Preserving Water Quality in Building Design

November, 2018
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# Plumbing

**plumbing**

[ˈplʌmiNG]  
**noun**

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

<table>
<thead>
<tr>
<th>Time</th>
<th>Event/Invention</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000-3000 BCE</td>
<td>Copper water pipes in buildings (India)</td>
</tr>
<tr>
<td>1500 BCE</td>
<td>Rainwater cisterns (Greece)</td>
</tr>
<tr>
<td>500 BCE-250 AD</td>
<td>Lead &amp; bronze pipes, marble fixtures, gold &amp; silver fittings (Egypt)</td>
</tr>
<tr>
<td>1928</td>
<td>First US plumbing code</td>
</tr>
<tr>
<td>1966</td>
<td>Copper shortage enabled plastics entry</td>
</tr>
</tbody>
</table>
Building plumbing is complex

Some images courtesy of: Gordon & Rosenblatt, LLC
“Pathogens in plumbing are the 1st source of waterborne disease in developed countries”

Pruden et al. (2013)

Waterborne diseases in the US 2000-2014

56% due to drinking water
22% cooling towers
7% hot tubs

44% at hotels and resorts
19% at long-term care facilities
15% percent at hospitals
2nd UW patient with Legionnaire's disease dies

4-year-old dies after brain-eating amoeba infection
By John Bohnfild, CNN
Updated 10:40 AM ET, Sat September 7, 2013

2 dead in Legionnaires' outbreak tied to downtown hotel

Water faucets at Bonham VA test positive for Legionella
BONHAM -- Seven water faucets at two North Texas VA Centers have tested positive for Legionella, a bacteria that can lead to Legionnaires' Disease.

The North Texas VA says 205 water samples were taken in November and the positive results were received on Tuesday.

Five of the faucets came from the Bonham VA Medical Center. Two were from the facility in Dallas.
Factors that Affect Unhealthy Drinking Water

Sediment (Solids)
Temperature
Water Age
Disinfectant Residual
**Legionella pneumophila**
Gram-negative bacteria causes “Legionnaires Disease”

![Graph showing water temperature growth and death]

120°F unless persons have suppressed immune system or chronic disease
Away 3 days+ turn temperature down or off

“… homeowners choose..120°F to reduce scalding risk or to save energy”
– San Francisco Chronicle

Image: Zeonda AB
Building Water Use has Been Declining


- Pre-1994 (4+ gpm)
- 1994 (2.5 gpm)
- 2015 (0.5 gpm)
- 2016? (0.01 gpm)

Water Use has Decreased From Lower-Flow Faucets
How old is your water before reaching the faucet?

\[
\frac{\text{Volume of water stored in pipes}}{\text{Flowrate of water exiting the Faucet}}
\]

...our water systems are not designed to handle lower use
Some products are being installed with little understanding about their drinking water impacts.

Leaching can provide organisms food, pH affected
Leaching differs across and within pipe brands
No long-term leaching studies
Metal fittings can release heavy metals
Plastics affect lead and copper levels
Compounds causing taste and odors not identified
Rebecca Ives, Kyungyeon Ra, Christian Ley, Tolu Odimayomi, Sruthi Dasika, John Mayo, Xianzhen Li, Xiangning Huang, Kara Dean, Ryan Julien, Erica Wang, Miriam Tariq, Emerson Ringger, Bill Schmidt, Kim Petersen, Caitlin Proctor, Mohammad Abouali, Paul Robinson, Jennifer Sturgis
Project Goal and Objectives
To better understand and predict water quality and health risks posed by declining water usage and low flows

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 1. Industrial Stakeholder Plumbing Research Questions
What is the Most Monitored Home in America?

3 Bedroom, 1.5 baths
Renovated 2014
Solar panels
Net-zero waste
Energy efficient appliances
Rainwater catchment
Greywater recycling
Online monitors throughout bldg

ReNEWW Home Preliminary Results

October 2017 to October 2018

30,000+ individual water quality measurements completed - does not include flow monitoring, pressure monitoring, or qPCR

600+ million online plumbing related measurements

Water in pipes equilibrates to ambient temperature quickly (<4 hours)

Usage events are short; ~70% of events are less than 5 seconds
not found in **more than 50%** of water samples exiting the water heater, at the 1\textsuperscript{st} floor kitchen sink cold, 2\textsuperscript{nd} floor bathroom sink cold, and 2\textsuperscript{nd} floor shower
7 year old LEED school receives chloraminated water from a public water system; Copper plumbing, water softener, hot water recirculation system - 4 zones.

Study Goal: Understand how drinking water chemical and microbial parameters change during the *transition from Summer to Fall*

- Service line, staff kitchens, bathrooms, showers, classroom, water bubblers
More than 4,500 tests: Copper drinking water action level was exceeded June 2018 to October 2018

October 2018
19 additional locations sampled (see next slide)

Health Based AL (1.3 mg/L)

Side by Side Water Bubblers
### New Sampling Locations in October

<table>
<thead>
<tr>
<th>Routine Sampling Locations in October</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; grab (mg/L)</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; grab (mg/L)</th>
<th>Our Experience with Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2C</td>
<td>0.996</td>
<td>1.470</td>
<td>3 of 7 prior samples exceeded the AL</td>
</tr>
<tr>
<td>SKC</td>
<td>1.470</td>
<td>0.561</td>
<td>7 of 7 prior samples exceeded the AL</td>
</tr>
</tbody>
</table>

None of our other routine locations exceeded the copper AL during the October sampling event.

### In October we added 19 new cold water sampling locations

<table>
<thead>
<tr>
<th>New Sampling Locations in October</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; grab (mg/L)</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; grab (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRS - shower room right sink</td>
<td>0.123</td>
<td>0.149</td>
</tr>
<tr>
<td>SLS - shower room left sink</td>
<td>0.479</td>
<td>0.164</td>
</tr>
<tr>
<td><strong>B2CR - bathroom 2 cold right</strong></td>
<td><strong>0.949</strong></td>
<td><strong>1.403</strong></td>
</tr>
<tr>
<td><strong>B2CL - bathroom 2 cold left</strong></td>
<td><strong>1.164</strong></td>
<td><strong>1.452</strong></td>
</tr>
<tr>
<td>SKD - student kitchen sink D</td>
<td><strong>1.32</strong></td>
<td><strong>0.832</strong></td>
</tr>
<tr>
<td>SKF - student kitchen sink F</td>
<td><strong>1.58</strong></td>
<td><strong>0.529</strong></td>
</tr>
<tr>
<td>FK - faculty kitchen - A108</td>
<td><strong>0.831</strong></td>
<td><strong>0.120</strong></td>
</tr>
<tr>
<td>ARRS - art room right sink - F105</td>
<td><strong>0.424</strong></td>
<td><strong>0.638</strong></td>
</tr>
<tr>
<td><strong>WF3 - water fountain 3 - F112 (choral room)</strong></td>
<td><strong>1.773</strong></td>
<td><strong>1.360</strong></td>
</tr>
<tr>
<td>WF4 - water fountain 4 - F115W</td>
<td><strong>1.047</strong></td>
<td><strong>0.902</strong></td>
</tr>
<tr>
<td>WF5 - water fountain 5 - B103B</td>
<td><strong>0.945</strong></td>
<td><strong>0.374</strong></td>
</tr>
<tr>
<td><strong>ABS - auditorium back sink</strong></td>
<td><strong>1.141</strong></td>
<td><strong>1.314</strong></td>
</tr>
<tr>
<td>B3LS - bathroom 3 left sink</td>
<td><strong>0.898</strong></td>
<td><strong>0.866</strong></td>
</tr>
<tr>
<td>B4 - bathroom 4 - C124G - next to sink 2</td>
<td><strong>1.141</strong></td>
<td><strong>0.868</strong></td>
</tr>
<tr>
<td>B5 - bathroom 5 - B103B</td>
<td><strong>0.275</strong></td>
<td><strong>0.216</strong></td>
</tr>
<tr>
<td>B6 - bathroom 6 - B124B</td>
<td><strong>1.097</strong></td>
<td><strong>0.819</strong></td>
</tr>
<tr>
<td>B7 - bathroom 7 - B112W - staff bathroom</td>
<td><strong>0.649</strong></td>
<td><strong>0.618</strong></td>
</tr>
<tr>
<td>B8 - bathroom 8 - C112W - staff bathroom</td>
<td><strong>0.697</strong></td>
<td><strong>0.646</strong></td>
</tr>
<tr>
<td>B9 - bathroom 9 - A108M - in office</td>
<td><strong>0.142</strong></td>
<td><strong>0.105</strong></td>
</tr>
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</table>
Our Plumbing Testing Facility is Ready: Plumbing, Water Use, and Water Quality Relationships

Full-Scale Testing

Plumbing Testing Facility @ Purdue
Other Field/Bench-scale tests
Thank You.

Questions: Andrew Whelton, awhelton@purdue.edu
Learn more at www.PlumbingSafety.org
Follow us on Twitter @TheWheltonGroup

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