Plastic Plumbing Pipes in Your Home

Water quality, service-life, and beyond

Andrew J. Whelton, Ph.D.

awhelton@purdue.edu

Purdue University

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The Whelton Group

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Homeowners who let us in!

American Water, Lauren Wienrich, Mark LeChevallier

Whirlpool Corporation, Eric Bowler

And many more….

Questions?

Andrew Whelton, Ph.D.
T: (540) 230-6069
awhelton@purdue.edu

Q:

Would your family shower in tap water if it smelled like gasoline?

What if I told you it was safe?

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Material Application and Name	Cost, $ USD	
	per 100 feet	per foot
Hot and Cold Use		
Copper (Type L)	$255.10	$2.55
Polypropylene (PP)	$94.10	$0.94
Chlorinated PVC (cPVC)	$53.80	$0.53
Crosslinked Polyethylene (PEX)	$48.69	$0.48
Cold Use Only		
Galvanized Iron	$174.20	$1.74
High Density Polyethylene (HDPE)	$23.98	$0.23
Polyvinylchloride (PVC)	$21.80	$0.21

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Connell et al. (2013)

Drinking Water Quality Impact Data Must be Obtained Regarding Existing Pipe Materials

Current, NSFI 61 Testing

- First 2 weeks not considered
- No microbial growth
- No odor
- No field data
- No surrogate chemical indicators
- No emerging contaminants
- No contaminants considered for regulation

Whelton & Nguyen (2013) Crit. Rev. ES&T

Importance to Green Building Design

- Limit organism growth in plumbing systems
- Less hydration if it stinks
- Does lab test = Field?
- Other chemicals of interest: TOC, UV_{254}, DBPs
- Is impact at Day 21 = impact at Year 21?
- Materials may release chemicals that are deemed toxic post-installation (i.e., PVC 1970s)

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Our Ongoing NSF Plastic Plumbing System Project has Three Efforts

Laboratory	Field	Industry / Public
Cleaning method impacts 2 PEX 4 methods	Homes – 6 States AL, CO, MD, OK, PA, VA	Standard & Policy USGBC LEED Others Workshops USGBC, AWWA, WEFTEC Gen. Public Info News/media Seminars Publications Q&A's
30 day impacts 8 PEX (a,b,c) 1 PP 1 HDPE (part) 1 PVC (part)	Probing Factors Multiple brands Multiple temps Multiple durations W/ and w/o disinfectant	

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Our Investigative Approach

- Indirectly and directly measure contaminant release from materials into water
  - sVOCs, LLE GCMS
  - VOCs, HS-SPME GCMS
  - Drinking water odor
  - Total organic carbon, TOC
  - DBP formation: TTHMs
  - Assimiable organic carbon, AOC
- Characterize the material to better understand their potential for water quality impacts
  - Polymer testing (DSC)

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Before Mass Testing…Newly Installed Pipes are Disinfected Differently Based on the Building Owner and Plumber

Method	Description of Applied Pipe Cleaning Protocols
Alabama Survey	30 min tap water flush
International Plumbing Code	200 mg/L Cl_2 static for 3 h
Mod. Intl. Plumbing Code	500 mg/L Cl_2 static for 3 h
California Plumbing Code	10 min tap water flush followed by 2 mg/L Cl_2 static for 7 days

Factors: Timed Flush vs. Stagnation vs. Chlorine Dose

Question: Do any of these conditions affect water chemical or odor quality once the pipe is installed?

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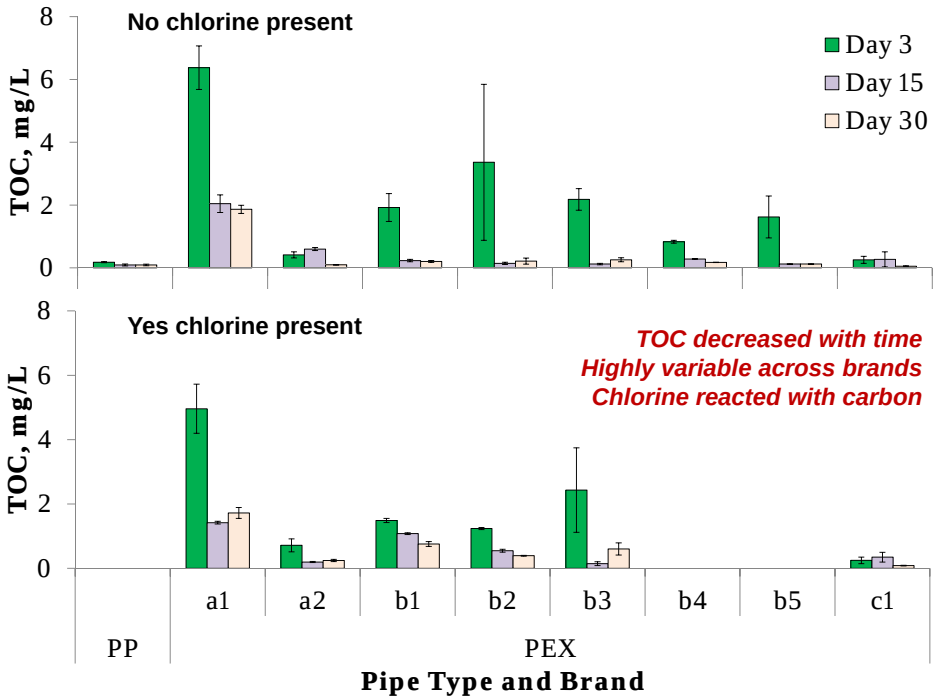
Kelley et al. 2014

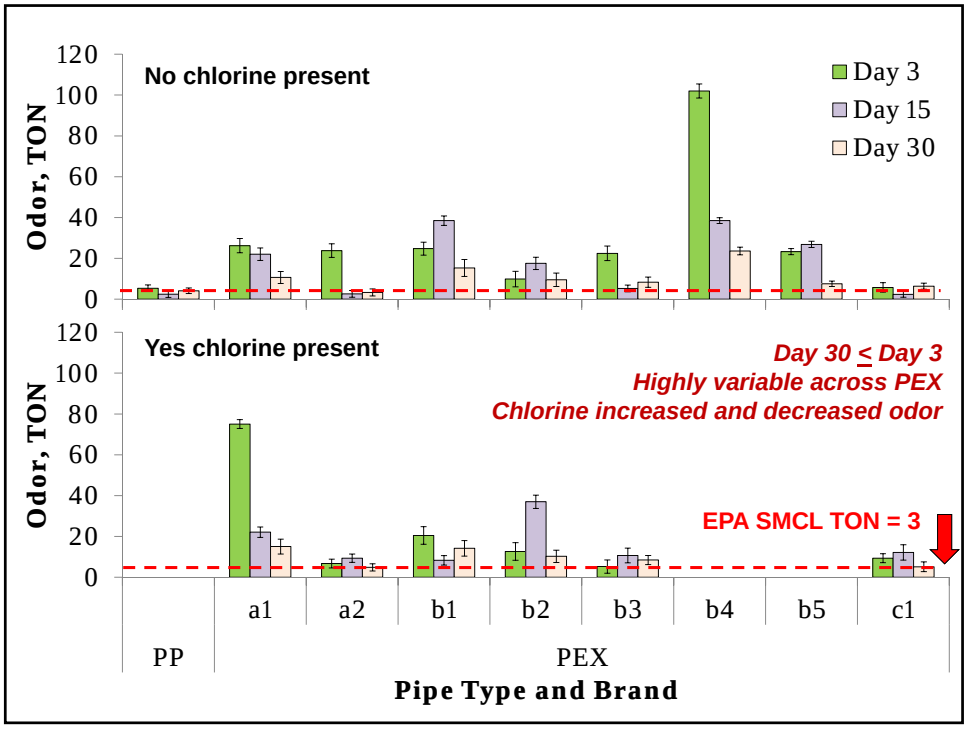
Cleaning Methods Affected Short-Term Water Quality

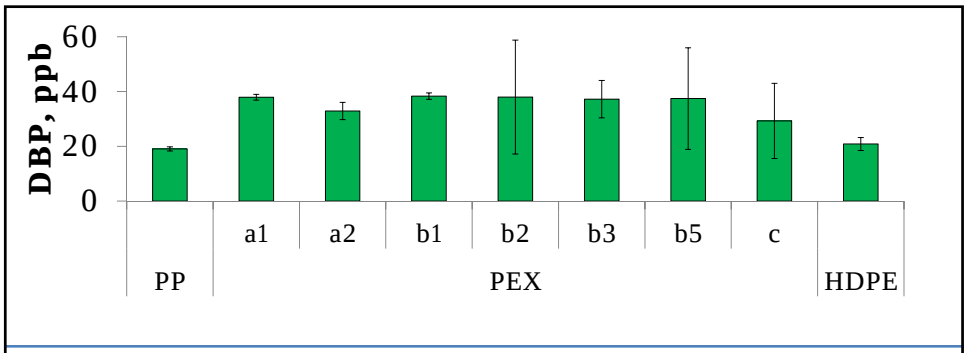
The Whelton Group

1. Three consecutive 3 day fill/dump cycles leached **38% more** TOC than a single 9 day fill/dump cycle
2. PEX-b2 leached **2x to 4x** more TOC than PEX-b1
3. TOC and TON results varied for cleaning methods. Odors > EPA SMCL of 3 TON.
4. We selected the **California Plumbing Code (CPC) method. It degraded water quality the most**.

Kelley et al. 2014




No chlorine present
Day 3
Day 15
Day 30
Odor, TON
120
100
80
60
40
20
0
Yes chlorine present
Day 30 ≤ Day 3
Highly variable across PEX
Chlorine increased and decreased odor
EPA SMCL TON = 3
a1
a2
b1
b2
b3
b4
b5
c1
PP
PEX
Pipe Type and Brand


DBP, ppb
60
40
20
0
a1
a2
b1
b2
b3
b5
c
PP
PEX
HDPE

Regulated and Unregulated Contaminants Leached from these Pipes

Compounds Detected	Pipe Type and Brand							
	PP	PEX						
		a1	a2	b1	b2	b3	b4	b5	c1
ETBE **[MI, NH, NY MCL]**				X	X	X	X	X	
Toluene **[FED MCL]**				X			X		
p-Xylene **[FED MCL]**				X			X		
Cyclohexane							X		
Pyridine						X			
7,9-di-t-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	X			X	X	X	X	X	
Methyl 3-(3,5-di-t-butyl-4-hydroxyphenyl)propanoate				X	X		X	X	
Phenol, 3,5-bis(1,1-dimethylethyl)-						X			
Phenol, 2,6-bis(1,1-dimethylethyl)-						X			
Phenol, 2,5-bis(1,1-dimethylethyl)-						X			
Hexanedioic acid, bis(2-ethylhexyl) ester		X				X			X
Furan, tetrahydro-2,2,5,5-tetramethyl-						X			
Benzotriazol-1-carboxylic acid, 3-oxide, ethyl ester						X			
Others and Multiple unidentified		X				X	X		X

Regulated: ETBE 179 ppb (day 3); 74 ppb (day 30) *NH MCL = 49 ppb*

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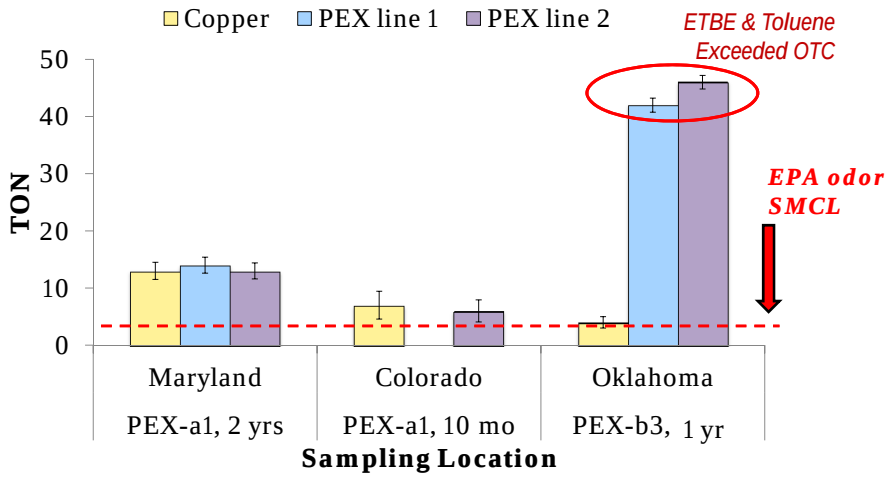
Field Testing of PEX Plumbing Systems in Six States Provided Valuable Data

St.	Brand	Age, Yr	Contaminant Detected in Field Plumbing System	Likely Source
MD	a1	0.5	2,5–Di–*t*–butyl–phenol	AOX deg. product
			2,6–Di–*t*–butyl–*p*–benzoquinone	AOX deg. product
			2,5–Dimethyl–2,5–hexanediol	Mfg. byproduct
			2–Ethyl–hexanal	AOX
			2–Ethyl–1–hexanol	Mfg. aide
			Tetrahydro–2,2,5,5–tetramethyl–furan	Mfg. aide
			2–Nonanone	Solvent
			T–amyl methyl ether (TAME)	Initiator degradate
			Toluene **[FED MCL]**	Solvent
			Octanol	Mfg. aide
			5–Methyl–2–hexanone	Solvent
CO	a1	0.8	Butyl 2-methoxyethyl-phthalic acid ester	Plasticizer
OK	b3	1	7,9-Di-*t*-butyl-1-oxaspiro-(4,5)deca-6,9-diene-2.8-dione	AOX deg. product
			p-Cresol	Mfg. byproduct
			1,3-Di-*t*-butyl benzene	Unknown
			Ethy-tert-butyl-ether (ETBE) **[MI, NH, NY MCL]**	Initiator degradate
			Toluene **[FED MCL]**	Solvent
MD	a1	2	Triethyl citrate	Plasticizer
VA	b5	3	None detected	
PA	b4	4	None detected	
AL	a3	7	None detected	

Dechlorinated Tap Water from Three Plumbing Systems Contained Odors



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Literature Dominated by Deficient Material Testing Standards and Poorly Designed Studies

PB pipe failures (1980s-Pres)

Class Action
$300 million

HDPE pipe ClO_2 failures (2002-Pres)

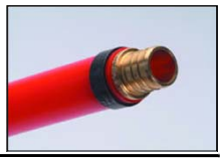
Water

Hypochlorite

Chlorine Dioxide

PEX fitting failures (2010-Pres)

Class Action
200 million fittings sold



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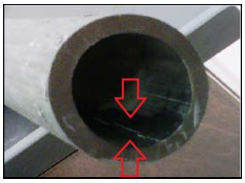
"Approved" Technologies Keep Entering the Marketplace Yet Fail Unexpectedly



2000s: **Widespread EPDM failures** due to chloramines

2008-2014: **More than 25 CIPP incidents** of fish kills, activated sludge inhibition, facility evacuations, inhalation chemical exposures

2010: **EPDM gaskets linked to nitrosamine** contamination

2010–2012: "**Tens of thousands"** of HDPE water pipe failures costing $1,800/repair

2012: **Premature PP water pipe failures** in presence of copper

2014: PEX pipe causes **"gasoline" odors**, but water is safe

2015: **7 year HDPE water pipe life** (American Samoa, some Western US)

PURDUE UNIVERSITY

Water Infrastructure Testing & Evaluation (T&E) Facility

Recreate field conditions, Evaluate system design and contamination scenarios, Explore material-contaminant interactions, Challenge decontamination aide effectiveness

Plastic plumbing systems are complex and poorly understood

Lab work:

How you clean the pipe affects leaching

Not all PEX is created equal

Chemicals v. odor v. microbial regrowth

Free chlorine reacts with leached chemicals

Causes high/lower odor, DBPs formed

Some State drinking water limits exceeded

Field work:

PEX pipes alter drinking water chemical and odor quality for months

What can you do moving forward?

Pipe		Indoor Water Quality Metric			
Brand	Type	Leaching	Odor	ETBE or MTBE	Regulated Chemicals
Aquatherm	PP	Very low	Very low	No	No
AquaPEX	PEX-a	Very high	Very high	No	Yes
FlexPEX	PEX-a	Low	High	No	No
Sharkbite	PEX-b	High	High	Yes	Yes
Apollo	PEX-b	High	High	Yes	No
CanPEX	PEX-b	High	High	Yes	No
ViegaPEX	PEX-b	Low	Very high	Yes	Yes
ZurnPEX	PEX-b	High	High	Yes	Yes
NIBCO	PEX-c	Very low	Very low	No	No

Release of drinking water contaminants and odor caused by green building cross-linked polyethylene plumbing systems. 2014. Kelley et al. *Wat. Res.* 67, 19-32.

The cleaning method selected for new PEX pipe installation can affect short-term drinking water quality. 2014. Kelley et al. *Journ. Wat. Health.* In Press.

Angie's list

Does PEX Piping Affect Drinking Water Quality?

41 SHARES

June 4, 2015
By Jason Michael White

Researchers find that popular PEX plumbing may harm the water coming from the tap in your home.

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USGBC LEED Pilot Credit

Water quality monitoring of the
Whirlpool ReNEWW home PEX plumbing system

Leaching: Hot vs. cold; microbial regrowth

Pipe performance (2012 pipe vs. 2015 pipe)

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