Working Toward Safer Drinking Water at Home, Work, and School

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Our Project Goal

To better understand and predict water quality and health risks posed by declining water usage and low flows

Prepared by Andrew Whelton (Purdue)
plumbing

[ˈplæmiŋ]  NOUN

the system of pipes, tanks, fittings, and other apparatus required for the drinking water supply, heating, and sanitation in a building

4000-3000 BCE
Copper water pipes in buildings (India)

1500 BCE
Rainwater cisterns (Greece)

500 BCE - 250 AD
Lead & bronze pipes, marble fixtures, gold & silver fittings (Egypt)

1928
First US plumbing code

1966
Copper shortage enabled plastics entry

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Service Lines

Hot vs. Cold Water Pipes

Fixtures and Aerators

POU Devices

Corrosion Products

Metals and Plastics

Water Softener

Whole House Filter

Habitat

Water Heater

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Building Water Use has Been Declining


Water Use has Decreased From Lower-Flow Faucets

Pre-1994 (4+ gpm)

1994 (2.5 gpm)

2015 (0.5 gpm)

2016? (0.01 gpm)

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Safe Water at the Tap

- While the SDWA addresses national water quality, it will be the collective efforts of the water utilities, building/housing and plumbing professionals that achieve safe water for consumers at the tap.

- Where ever there is water there are microbes and the distribution system and premise plumbing are no exceptions.

- There is a great need to manage the microbial biofilm for pathogens that cause disease via the plumbing system.
**Opportunistic pathogens** are those naturally occurring microbes that opportunistically - can cause disease in humans especially those who are immunocompromised.
Opportunistic pathogens are now the primary source of waterborne disease outbreak in U.S.


- **2011–2012**, 32 drinking water–associated outbreaks were reported
  431 cases of illness, 102 hospitalizations, and 14 deaths
- **Legionella** was responsible for **66% of outbreaks** and **26% of illnesses**
- Most commonly identified deficiencies leading to drinking water–associated outbreaks were **Legionella in building plumbing systems (66%)** and **untreated groundwater (13%)**

Source: CDC
Biofilms are common in all pipes

Source: Dr. Joan Rose http://www.nature.com/nature/journal/v523/n7562/fig_tab/nature14660_SV1.html
Project Objectives

1. Improve the public’s understanding of decreased flow and establish a range of theoretical premise plumbing flow demands from the scientific literature and expert elicitation with our strategic partners.

2. Elucidate the factors and their interactions that affect drinking water quality through fate and transport simulation models for residential and commercial buildings.

3. Create a risk-based decision support tool to help guide decision makers through the identification of premise plumbing characteristics, operations and maintenance practices that minimize health risks to building inhabitants.
OBJ. 2A: FIELD MEASUREMENTS

Pipe Network Design - pipe sizes, layout, fixtures.

Water Quality Parameters
- Water pH
- Alkalinity
- NOM
- Disinfectant
- Larson Index
- Metal Content

Input

OBJ. 2B: EPANET-MSX
Integrative Hydraulic-Water Quality Models

- Water Demand, Flow and Use
- Water Demand, Flow and Use
- Chemical and Microbial Contaminant Concentrations

Water Age – Stagnation time/Residence Time

Output
- TOC/AOC
- Disinfectant Residual
- Metal Content
- Pathogen Content
- By-Products

OBJ. 2C: WATER QUALITY MODELS

Which factors (inputs) significantly influence water quality?

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OBJ. 3A: RISK ASSESSMENT MODELS

What are the human health risk associated with the measured and predicted contaminant concentrations?

OBJ. 2B SIMULATIONS – DIFFERENT WATER DEMAND, WATER QUALITY, HYDRAULIC PRESSURES

Input

)obj. 2A: FIELD MEASUREMENTS

OBJ. 1: LITERATURE, PARTNERS, WORKSHOP

Water Treatment Process
- Well Water
- Lake Water
- River Water

Rate Constants
- Pilot Study
- Field Study

Bench Scale Experiment

Model Calibration

Model Benchmark/Validation
Full-Scale Buildings

Efroymson Center, Indiana

ReNEWW House, Indiana

MSU Chemistry Building, Michigan

Avon Middle School, Indiana

Legacy renovated office building, 16 floors, Michigan
Early Results:
We monitored water use at 4 locations in a new green building during a 3 month period (Oct to Dec).

<table>
<thead>
<tr>
<th>Water Sampling Location</th>
<th>Total Volume of Water Used, m³</th>
<th>Number of Events</th>
<th>Average Stagnation Time, hr</th>
<th>Maximum Stagnation Time, hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Line</td>
<td>5.2</td>
<td>3535</td>
<td>0.1</td>
<td>72</td>
</tr>
<tr>
<td>Basement-Cold</td>
<td>0.4</td>
<td>60</td>
<td>0.5</td>
<td>72</td>
</tr>
<tr>
<td>Basement-Hot</td>
<td>0.04</td>
<td>21</td>
<td>0.7</td>
<td>72</td>
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<tr>
<td>1st Floor-Cold</td>
<td>0.3</td>
<td>619</td>
<td>0.6</td>
<td>72</td>
</tr>
<tr>
<td>1st Floor-Hot</td>
<td>0.2</td>
<td>389</td>
<td>0.9</td>
<td>72</td>
</tr>
<tr>
<td>2nd Floor-Cold</td>
<td>0.1</td>
<td>145</td>
<td>2.0</td>
<td>72</td>
</tr>
<tr>
<td>2nd Floor-Hot</td>
<td>1.0</td>
<td>825</td>
<td>0.5</td>
<td>72</td>
</tr>
</tbody>
</table>

Salehi et al. 2018.
During the same period, bacteria levels increased with time and bacteria were more numerous in hot water vs. cold water.

Salehi et al. 2018.
We’re currently sampling the same building for pathogens.

Legionella spp. log$_{10}$ gene copies/100 mL

Highest value was observed in

Indicates values are below limit of detection of qPCR assay
Mycobacterium log_{10} gene copies /100mL

Mycobacterium was not detected in cold water taps

Sampling locations

City water
Water Heater Tank
1st Floor kitchen sink cold
1st Floor kitchen sink hot
2nd Floor bath sink cold
2nd Floor bath sink hot
2nd Floor shower head

10/10/2017
10/12/2017
10/14/2017
10/16/2017

Indicates Values are below limit of detection of qPCR assay
CDC Legionella Toolkit
- Provide guidance for developing, implementing and evaluating a Legionella water management program for your building
Top 10 Tips for Your Safety

1. Clean your aerators

2. Do not drink water from a shower

3. Do not drink hot water from a fixture

4. Water heater should be at least 120°F

5. Drain, flush-out your water heater

6. Flush unused faucets before use (i.e., guest bath, vacation)

7. Hotels, motels, hospitals? Flush taps before use

8. Determine what type of drinking water pipes are in your building

9. Do you have a lead pipe? Need a water filter

10. When told to flush for a certain time period ask how that time period was determined

Learn more at www.PlumbingSafety.org

Prepared by Andrew Whelton (Purdue)
Thank You!

Acknowledgement:

Funding agency: US EPA