VOC Fate in Water Systems

Discussion to Support the Water Systems Task Force

11:30 AM EST (8:30 AM PST)  
March 4, 2019

Convener: Andrew Whelton, awhelton@purdue.edu  
Caitlin Proctor, Juneseok Lee, Amisha Shah  
Purdue University & Manhattan College
CALL IN INFO
Time: Mar 4, 2019 11:30 AM Eastern Time (US and Canada)
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Meeting ID: 710 128 445
Find your local number: https://zoom.us/u/adsJGYs1YG
Agenda

5 min  Review of some PID water contamination data
5 min  Purdue’s work on building plumbing and plastics
5 min  EPA’s work relating water systems
45 min + Open discussion

Only a few slides will be touched upon by Purdue/EPA. Other slides provided for background.

KEY TERMS
PID = Paradise Irrigation District
VOCs = Volatile organic compounds
SVOCs = Semi-volatile organic compounds
Review of some PID water contamination data

Andrew Whelton, awhelton@purdue.edu
Caitlin Proctor, Juneseok Lee, Amisha Shah
### Review of PID’s Water Contamination Data:

Let’s First Compare PID and the City of Santa Rosa Fire Damage Areas

<table>
<thead>
<tr>
<th>Fire Impact Characteristics</th>
<th>PID, 2018 Camp Fire</th>
<th>City of Santa Rosa, 2017 Tubbs Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td># of People</td>
<td>26,032</td>
<td>932 (35 in standing homes)</td>
</tr>
<tr>
<td># of Service Lines</td>
<td>10,480</td>
<td>542 (13 remained)</td>
</tr>
<tr>
<td>Types</td>
<td>HDPE, copper, PB</td>
<td>HDPE, copper, PB</td>
</tr>
<tr>
<td>Water Mains, miles</td>
<td>172</td>
<td>5.2</td>
</tr>
<tr>
<td>Types</td>
<td>PVC (35%), Steel (33%), CML (19%), AC (10%), Irons (6%)</td>
<td>PVC (85%), AC (15%)</td>
</tr>
<tr>
<td># of Hydrants</td>
<td>1,400</td>
<td>64</td>
</tr>
<tr>
<td>Storage Tanks</td>
<td>6 for 10 Million Gallons</td>
<td>0</td>
</tr>
<tr>
<td>Pump Stations</td>
<td>1 of 1</td>
<td>0</td>
</tr>
</tbody>
</table>

Santa Rosa serves 175,155 people. Less than 0.5% were affected by the Tubbs Fire.
Review of PID’s Water Contamination Data:
So far benzene has exceeded the drinking water limit, but PID results are too limited to predict the future

<table>
<thead>
<tr>
<th>Chemical Detected</th>
<th>PID as of Feb. 13</th>
<th>DDW 1 sample in PID</th>
<th>City of Santa Rosa as of Feb. 23</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>118</td>
<td>410</td>
<td>2,217</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>35</td>
<td>278</td>
<td>693</td>
</tr>
<tr>
<td>Styrene</td>
<td>35</td>
<td>30.0</td>
<td>378</td>
</tr>
<tr>
<td>TBA (NL)</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Toluene</td>
<td>35</td>
<td>90</td>
<td>676</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>35</td>
<td>ND</td>
<td>-</td>
</tr>
</tbody>
</table>

**CA Notification levels (NL):** health-based advisory levels established by DDW for chemicals in drinking water that lack maximum contaminant levels (MCLs).

- **Santa Rosa:** Highest levels typically found at meters
- **PID:** Not many meter samples yet

*TBA, tert-butyl alcohol has a health based drinking water limit, is an EPA Method 524.2 compound, but PID has not tested for it*
Other Chemicals were Found during Santa Rosa’s Exploratory Testing

**VOCs**
- 18 others found in Santa Rosa and tentatively identified compounds (TICs)
- PID has not tested for 5 VOCs or TICs

  *Waterboard analyzed TICs for 1-2 samples*

**SVOCs**
- Santa Rosa tested for SVOCs during exploratory testing
- PID has not tested for SVOCs

  *After the exploratory phase was complete, Santa Rosa decided on 33 specific chemicals (wide scan VOC) for recovery testing*
Purdue University’s Work on Building Plumbing and Plastics

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Caitlin Proctor, Juneseok Lee, Amisha Shah

Visit www.PlumbingSafety.org
plumbing

[ˈplʌmiŋ]  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
Corporation Stop
Water Main (metal, plastic) <0 to >80 psig
Curb Stop
Backflow preventer (maybe)
Water meter
PREMISE (PROPERTY) PLUMBING
Service Line (metal, plastic)
Irrigation system (maybe)

Modified from Lee et al. (2013) Water Supply AQUA 64(2)
A single faucet can contain a variety of metal and plastic materials.

Inside of a single faucet (pictured left), one can find many different materials (right), including several types of plastic.
Residential Plumbing ≠ Commercial Plumbing

- Flow demands
- Fixture use (stagnation) frequency
- Pipe size and device layouts
- Types of contact materials (SA/V)
- In-building storage volumes
- In-device temperatures and profiles
- And more...

Commercial

- Schools
- Offices
- Multi-Family
- Hospitals
- Daycares
- Extended Care
- Government Buildings
- Correctional Institutions
- Hotels & Motels
- Sports & Entertainment Venues
- Summer Communities, Casinos, and more...
Premise plumbing is complex

Some images courtesy of: Gordon & Rosenblatt, LLC
Where plastics can be in building drinking water plumbing

At Fixtures
• Faucets
• Faucet connectors
• Showerheads
• Shower/tub wand

Drinking water pipe – cold
• HDPE, PVC

Drinking water pipe – cold/hot
• PB, PEX, CPVC, PP, multilayer

Interior pipe coatings

Appliances
• Water heaters, dishwashers, washing machines, humidifiers, refrigerators

In-building devices
• Water softeners, filters, tanks

Other places
• Valves, fittings, couplings, refrigerator lines, gaskets

And more…
Water Stagnates Differently in Different Parts of the Plumbing

<table>
<thead>
<tr>
<th>Location in Single Family 3 Bed, 1.5 Bath Home</th>
<th>Daily Average Stagnation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Service Line</td>
<td>0.1 to 0.5 hours</td>
</tr>
<tr>
<td>1st Floor Kitchen Sink Cold</td>
<td>1.0 to 2.2 hours</td>
</tr>
<tr>
<td>2nd Floor Bathroom Sink Cold</td>
<td>2.2 to 5.3 hours</td>
</tr>
<tr>
<td>Water Heater</td>
<td>0.4 to 0.7 hours</td>
</tr>
<tr>
<td>1st Floor Kitchen Sink -Hot</td>
<td>1.0 to 1.6 hours</td>
</tr>
<tr>
<td>2nd Floor Bathroom Sink Hot</td>
<td>1.1 to 2.5 hours</td>
</tr>
<tr>
<td>2nd Floor Shower</td>
<td>2.3 to 5.7 hours</td>
</tr>
</tbody>
</table>

Stagnation can allow time for chemicals to diffuse into and out of plastics.

After a disaster, in-building stagnation can increase because of less water use.

More than 1 million measurements per location, 2017-2018, Indiana
VOCs and SVOCs can be difficult to remove from plastic materials

- Purdue (2017): VOCs more easily removed from copper pipes than plastic. 30 days for benzene removal from PEX pipe after only short 24 hr exposure. Less time needed for CPVC pipe. 6 days for copper pipe.
- Purdue (2017): Surfactant solution found to catastrophically damage plumbing gaskets and PEX pipe
- Purdue (2017): Procedure for water heater decontamination by flushing
- Purdue (2015): Plumbing decontamination by flushing not always effective
- Others (2015): PVC resists VOC (BTEX) permeation at low concentrations
- Circa Purdue (2009/2011): Chemicals diffused into older plastic pipes faster than newer pipes, PB, HDPE, PEX vulnerable
  - Hot water had significantly greater pesticide concentrations than cold water
  - Service lines and plumbing components were replaced.

Flushing for Plumbing Decontamination: [https://pubs.rsc.org/en/content/articlehtml/2015/ew/c5ew00118h#cit38](https://pubs.rsc.org/en/content/articlehtml/2015/ew/c5ew00118h#cit38)
Directly relevant studies can be found here...


We have field- and pilot-scale plumbing studies ongoing for other efforts.
Questions: Andrew Whelton, awhelton@purdue.edu
Learn more at www.PlumbingSafety.org
Tentative Analysis of Santa Rosa Water Quality Testing Results for Tubbs Fire

Caitlin Proctor, Andrew Whelton
Stages of Santa Rosa water quality response to the Tubbs Fire

- Q3 (Apr – Jun 2018)
- Q4 (July – Sept 2018)
- Q5 (Oct – Dec 2018)
- Q6 (Jan – Mar 2019)

Samples Taken | These chemicals exceeded health-based limits
---|---
| Benzene | Naphthalene | TBA | Toluene | Styrene | Vinyl chloride
Q1 | 481 | 1 | 0 | 481 | 1 | 1
Q2 | 3375 | 660 | 339 | 3375 | 2089 | 2089
Q3 | 1739 | 0 | 0 | 1739 | 1345 | 1345
Q4 | 1782 | 0 | 0 | 1782 | 1782 | 1782
Q5 | 703 | 0 | 0 | 703 | 703 | 703
Q6 | 142 | 0 | 0 | 142 | 142 | 142
Was benzene a “good indicator” in Santa Rosa’s WATER DISTRIBUTION SYSTEM?

• Looking at the 51 chemicals that were detected:
  • For 17 chemicals, Benzene was a *reasonably good indicator*.
    • Whenever a sample was “benzene clear”, the other chemical was *not* detected.
    • In at least one sample, benzene and this chemical co-occurred.
  • For 15 chemicals, Benzene was a *very bad indicator*.
    • The *highest concentrations* were in samples that were “benzene clear”.
    • For TBA, this included several samples which exceeded notifiable limits.
  • For 19 chemicals, the relationship was *unclear, but likely bad*.
    • Detected even if “benzene clear”, but not in its highest concentration.
    • For 5 analytes, at least one “benzene clear” sample had a concentration in the same range (within 50%) as the highest concentration measured.
### Tentative Analysis of Santa Rosa Water Quality Testing Results for Tubbs Fire

#### Seemed good for:
- 1,1-Dichloroethane
- 1,1,1-Trichloroethane (TCA)
- 1,2-Dichlorobenzene
- 1,2-Dichloropropane
- 1,2,3-Trichlorobenzene
- 1,2,4-Trimethylbenzene
- 1,3-Dichloropropane
- 1,3,5-Trimethylbenzene
- Bromomethane
- Chlorobenzene
- Chloroethane
- *n*-Butylbenzene
- *n*-Propylbenzene
- *p*-Isopropyltoluene
- Tetrachloroethene (PCE)
- trans-1,3-Dichloropropene
- 1,2-Dichloroethane (EDC)

#### Seemed bad for:
- 1,1,1-Trichloroethane
- 1,2,4-Trichlorobenzene
- 2-Butanone
- Acetonitrile
- Bromochloromethane
- Bromodichloromethane
- Carbon Disulfide
- Carbon tetrachloride
- Ethanol
- Methyl isobutyl ketone
- MTBE
- Methylene chloride
- **Tert-Butyl Alcohol (TBA)**
- Tetrahydrofuran
- Trihalomethanes (total)

#### Unclear relationship for:
- Acetone
- Acrylonitrile
- Bromoform
- Chloromethane
- Ethylbenzene
- Isopropylbenzene
- *m*-*p*-Xylene
- **Naphthalene**
- *o*-Xylene
- Styrene
- Toluene
- Vinyl chloride
- Xylenes (total)

#### “benzene clear” sample in same range as max seen:
- Chloroform
- Dibromochloromethane
- Iodomethane
- Methyl ethyl ketone
- Total Trihalomethanes
Our website has historically been dedicated to answering plumbing safety questions for our other efforts.

Because of public demand, we will begin providing educational information to respond to Camp Fire plumbing questions.

A Camp Fire area continuing problem: There are no representative building plumbing testing results to make public health or safety decisions with.