

What Happened in Flint?

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What Happened?

- Flint changed water source supply from Lake Huron (treated by Detroit Water & Sewer prior to delivery) to Flint River
- Didn't adequately control water's ability to corrode existing lead and iron pipes
- Resulted in high levels of lead, rusty water and possibly pathogenic microbes



Why did they choose Flint River?

- In 2013 made decision to get water from Karengnondi Water Authority via a pipeline being built from Lake Huron (same source)
- Detroit Water & Sewer notified Flint they would terminate long-term contract within a year and offered short-term agreement.
- Flint declined and as new pipeline wasn't yet completed, begin using Flint River water and treating via Flint's city plant



Initial Problems (2014)

- Summer 2014 – residents noticed foul-tasting, reddish water
- Aug/Sept 2014 - Flint issued E. Coli contamination alert and instituted boil order
- Oct 2014 – A GM plant stopped using water as it was corroding steel auto parts
- Dec 2014 – MI DEQ notified Flint was in violation of drinking water standards (trihalomethanes – a toxic by-product of chlorine disinfection)



Early 2015

- Jan 2015 – reports of high lead levels began making news – first at Univ of Michigan campus
- Feb 2015 – LeeAnn Walters' situation hit the news



The Walters' Home

- Virginia Tech researchers found one sample in her home with 13,200 parts per billion lead
- Almost 900 times the 15 ppb EPA regulatory limit
- Average in that home was 2,000 ppb (30 samples over 20 minutes)
- After flushing for 20 minutes – never fell below 300 ppb



Ongoing Problems (2015)

- Sept 2015 – Virginia Tech team had sampled 252 homes – 90th percentile of lead was 25 ppb
 - EPA action limit – 90th percentile of 15 ppb
- Sept 2015 – Study* found Flint children's blood levels increased from 2.4% to 4.9%

*Am. J. Public Health 2016, DOI: 10.2105/ajph.2015.303003



Attempt to Reverse the Tide

- October 2015 – Flint switched back to Detroit supply water
- But the damage had already been done
- According to a study* published in July 2016– two outbreaks of Legionnaires’ disease (in June ‘14 and May ‘15) were likely caused by the change in water. Samples taken just before the switch back were seven times higher than nearby baseline samples.

*Environ. Sci. Technol. Lett. 2016, DOI: 10.1021/acs.estlett.6b00192



What caused the catastrophe?

- Understand that water traveling through city pipes interacts with those pipes
- Essentially it is a geochemical reactor
- While lead pipes are becoming rare in the main distribution system, it is not uncommon for service lines (main to house) to still employ lead pipes
- Utilities treat the water to create a “crust” on the inside surface of their pipes



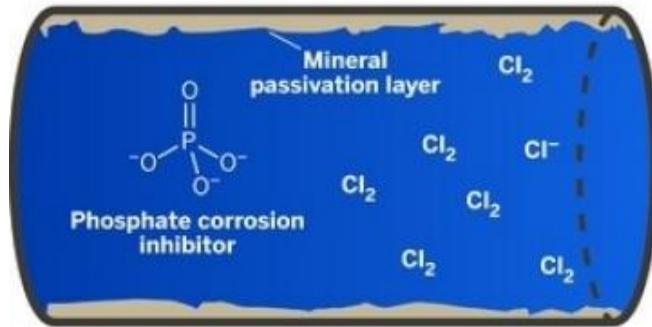
How water interacts with the pipes

- The treated water creates this “crust” (technically passivation layer) which protects the pipes from the oxidants in the water
- Incorrect water chemistry may cause dissolution of the passivation layer causing mineral particles to flake off pipes crust
 - This exposes bare metal allowing lead, iron, copper to oxidize and leach into the water



Before: Treated Detroit water

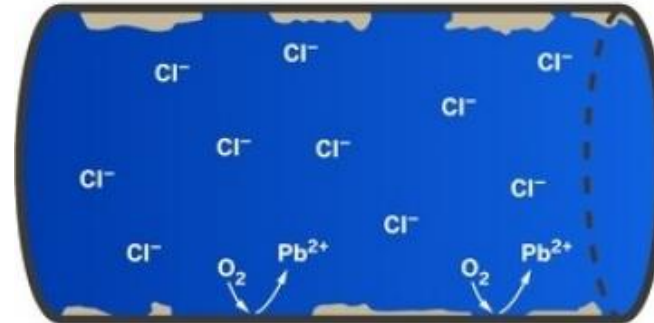
Phosphate corrosion inhibitor helps maintain a mineral passivation layer on the inside of Flint's pipes, protecting them from corrosion. With little corrosion, chlorine disinfectant levels remain stable.



Lead or iron pipe

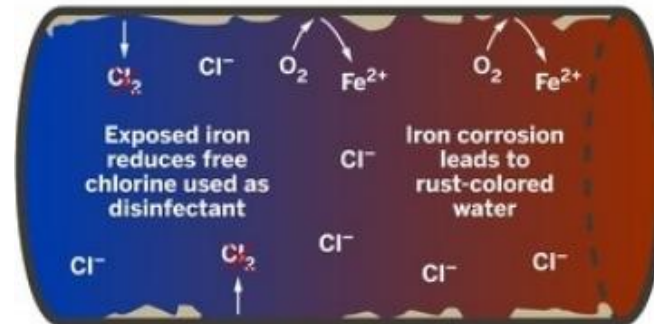
After: Treated Flint River water

Lack of a corrosion inhibitor, high chloride levels, and other factors cause the passivation layer to dissolve and fall off, leading to increased corrosion in Flint's pipes. As the pipes corrode, chlorine disinfectant breaks down.



Lead pipe

Oxidants such as dissolved O_2 corrode pipes and leach soluble metal.



Iron pipe

Graphics credit: American Chemical Society



More About the Problem

- Engineers contacted by ACS' Chemical & Engineering News contend that Flint did not optimize water chemistry to control corrosion
- Unlike the water supplied from Detroit, the Flint water lacked phosphate (specifically orthophosphate) used for anti-corrosion
- In theory – if orthophosphate had been added the catastrophe could have been avoided
 - One post-tragedy estimate to treat is only \$150/day



More About Water Corrosion

- Orthophosphate wasn't the only option
- Water pH can also be a factor
 - If pH drifts lower, it can contribute to higher metal leachates
- Flint water drifted from a pH of 8 in Dec 2014 to 7.3 in Aug 2015 indicating Flint lacked a target to minimize issues
- By contrast, Boston, with many lead pipes, tries to hold the pH around 9.6



Affects of Chloride Levels

- The Detroit water had an average 11.4 ppm chloride level in 2014
- The Flint water had an average 85 ppm chloride level in August 2015
 - Flint increased the chlorine as a reaction to the E. Coli
 - High trihalomethanes resulted
 - Flint tried to remove organic matter (contributing to high trihalomethanes) by adding ferric chloride which contributed to high chlorine levels



More About Chlorine

- Studies have shown that chloride to sulfate ratios that exceed 0.5 lead to higher corrosion
- The Detroit water had a ratio of 0.45
- The Flint water had a ratio of 1.6





August 2015: Virginia Tech group reports that Flint's 90th percentile lead level is 25 ppb.



Graphics credit: American Chemical Society

Problems Started Early

- The rusty water observed in Aug 2014 was an indication the passivation layer was dissolving
- Exposed iron pipes can reduce the free chlorine level
 - The Walters' home had NO free chlorine left in the water
- Also contributing to the problem was the water delivery system was built to serve a population that has since declined 50%.
 - Leads to longer in-pipe residual time (lowering residual chlorine)



What happens now?

- Switching back to Detroit water may take years to regain the passivation layer



Questions?

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