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Water Chemistry and Microbiology Changes as Plumbing Ages

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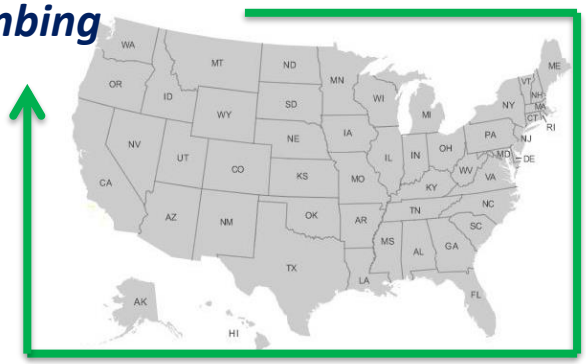
Outline

- ❑ Research Background & Significance
- ❑ Research Goal & Hypothesis
- ❑ Experimental Approach
- ❑ Result & Discussion
- ❑ Summary
- ❑ Future Work

Residential plumbing is critical for the health and safety of populations worldwide.

5-10 million miles of plumbing



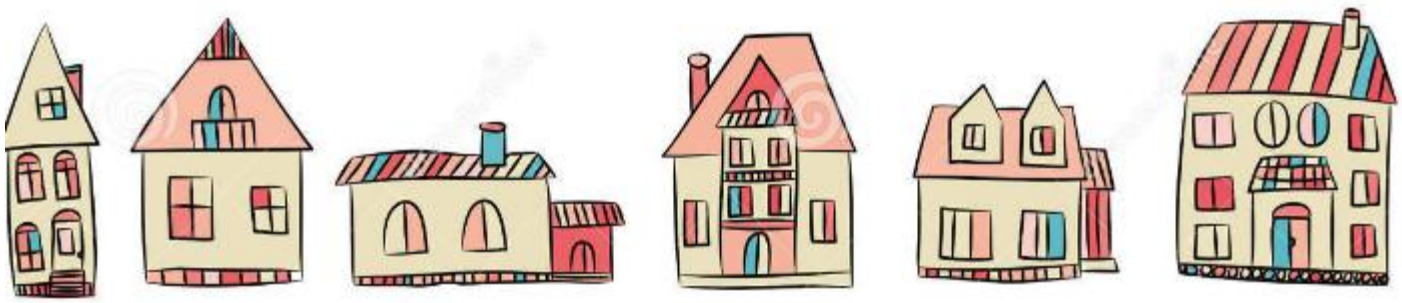
Water saving & Low-flow devices

Increased water age

Disinfectant residual loss

Microorganism proliferation

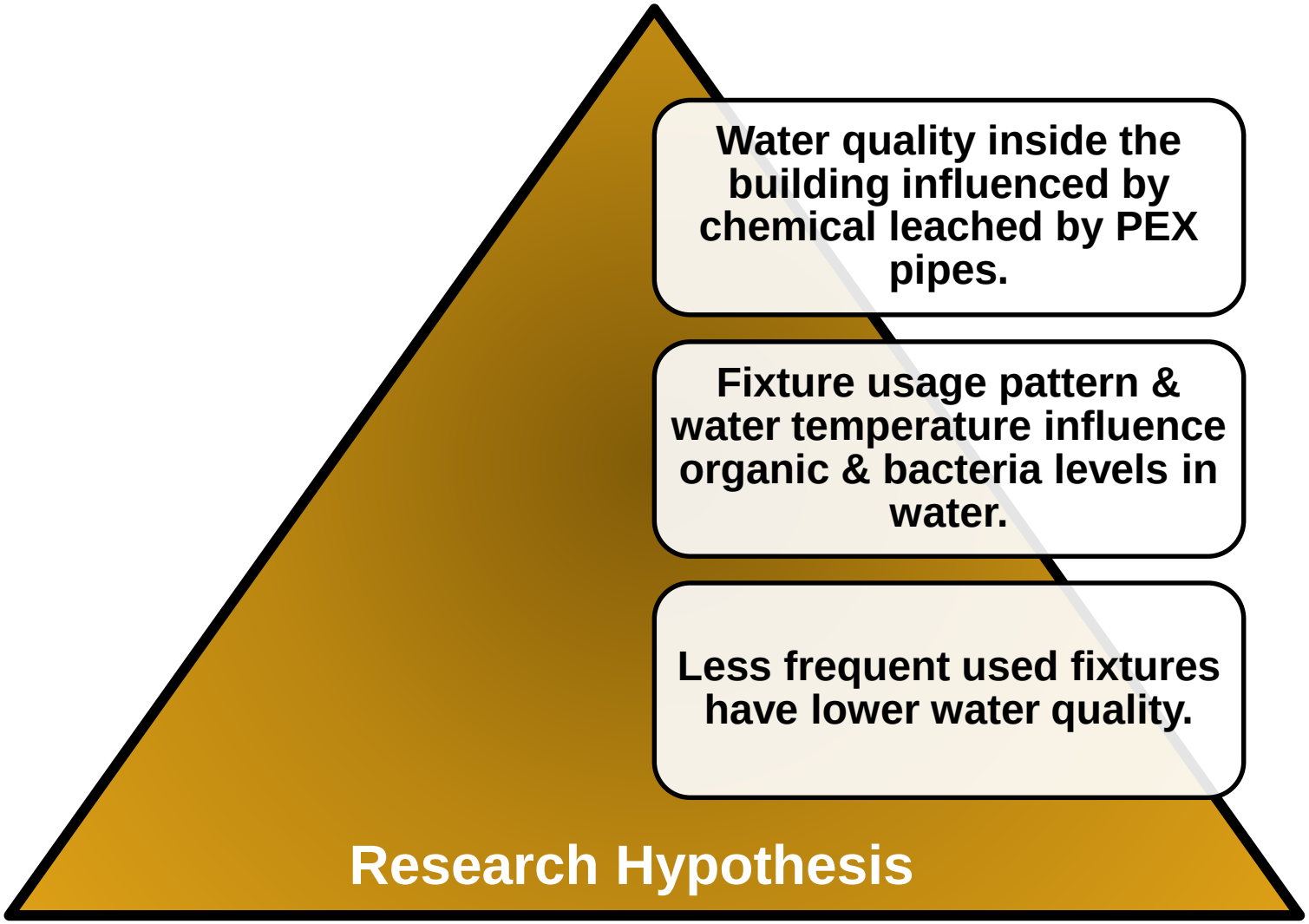
Enable contaminant leaching



Water Quality has been Monitored at Several Residential Buildings

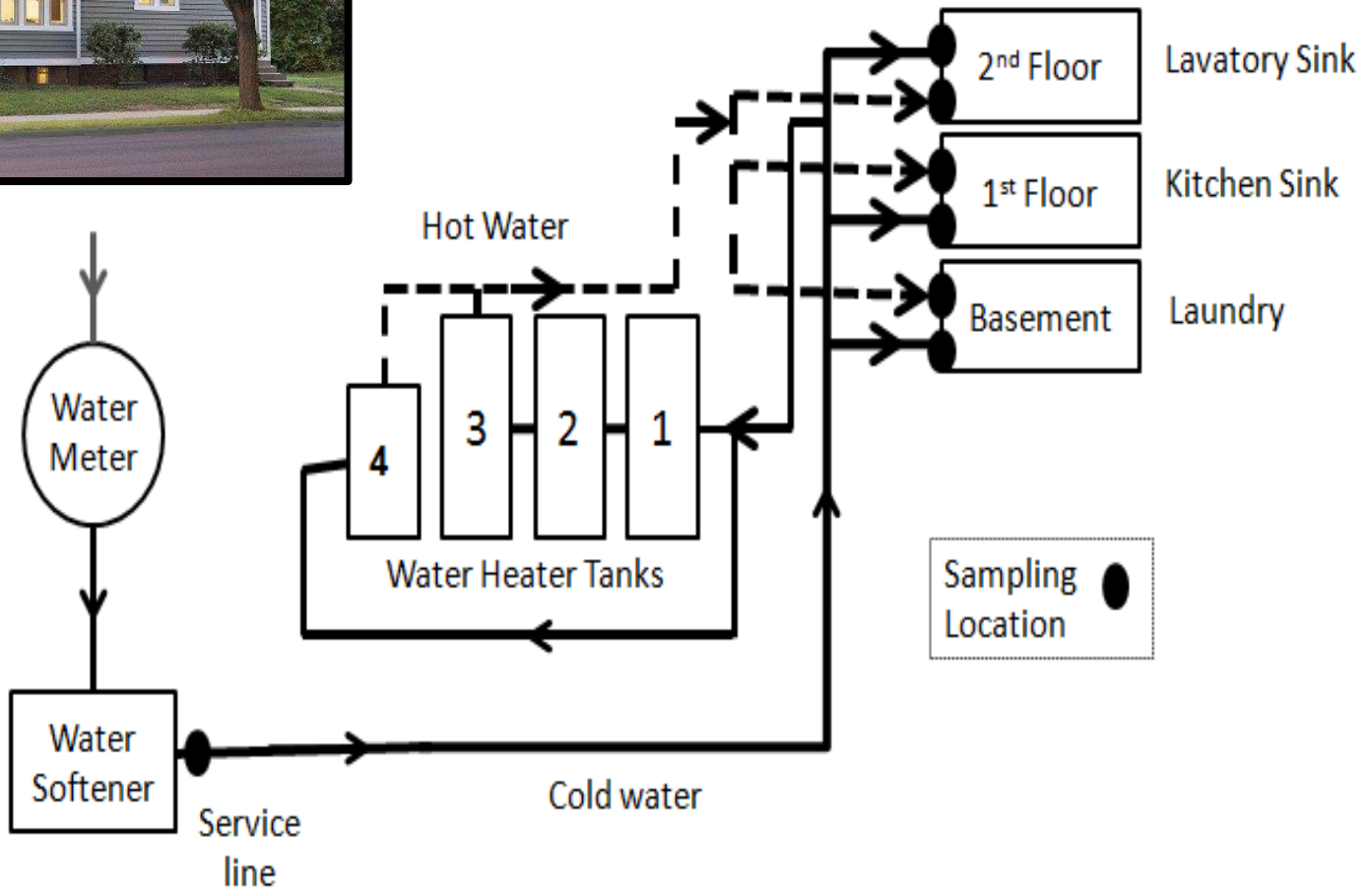
Location and Type of Buildings (Number)		Pipe Type / Plumbing Age (years)
USA	SFRBs (18)	nr/nr
	NZE SFRB (1)	PEX-a/ 0.5
	NZE SFRB & SFRB (2)	Cu, PEX/nr
	SFRB (3)	PEX-a, PEX-b/0.5-2
	Households (nr)	Cu, plastic/nr
CAN	SFRBs & Apartments (nr)	Cu, plastic/ <5, >10, >40
	SFRBs (6)	nr/nr
IT	SFRBs (nr)	Metal, plastic/nr
SWZ	Households (10)	nr/nr
DE	Households (1,674)	Cu/0.5-5
	Households (1,485)	nr
	SFRBs (nr)	Cu, plastic, galvanized steel/nr
	SFRBs (4)	Cu/nr

Goal: Better Understand the Link Between Water Use & Drinking Water Quality.



Water Sampling

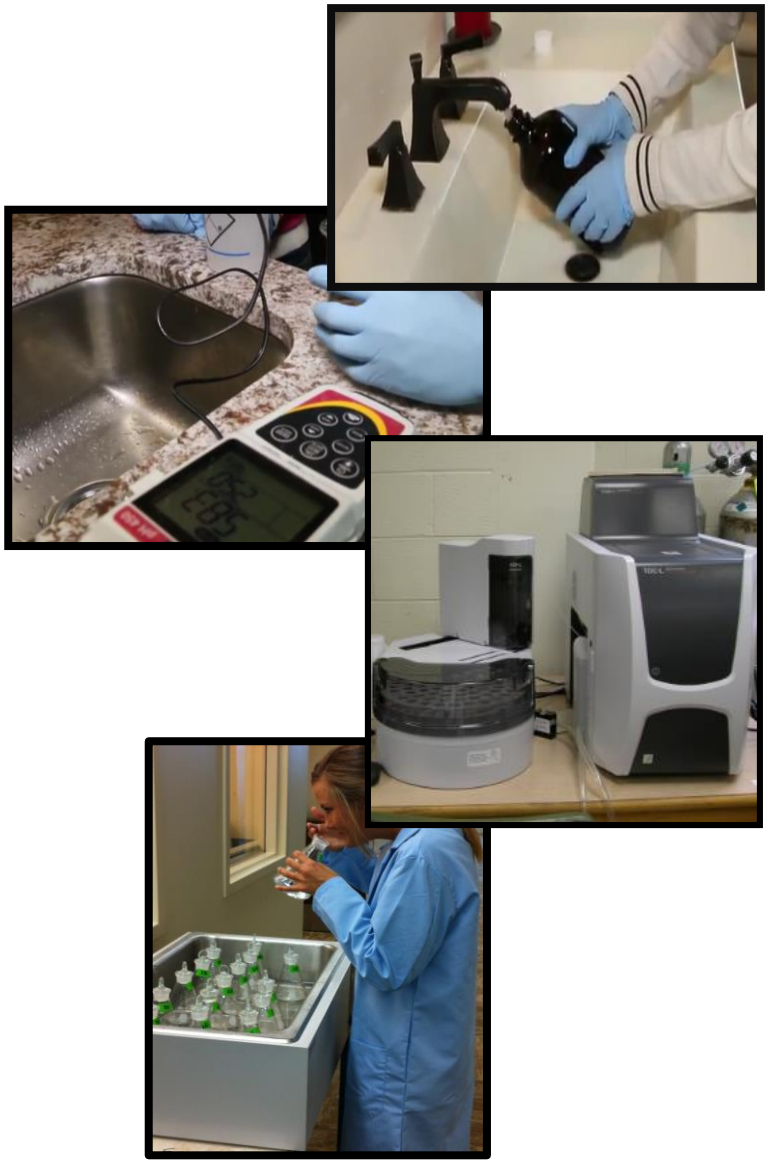
Water sampling (cold/hot) on day 3, 15, 30, 60 & 90



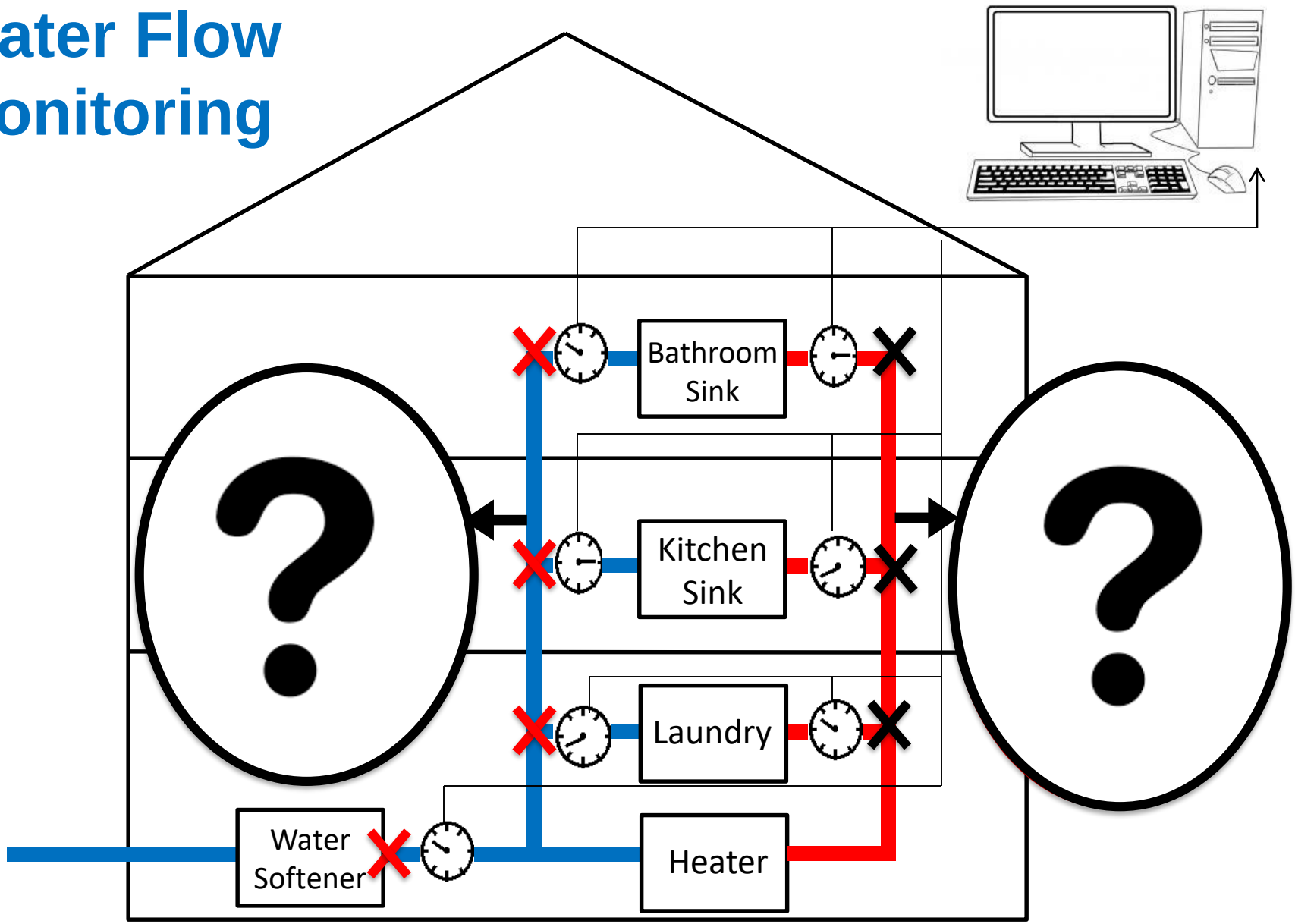
Water Quality Monitoring

Chemical Quality: Free chlorine, pH, Alkalinity, Total Organic Carbon (TOC),UV_{254} absorbance, Metals, Threshold Odor Number (TON)

Bacterial Quality: Culture-based HPC & Culture-independent quantitative real-time PCR (qPCR)

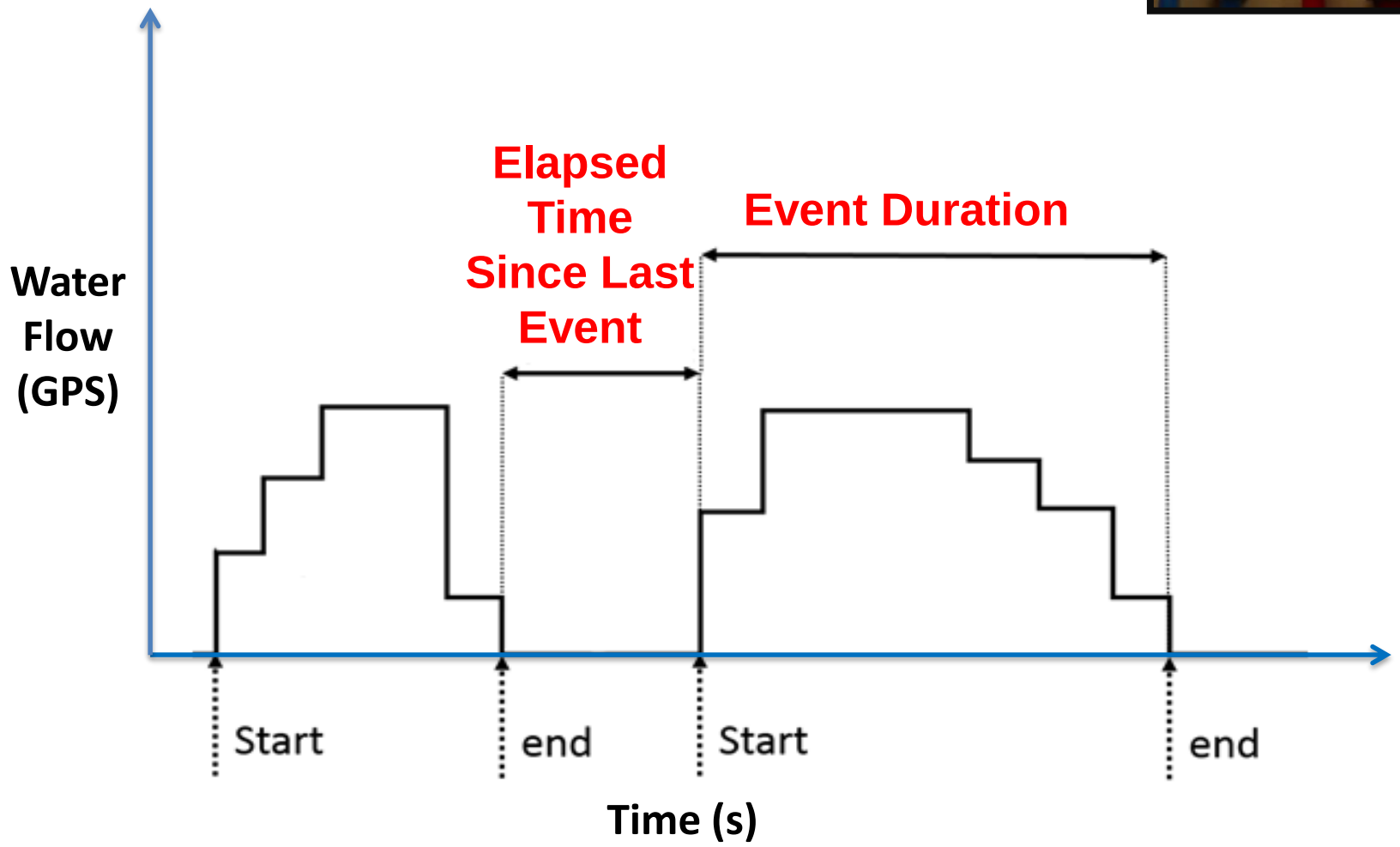


Water Flow Monitoring



Water Usage Analysis

64,891,484 *data points*



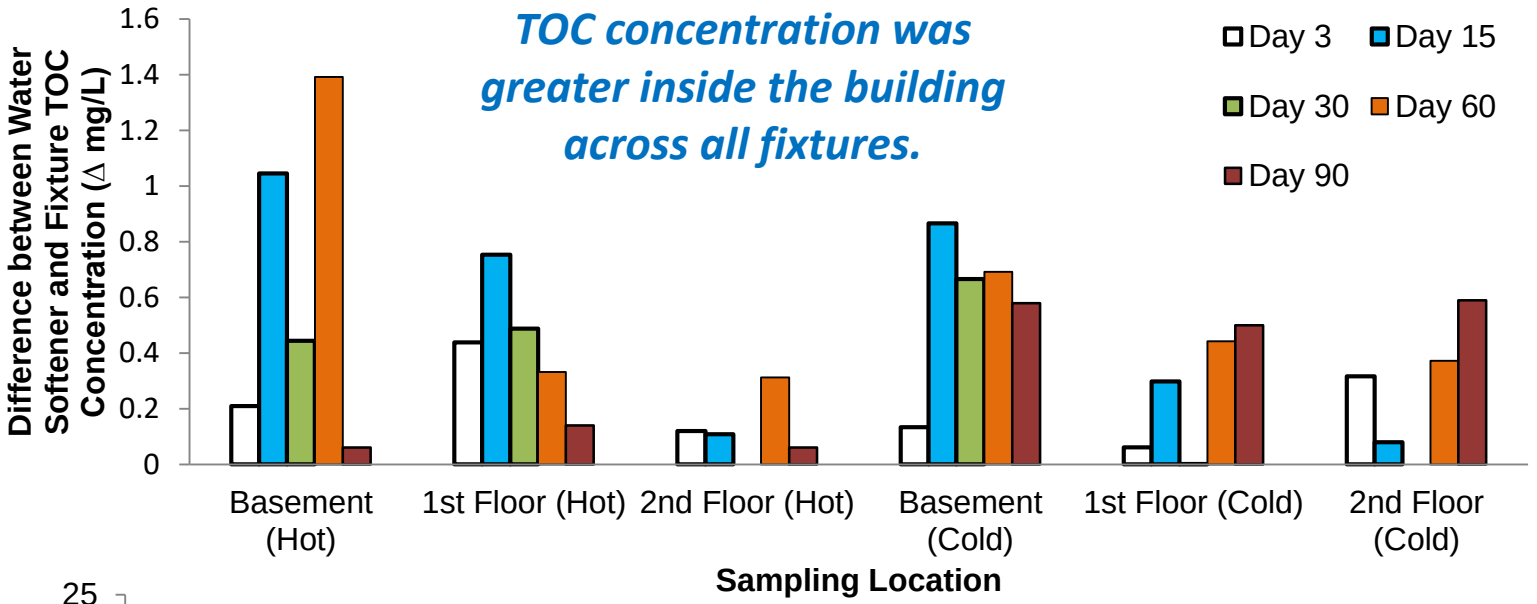
Water Usage Patterns in Dec 2015

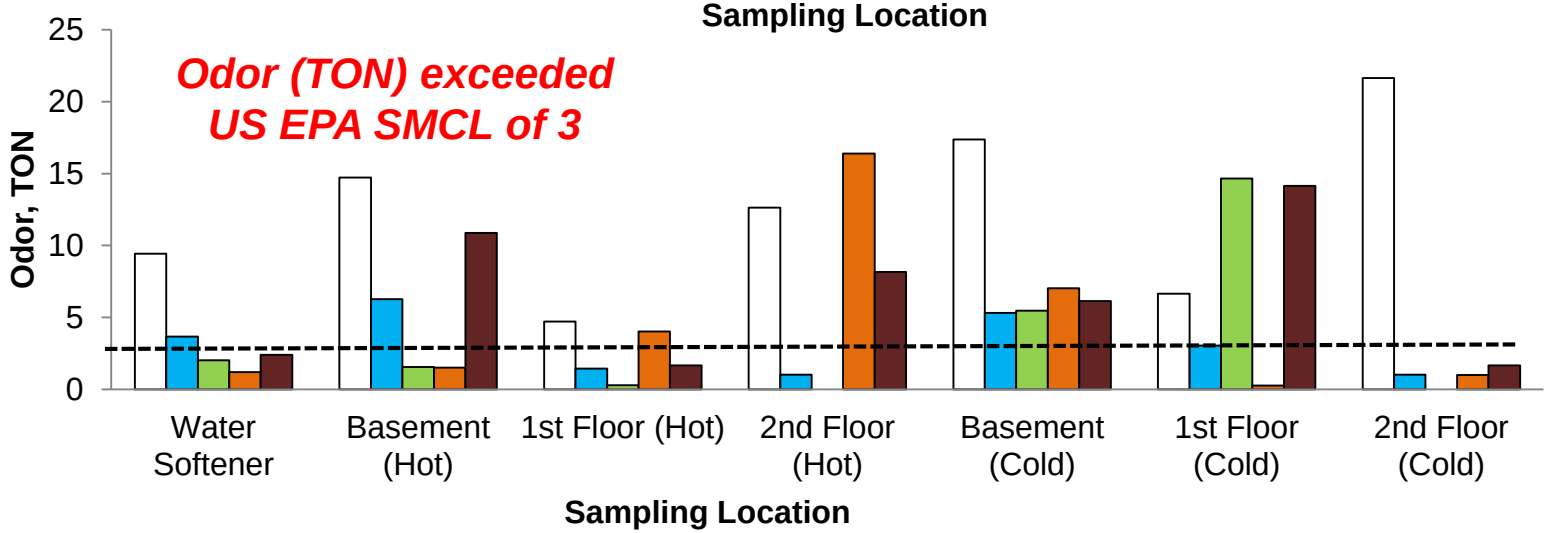
Parameter / Fixture	Total Volume Used (m^3)	Number of Events	Average Elapsed Time (hr)	Maximum Elapsed Time (hr)
Service Line	5.2	3535	0.1	72
Basement-Cold	0.4	60	0.5	72
Basement-Hot	0.04	21	0.7	72
1st Floor-Cold	0.3	619	0.6	72
1st Floor-Hot	0.2	389	0.9	72
2nd Floor-Cold	0.1	145	2.0	72
2nd Floor-Hot	1.0	825	0.5	72

Water Usage Patterns

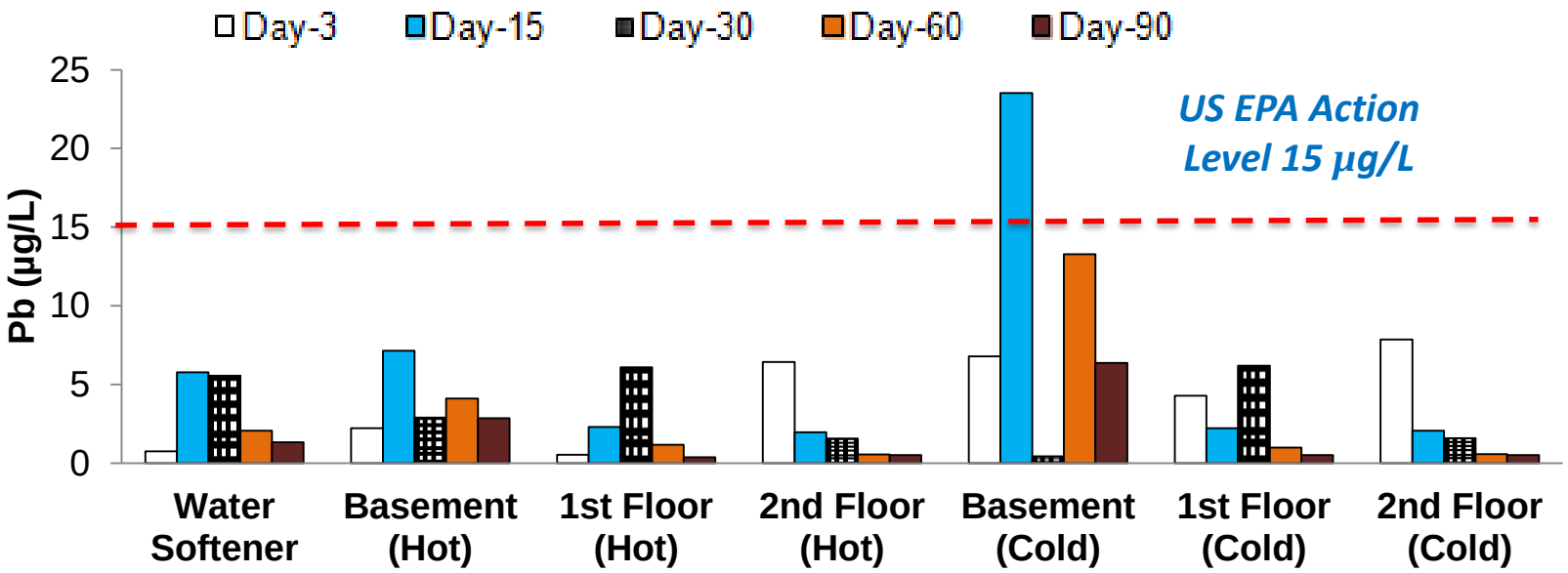
- During October to December the daily water usage varied between **0.169-0.245** m^3/d.
- **Basement fixture** was the least used (number of events at cold: 60-105, hot: 21-69) compared to the other fixtures in the building (number of events at cold: 145-856, hot: 326-2,230).
- During October to December the most frequently used fixture was the **2nd floor hot water** (bathroom sink, number of events per month 2,230).

TOC Concentration Increased Inside the Building



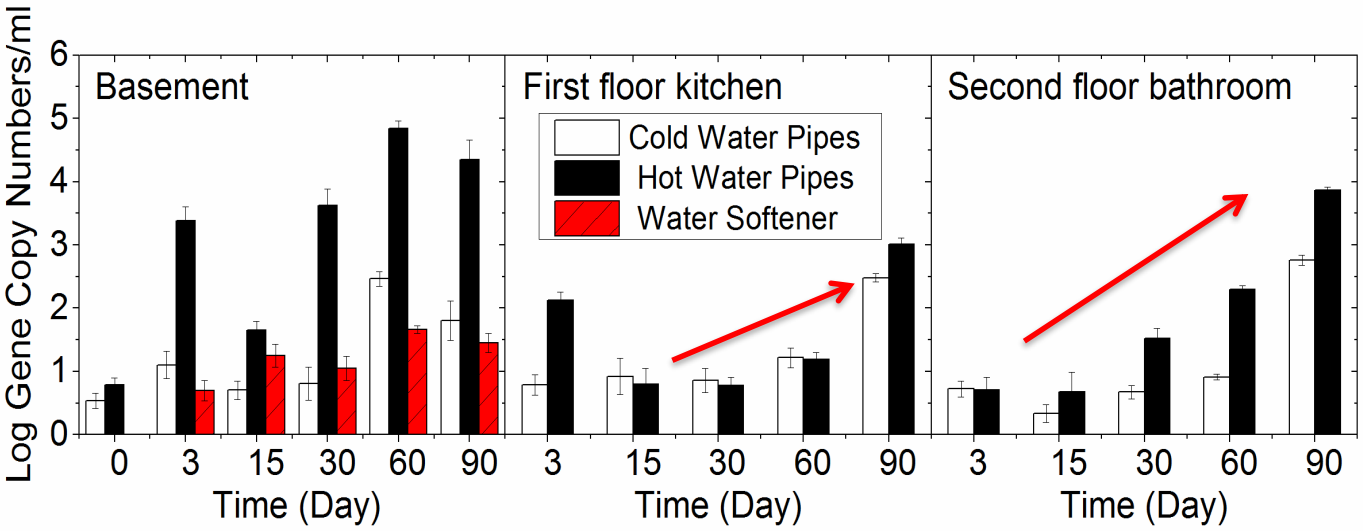


Several Heavy Metals with Health & Aesthetic Limits were Detected



The **basement fixture brass needle valve** may have caused maximum Zn (5.9 mg/L), Fe (4.1 mg/L), and Pb (23 µg/L) levels compared to other fixture water samples.

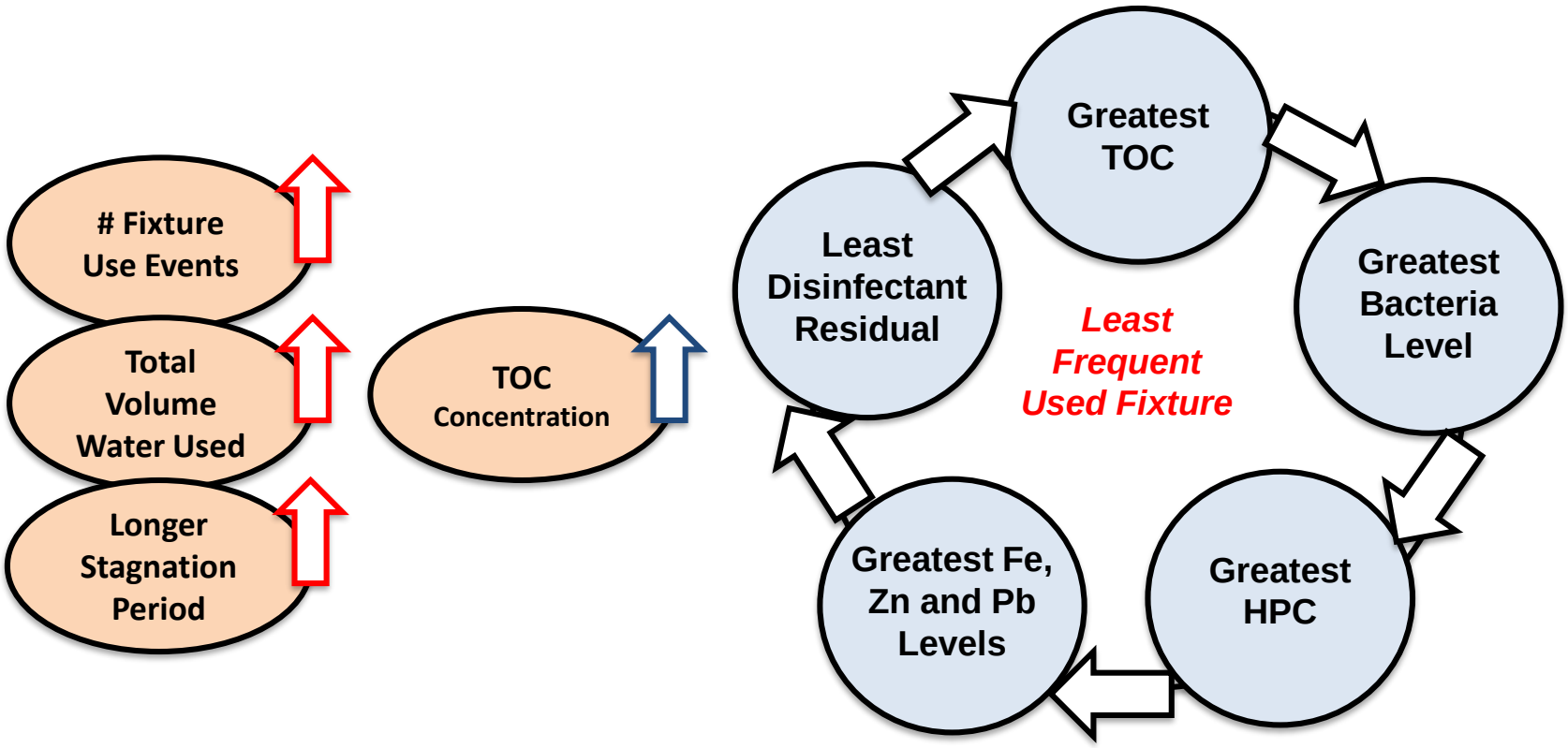
Both HPC & Gene Copy Number Increased at 1st & 2nd Floor



Greatest HPC level (856.7 CFU/mL) at day 90 basement hot water.

Positive correlations between TOC levels & bacterial gene copy numbers at water softener, 1st floor (cold), 2nd floor (cold/hot).

Water Use Influenced Chemical & Microbial Levels at each Fixture



Summary

- The maximum water stagnation time was 72.0 hr.
- Bacteria & organic carbon levels increased inside the plumbing system compared to the municipal tap water entering the building.
- A greater amount of bacteria was detected in hot water samples compared to cold water samples.
- At the basement fixture, where the least amount of water use events occurred, greater organic carbon, bacteria, and heavy metal levels were detected.

Future Research

- Integrate calibrated hydraulic water quality model for different plumbing designs.

Right Sizing Tomorrow's Water Systems for Efficiency, Sustainability, & Public Health

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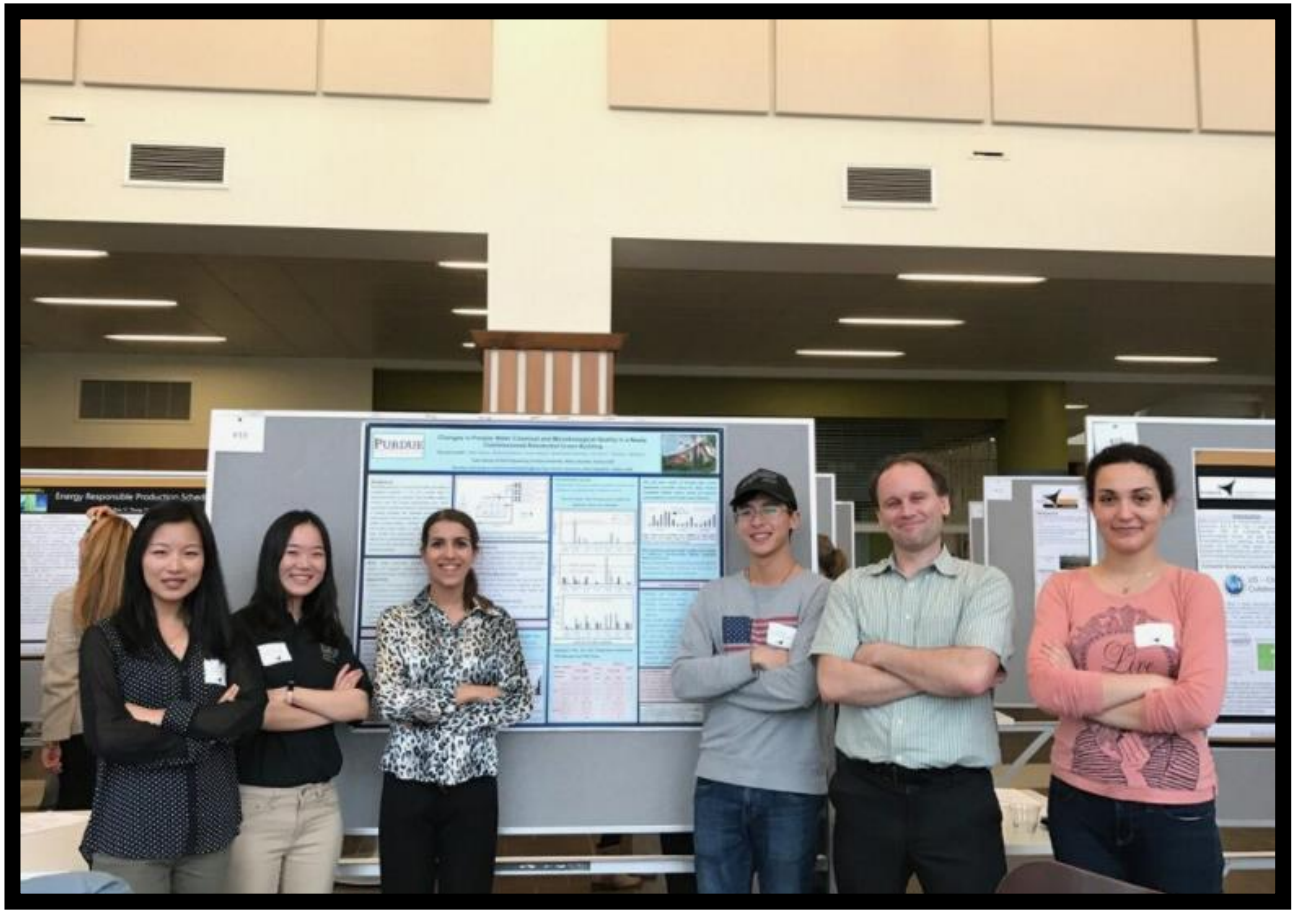
Question & Comments



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