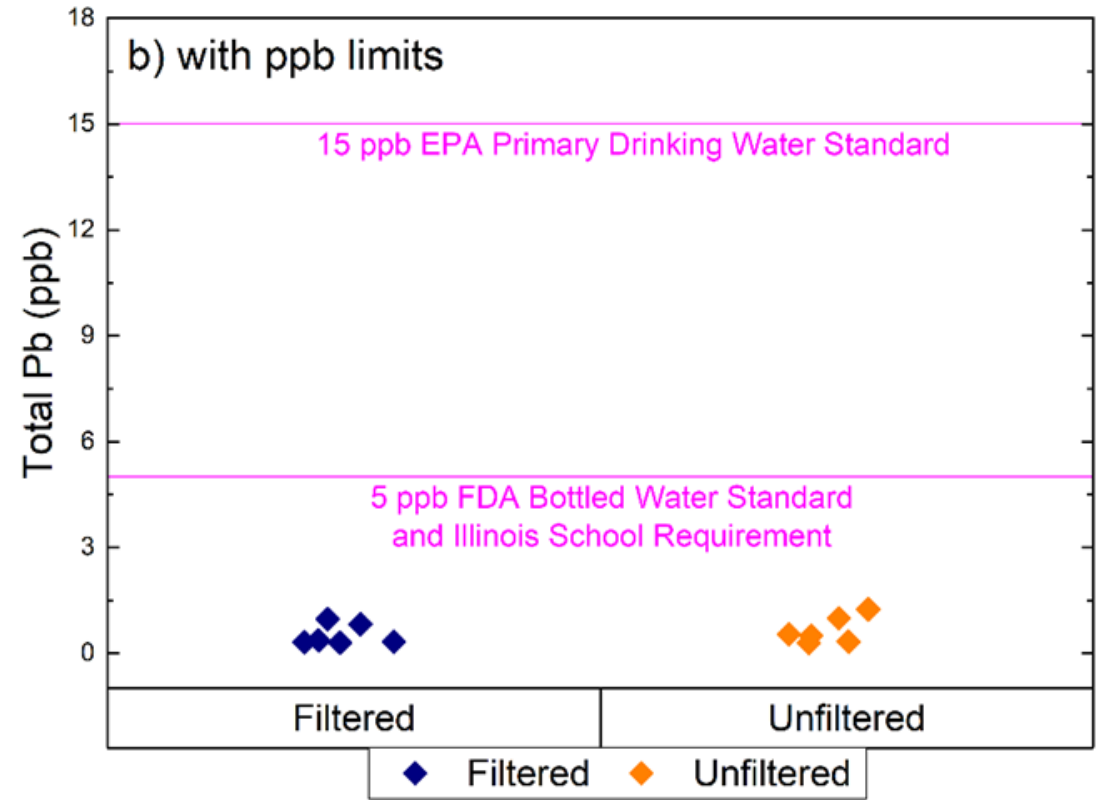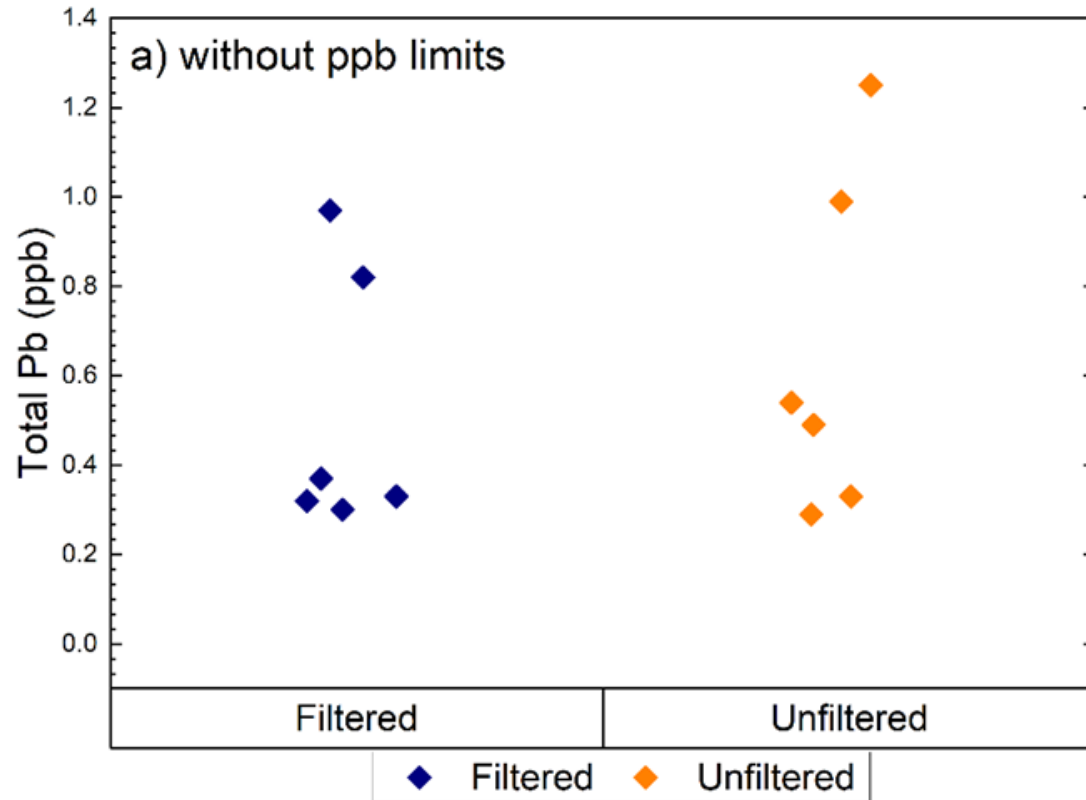
CIF Results (Copper)

a) without ppb limits — Total Cu (ppb) vs Filtered / Unfiltered

b) with ppb limits — 1300 ppb goal for drinking water per EPA

CIF Results (Lead)

Union Results (Copper)

Union Results (Lead)

a) without ppb limits — Total Pb (ppb), Filtered and Unfiltered

b) with ppb limits — Total Pb (ppb), Filtered and Unfiltered
15 ppb EPA Primary Drinking Water Standard
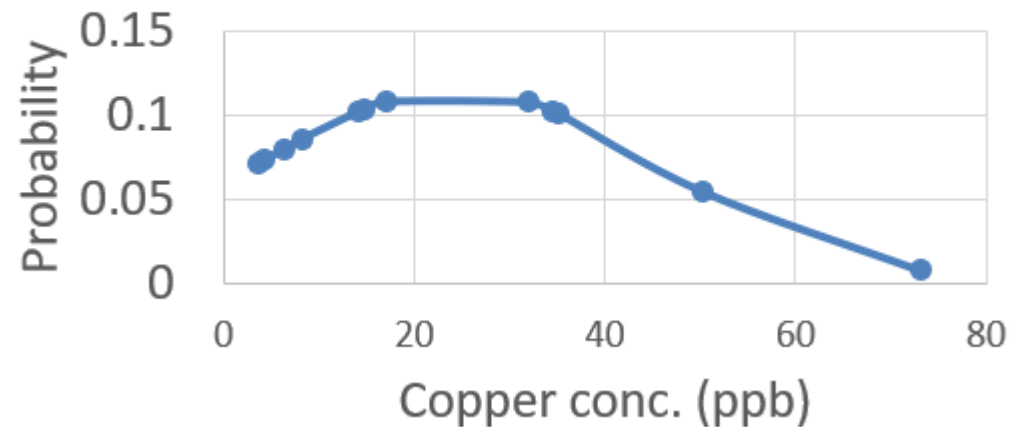5 ppb FDA Bottled Water Standard and Illinois School Requirement

2 Tailed, 2 sample T-test

- We performed 4 of these tests at 95% confidence level and t-critical of 2.07
- Requirements: Independent data values, SRS, normal distribution, standard deviations must be close

Distribution of Copper conc. in 12 Filtered Samples

σ = 21.3 ppb

Distribution of Copper conc. in 12 Unfiltered Samples
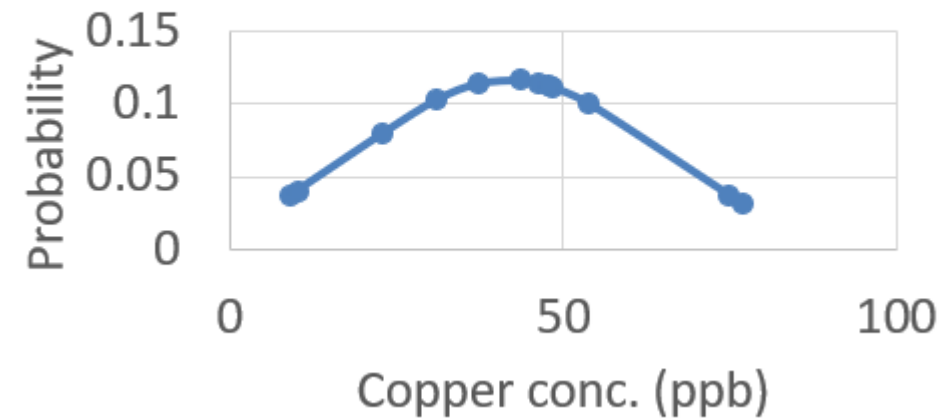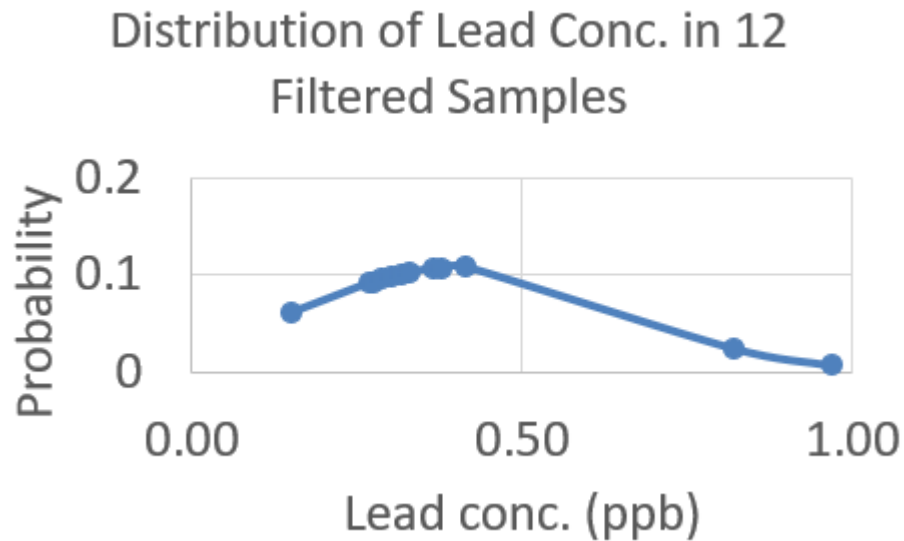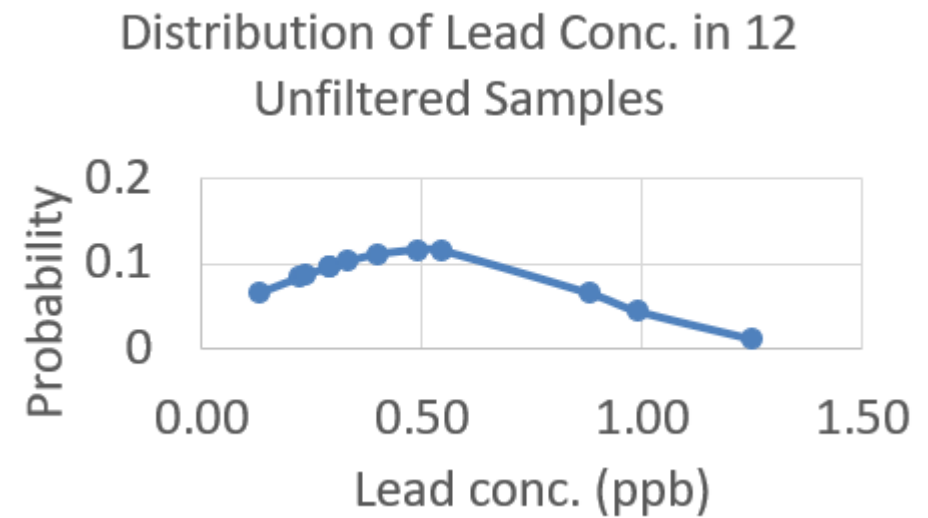
σ = 21.7 ppb

2 Tailed, 2 sample T-test

- We performed 4 of these tests at 95% confidence level and t-critical of 2.07
- Requirements: Independent data values, SRS, normal distribution, standard deviations must be close

Distribution of Lead Conc. in 12 Filtered Samples

σ = 0.24 ppb

Distribution of Lead Conc. in 12 Unfiltered Samples

σ = 0.35 ppb

Filtered vs. Unfiltered (Copper)
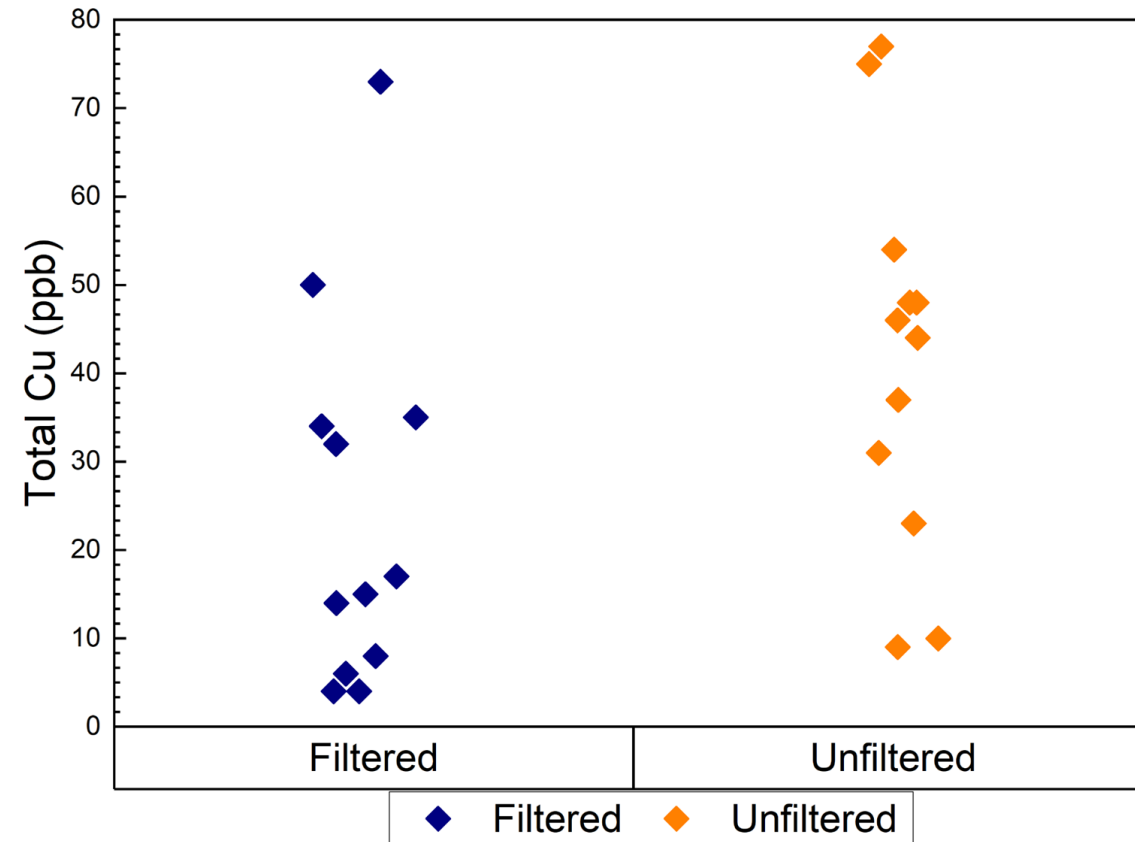
Filtered: x̄= 24 ppb, σ= 21.32; Unfiltered: x̄= 42 ppb, σ= 21.74
t= 1.988; p= 0.059

Filtered vs. Unfiltered (Lead)
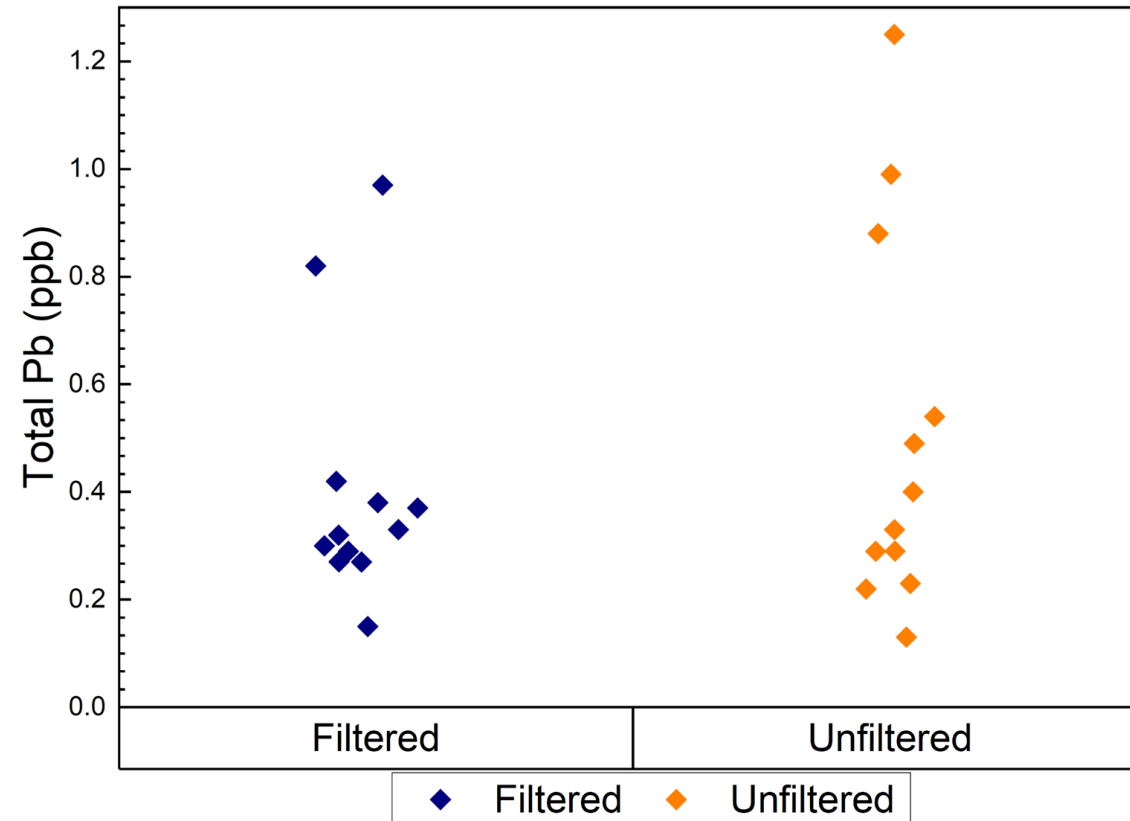
Filtered: x̄= 0.41 ppb, σ= 0.24; Unfiltered: x̄= 0.50 ppb, σ= 0.35
t= 0.793; p= 0.437

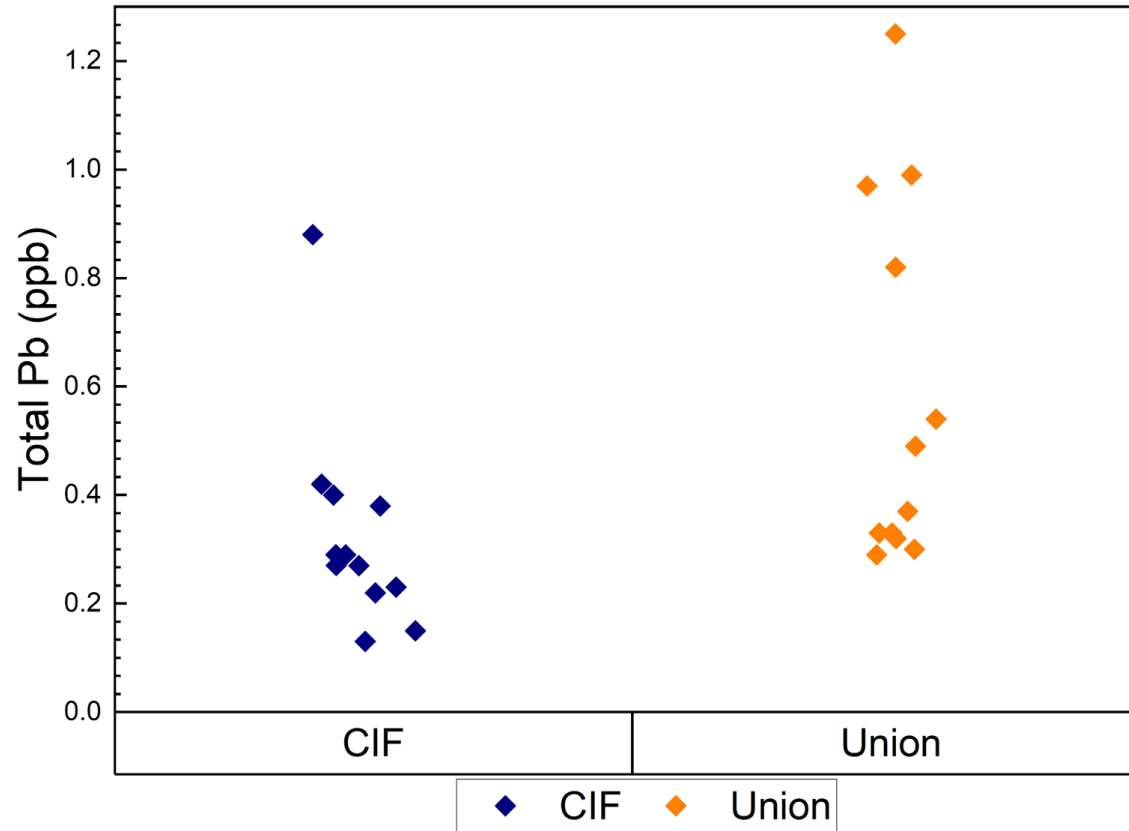# Old vs. New Building (Copper)
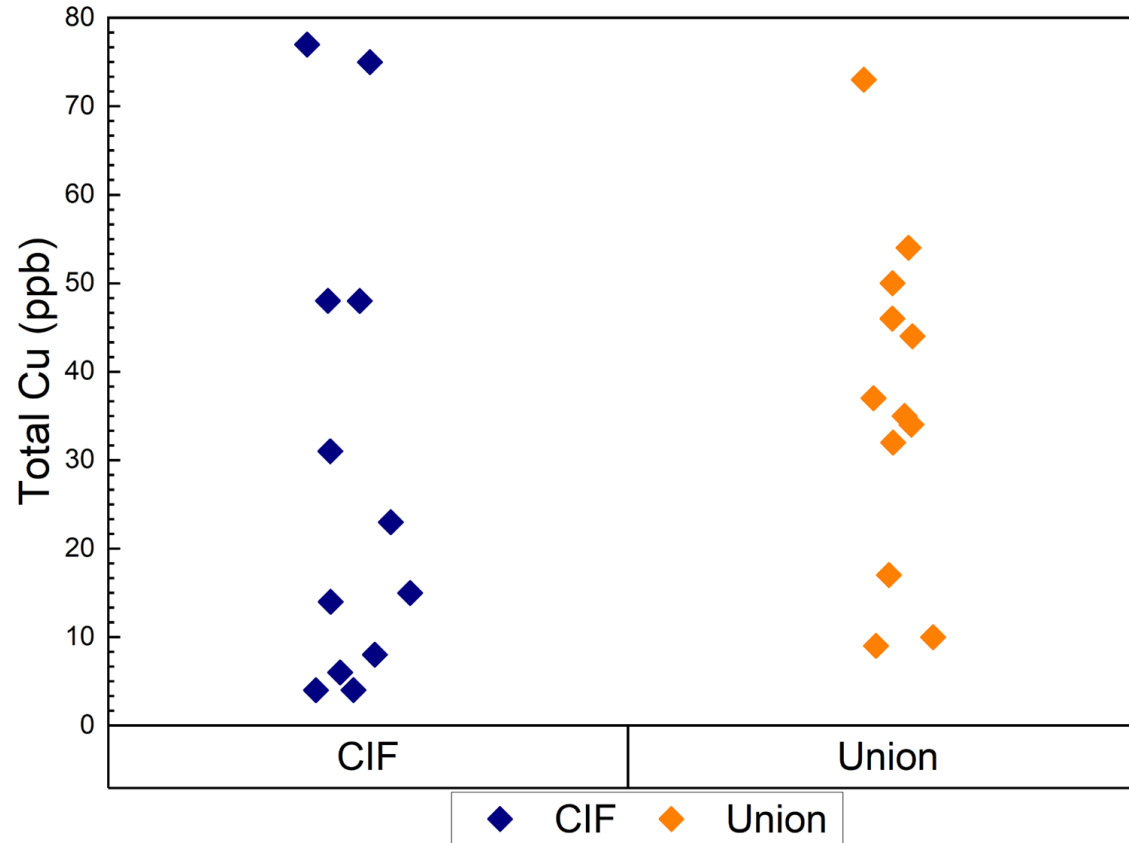
CIF: x̄= 29 ppb, σ= 26.73; Union: x̄= 37 ppb, σ= 18.70
t= 0.786; p= 0.441

Old vs. New Building (Lead)

CIF: x̄= 0.33 ppb, σ= 0.195; Union: x̄= 0.58 ppb, σ= 0.335
t= 2.28; p= 0.035

Design Results - Economic Analysis

Feature	Upgrade to Filtered Fountain	Unfiltered Fountain
Initial Investment	$2,250 - $2,500	$1,750 - $2,000
Annual Filter Cost 1	$65 - $75 per filter (once per year)	N/A
Annual Filter Cost 2	$130 - $150 (if replacing filters twice a year)	N/A
Additional Benefits	Reduced free chlorine; improved taste	N/A

Bottom Line:

- No statistically significant difference in contaminant concentrations between filtered and unfiltered sources
- Zero samples over EPA maximum contaminant levels

[1]*Specifications Elkay Watersentry Replacement Filter ...*, www.elkayfiles.com/spec-sheets/51300c_spec.pdf. Accessed 29 Feb. 2024.

[2]EPA, Environmental Protection Agency, www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations. Accessed 29 Feb. 2024.

Design Results

Different Aged Buildings

- No difference in copper concentrations
- Significant difference in lead concentrations

High Quality Water

Regulation	Maximum Lead Concentration (ppb)
EPA Primary Drinking Water Standard[1]	15
FDA Bottled Water Standard[2]	5
Illinois School Requirement[3]	5

CIF Pb: $\bar{x}$= 0.33 ppb; Union Pb: $\bar{x}$= 0.58 ppb

[1]EPA, Environmental Protection Agency, www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations. Accessed 29 Feb. 2024.
[2] "Bottled Water Everywhere: Keeping It Safe." U.S. Food and Drug Administration, FDA, 22 Apr. 2022, www.fda.gov/consumers/consumer-updates/bottled-water-everywhere-keeping-it-safe.
[3] "Lead in Drinking Water." Illinois Environmental Council, 5 Feb. 2021, ilenviro.org/clean-water/lead-in-drinking-water/#:~:text=If%20any%20sample%20at%20a,posted%20on%20the%20school%27s%20website.

Design Summary Conclusion

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University of Illinois water is SAFE

[1]

[2]

[1] Bhattacharyya, Amrita, and Alex Chang. "New Campus Instructional Facility Opens for Fall Semester." *The Daily Illini*, 31 Aug. 2021, dailyillini.com/news-stories/2021/08/31/campus-instructional-facility/.

[2]Catalystadmin. "A Brief History of UIUC." *Burnham 310*, 9 June 2023, burnham310.com/a-brief-history-of-uiuc/

Recommendations for Future Investigations

More Samples

- Our sample size of reputable data got cut in half (24) due to ICP-MS issues
- Would have been better to analyze more samples from more buildings to be able to apply our data to other University buildings

[1]

More Older Buildings

- Engineering Hall - 1894
- Altgeld Hall - 1896
- Armory - 1914

Filter Upgrade?

- 51300C → 71300C
- 2.125" longer, .1875" wider, designed for PFOA/PFOS removal as well
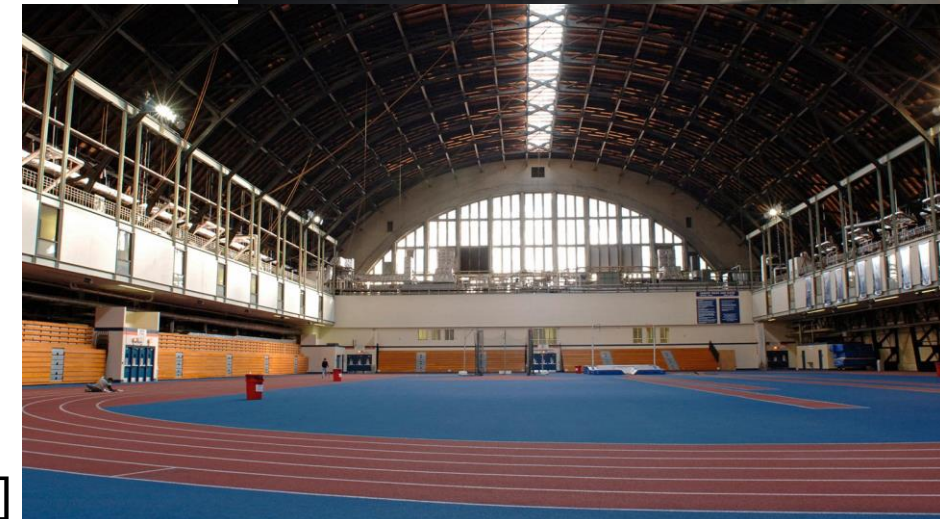
71300C

[3]   [2]

[1] Wikimedia Foundation. (2024, February 8). *Engineering Hall, University of Illinois Urbana-Champaign*. Wikipedia. https://en.wikipedia.org/wiki/Engineering_Hall,_University_of_Illinois_Urbana-Champaign

[2] *Ui Armory - Facilities*. University of Illinois Athletics. https://fightingillini.com/facilities/ui-armory/5   [3] *Elkay WaterSentry® PFOA/PFOS (PFAS) + lead + microplastics NSF/ANSI certified filter (enhanced bottle fillers)*. Elkay. https://www.elkay.com/products/details/71300C
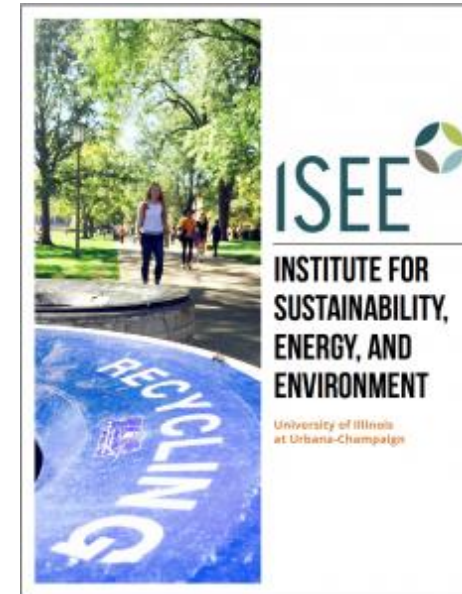
Communication with the Public
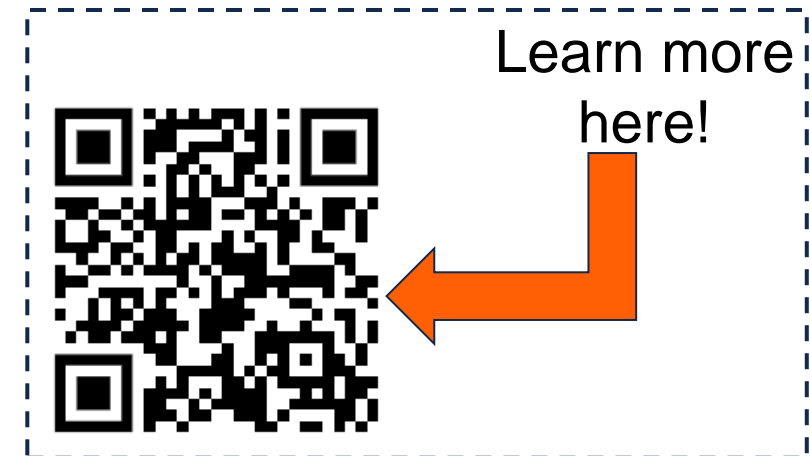
Collaboration with iSEE

- Make data publically available on iSEE site

- Attach plain language summary

Flyers

- Flyers with QR codes to iSEE website

- Near drinking water sources

- Increased exposure of class findings

[1]

Learn more here!

[1] University of Illinois at Urbana-Champaign. *Institute for Sustainability, Energy, and Environment.* https://sustainability.illinois.edu/about/

Q&A