DALHOUSIE UNIVERSITY

Managing lead in distribution systems: research outcomes

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Background: lead in drinking water

Lead in drinking water is correlated with lead in blood[1]

Elevated blood lead is strongly linked with cognitive deficits in children[2]

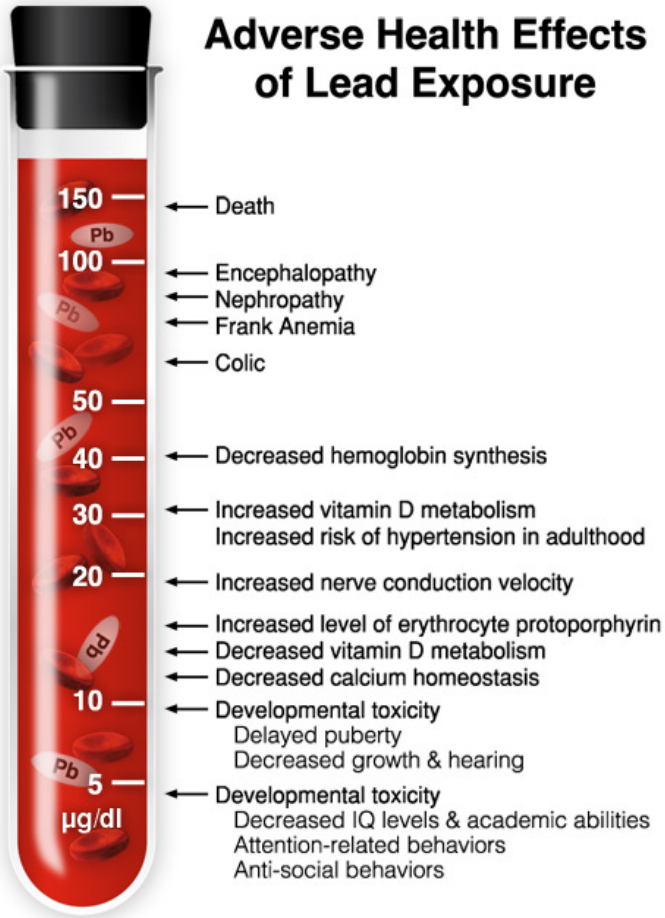


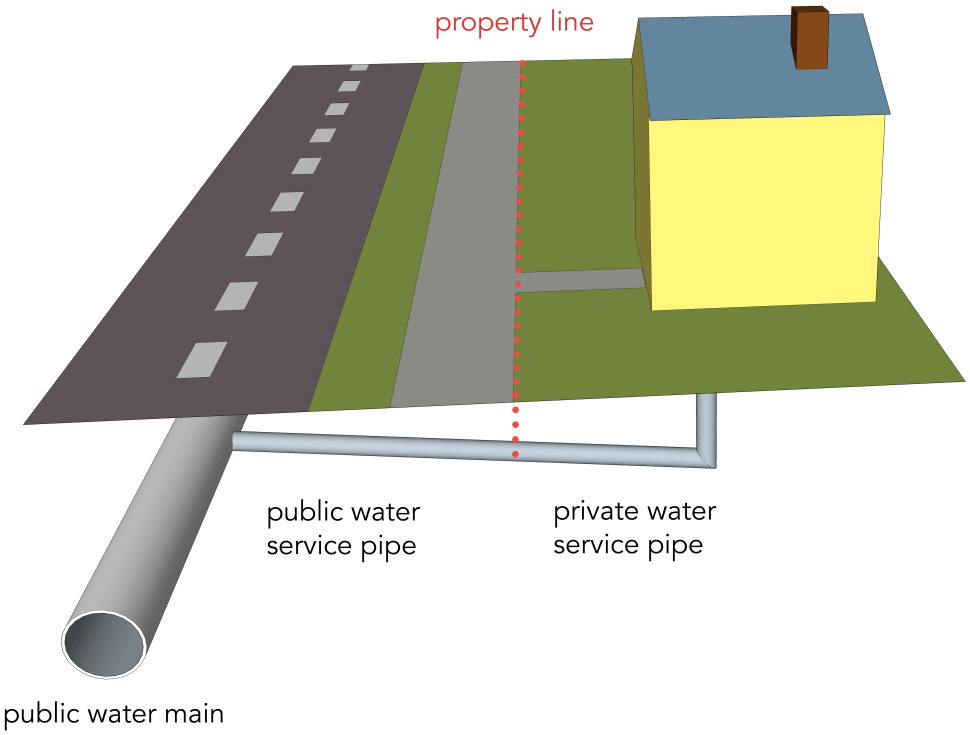
Figure source: [http://www.ehatlas.ca/lead/human-impact/health-concerns;](http://www.ehatlas.ca/lead/human-impact/health-concerns) adapted form Bellinger and Bellinger (2006)

(1) e.g., Edwards *et al*., 2009 **(2)** e.g., Evens *et al*. 2015

Background: sources of lead in drinking water

Recent study estimated 5.5 – 7.1 million lead service pipes remain in U.S.[1]

Leaded solder and brass in premises plumbing also represent important sources



(1) Cornwell *et al*. *J. Am. Water Works Assoc.* **2016**, *108* (4), E182-E191.

Background: sources of lead in drinking water

In water systems where Pb (II) minerals predominate, the lead service line (LSL) is often associated with peak lead levels in profile sampling

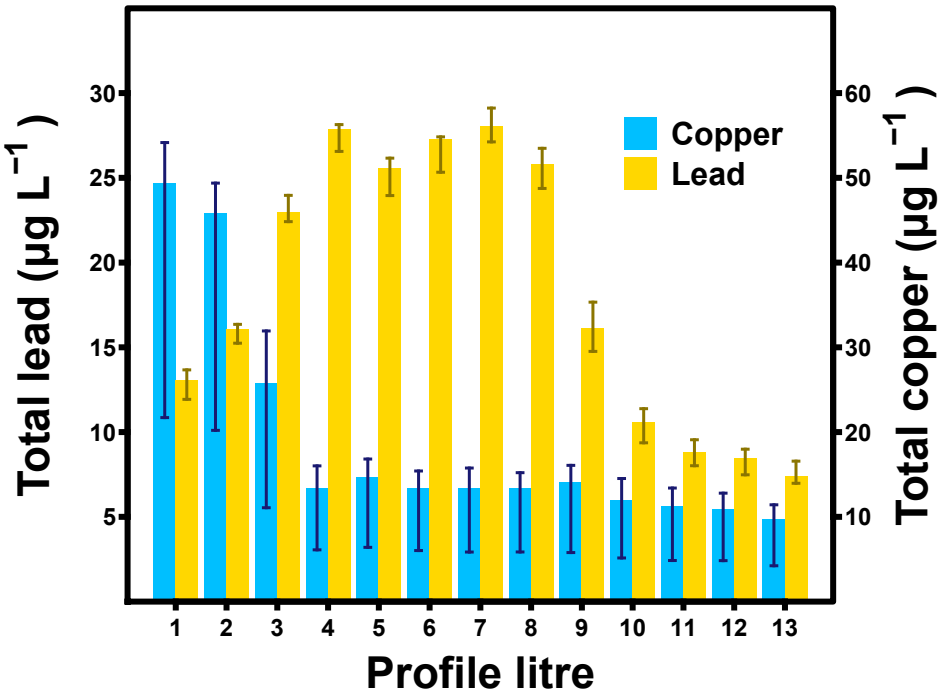


Figure source: Trueman *et al. Environ. Sci. Technol.* **2016,** 50, 7389−7396.

Full LSL replacement

Full LSL replacement (56 sites) reduced lead release from both the SL and premises plumbing within 1 month

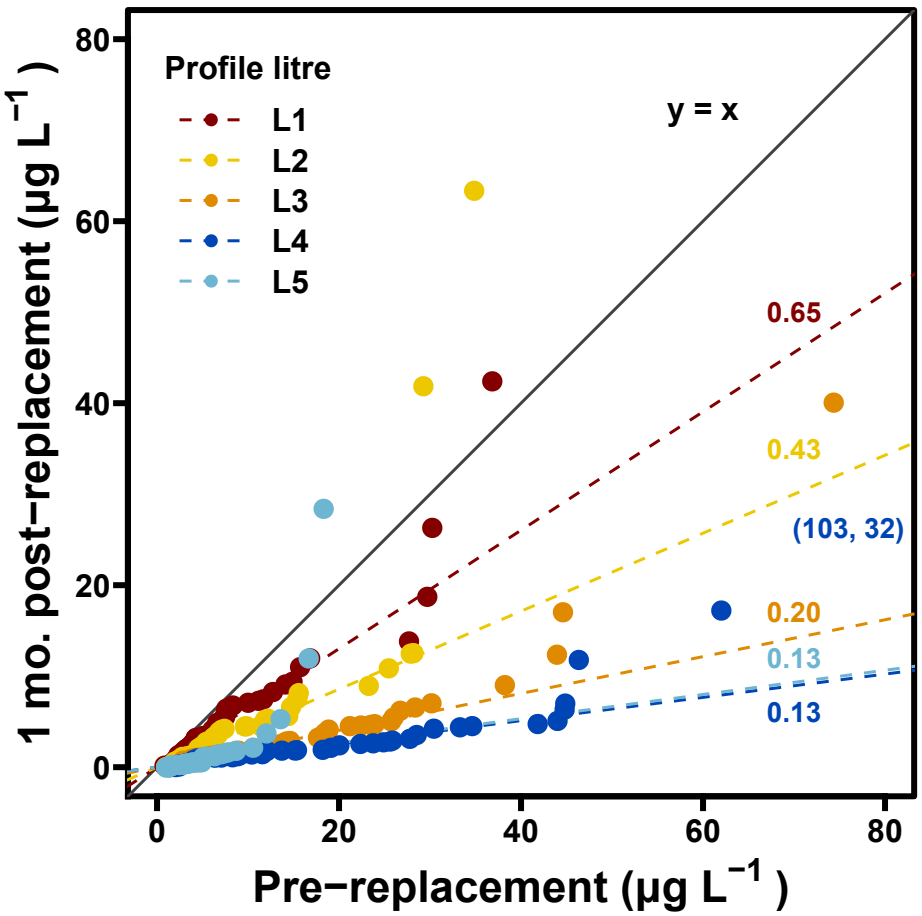
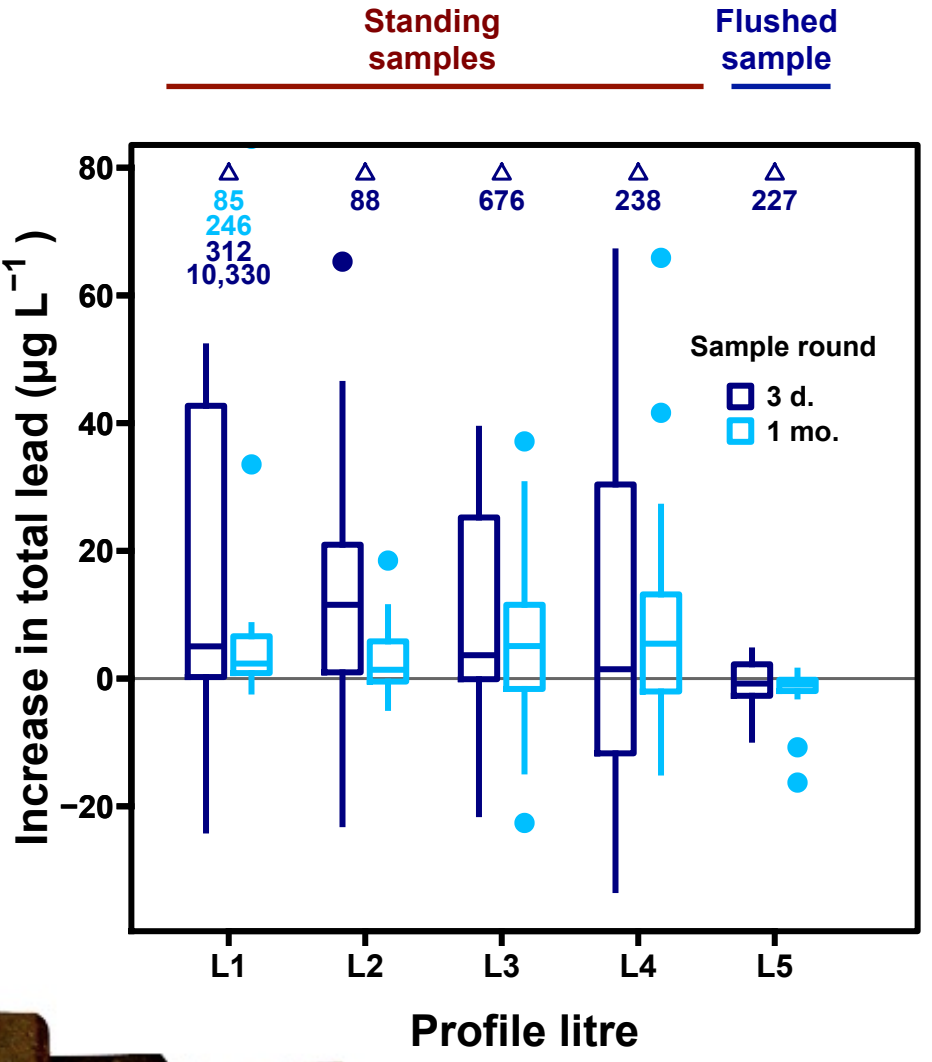
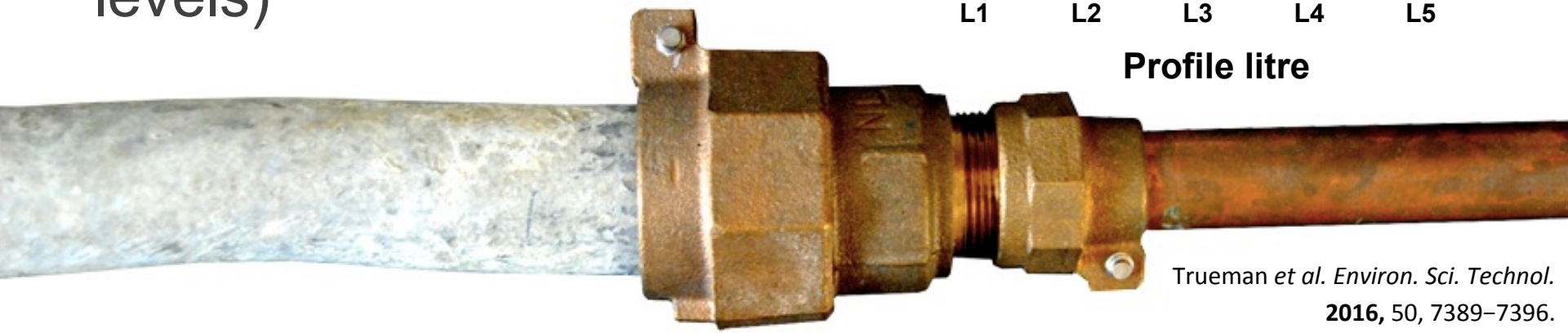


Figure source: Trueman *et al. Environ. Sci. Technol.* **2016,** 50, 7389−7396.

Partial LSL replacement

Associated with increased lead in standing samples (3 d. and 1 mo. post-replacement, relative to pre-replacement levels)

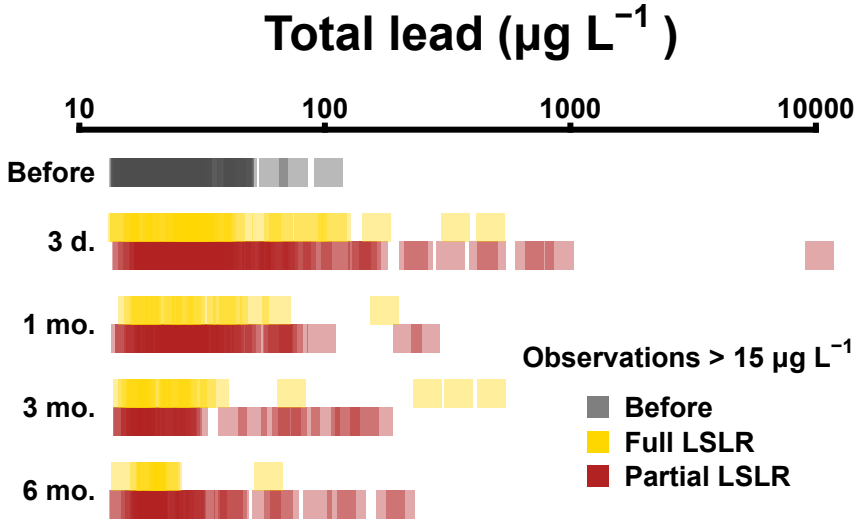


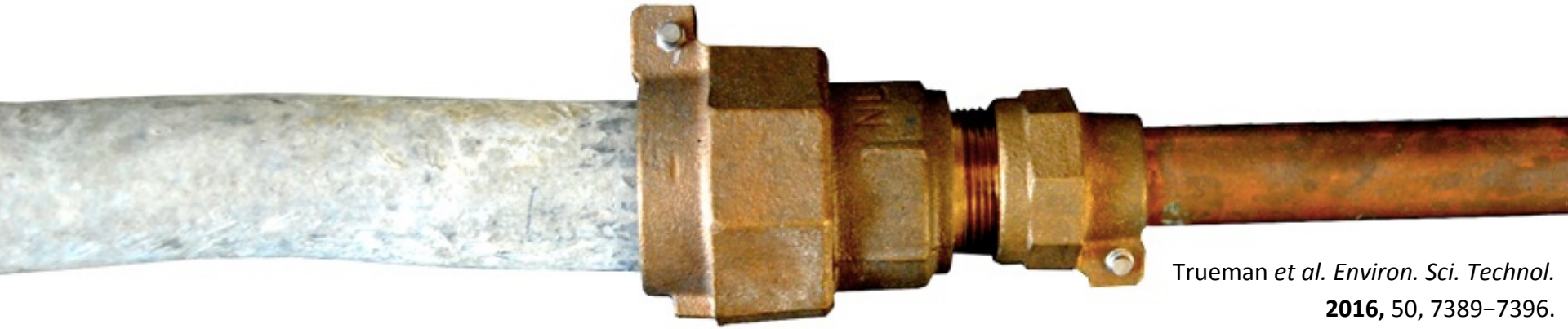


Trueman *et al. Environ. Sci. Technol.* **2016,** 50, 7389−7396.

Partial LSL replacement

6 mo. post-replacement, 27% of 1st draw lead levels were > 15 µg L^{-1}, compared with 13% pre-replacement





Trueman *et al. Environ. Sci. Technol.* **2016,** 50, 7389−7396.

Lead-iron interactions in water systems

Unlined cast iron distribution mains common in many water systems[1]

Presence of an iron main linked with elevated lead release[2]

Several studies have linked iron and lead concentrations in drinking water[3,4]

(1) McNeil & Edwards, 2001 **(2)** Camara *et al.* 2013 **(3)** Deshommes *et al*. 2010 **(4)** Masters & Edwards, 2015

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Figure source: Ni Zhu *in* Pelley, J. *Chem. Eng. News.* **2016**, July 25.

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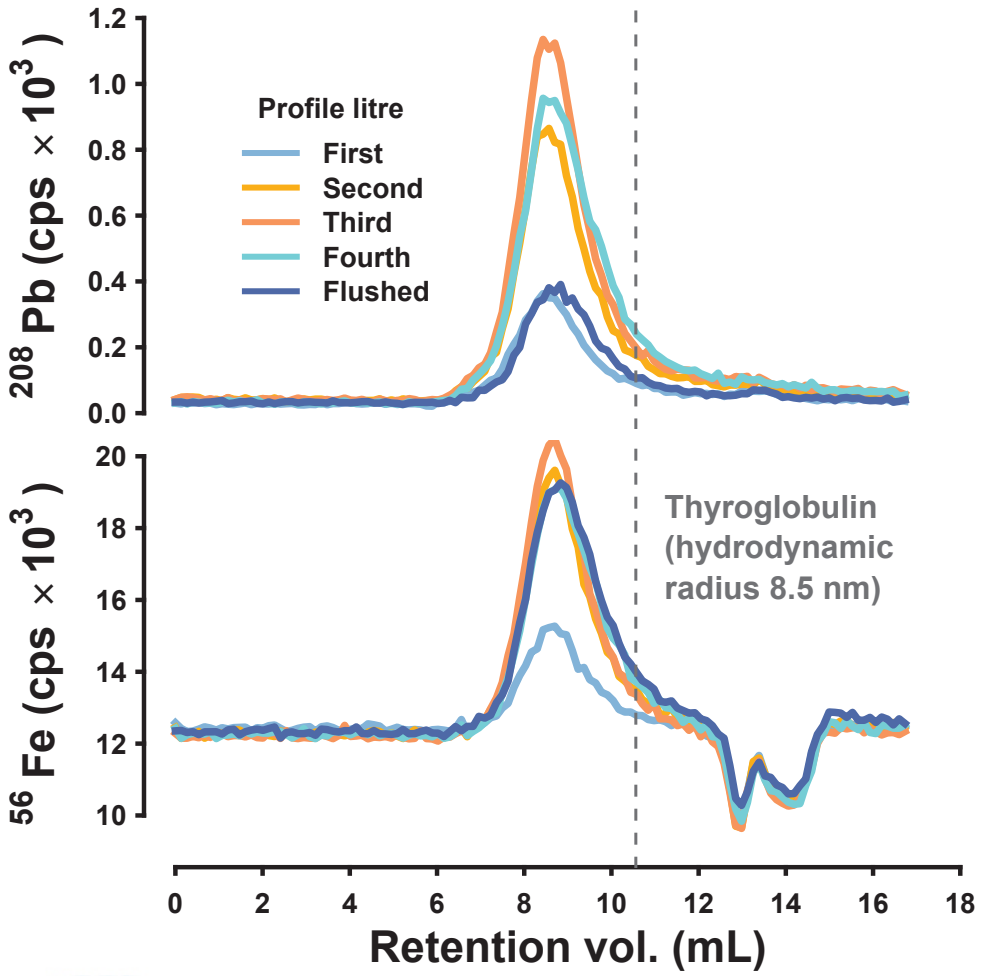
Colloidal/nanoparticulate lead and iron in drinking water

Method: size-exclusion chromatography with ICP-MS detection[1]

23 residential sites with full LSLs, partial LSLs, or recent full LSL replacements

Colloidal lead and iron strongly correlated under various separation conditions



(1) Trueman & Gagnon. *J. Hazard. Mater.* **2016,** *311*, 151-157.

Colloidal/nanoparticulate lead and iron in drinking water

Available data suggest that colloidal particles represent a significant fraction of total lead and iron at the point of use —colloidal lead and iron detected below 0.05 µm as well

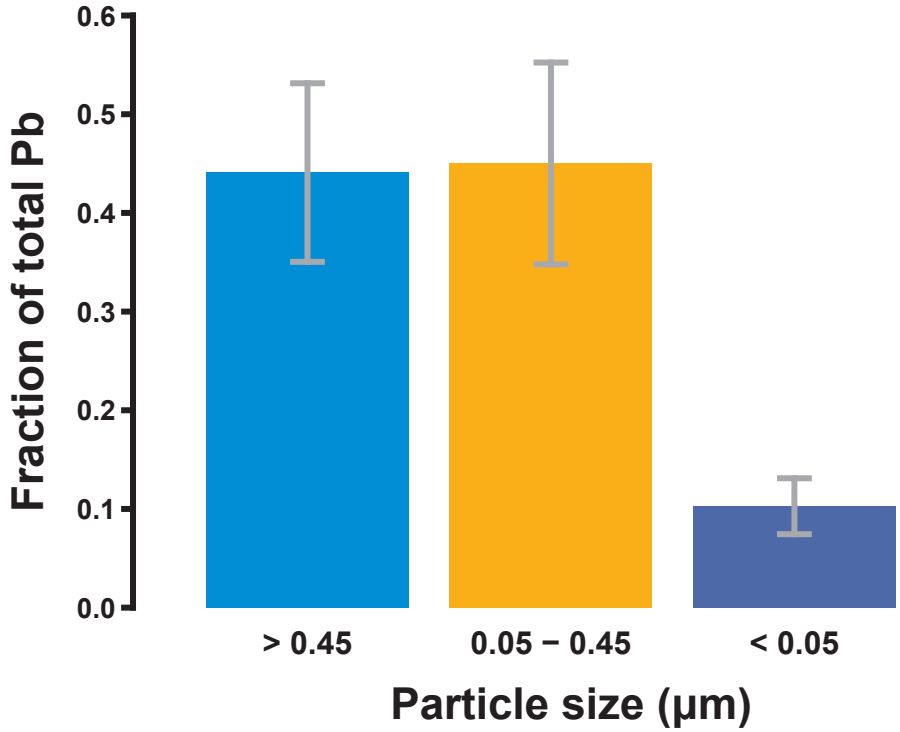


Figure source: Trueman & Gagnon. *J. Hazard. Mater.* **2016,** *311*, 151-157.

Colloidal/nanoparticulate lead and iron in drinking water

Colloidal particles originating from corroded iron distribution mains may enhance lead mobility

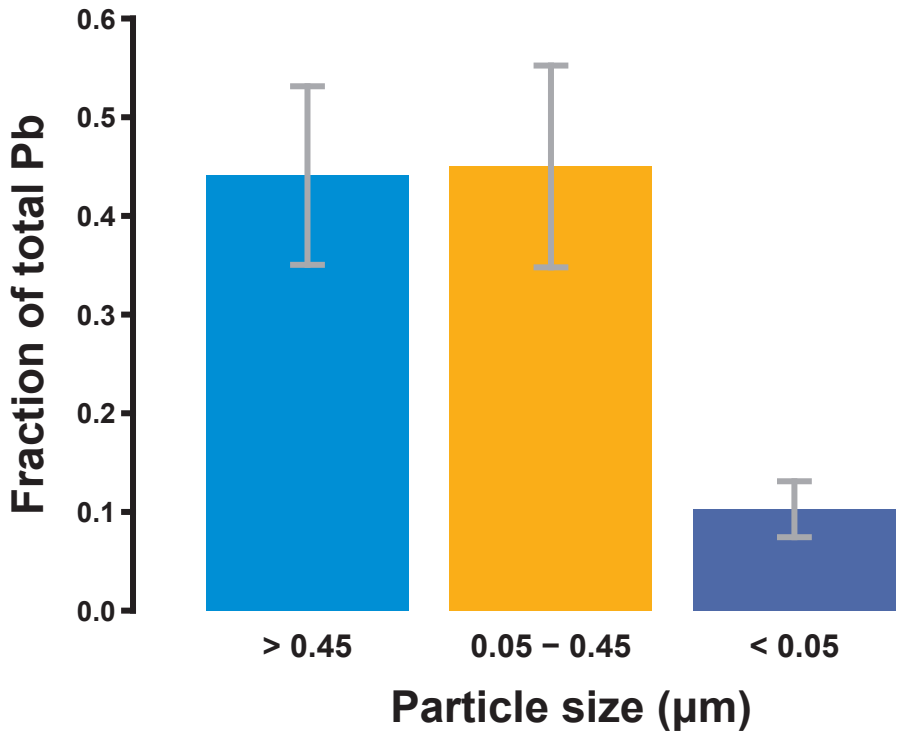


Figure source: Trueman & Gagnon. *J. Hazard. Mater.* **2016,** *311*, 151-157.

Effect of corroded iron pipe on lead in drinking water

Disturbed (pigged) iron distribution mains associated with elevated lead release

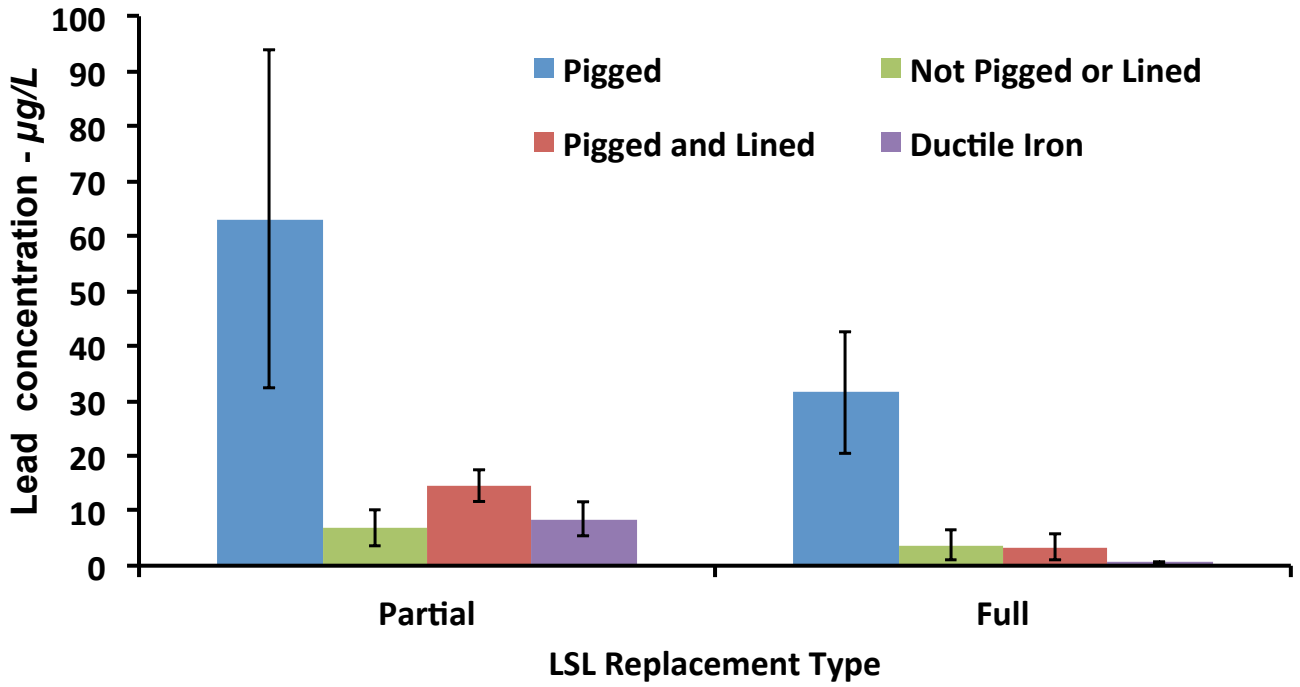


Figure source: Camara *et al. J. Am. Water Works. Assoc.* **2013,** 105 (8), E423−E431.

Effect of corroded iron pipe on lead in drinking water

Presence of an upstream iron main increased lead release from LSLs, effect not diminished by increasing orthophosphate (0.5 to 1.0 mg L^{-1} as PO_4^{3-})

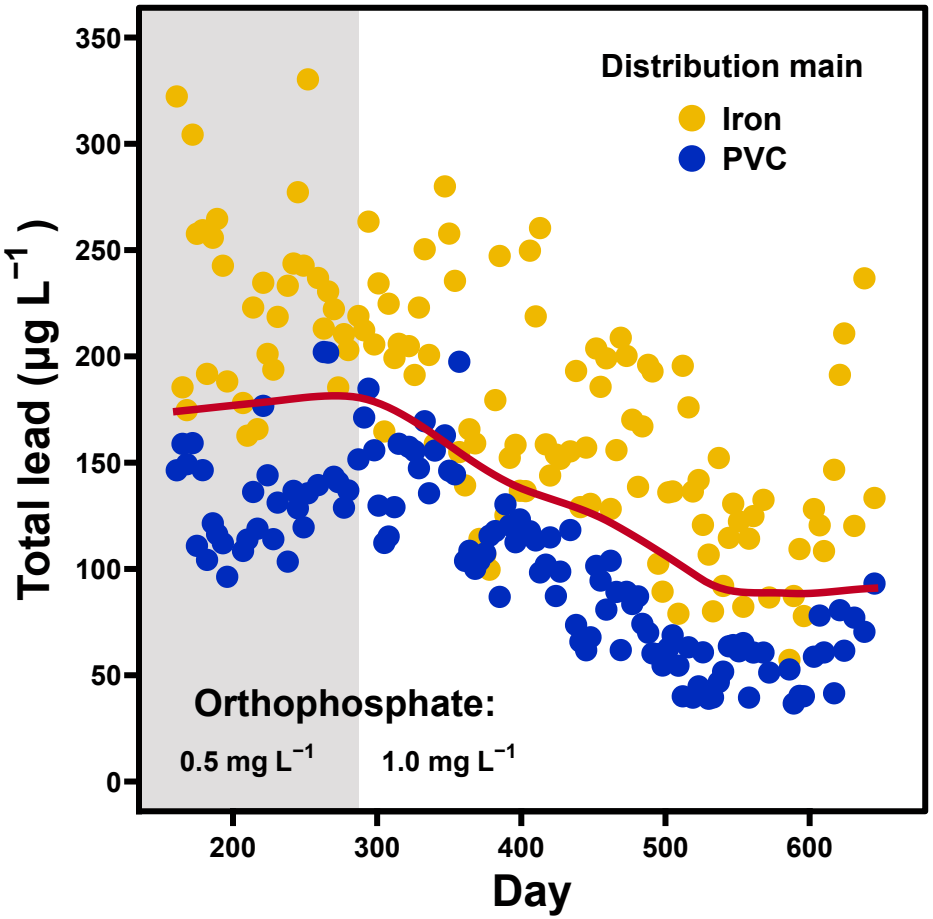


Figure source: Trueman & Gagnon. *Environ. Sci. Technol.* **2016**, *50*, 9053 – 9060.

Effect of corroded iron pipe on lead in drinking water

Mechanism appears to be complex, likely involving both adsorption and electrochemical phenomena

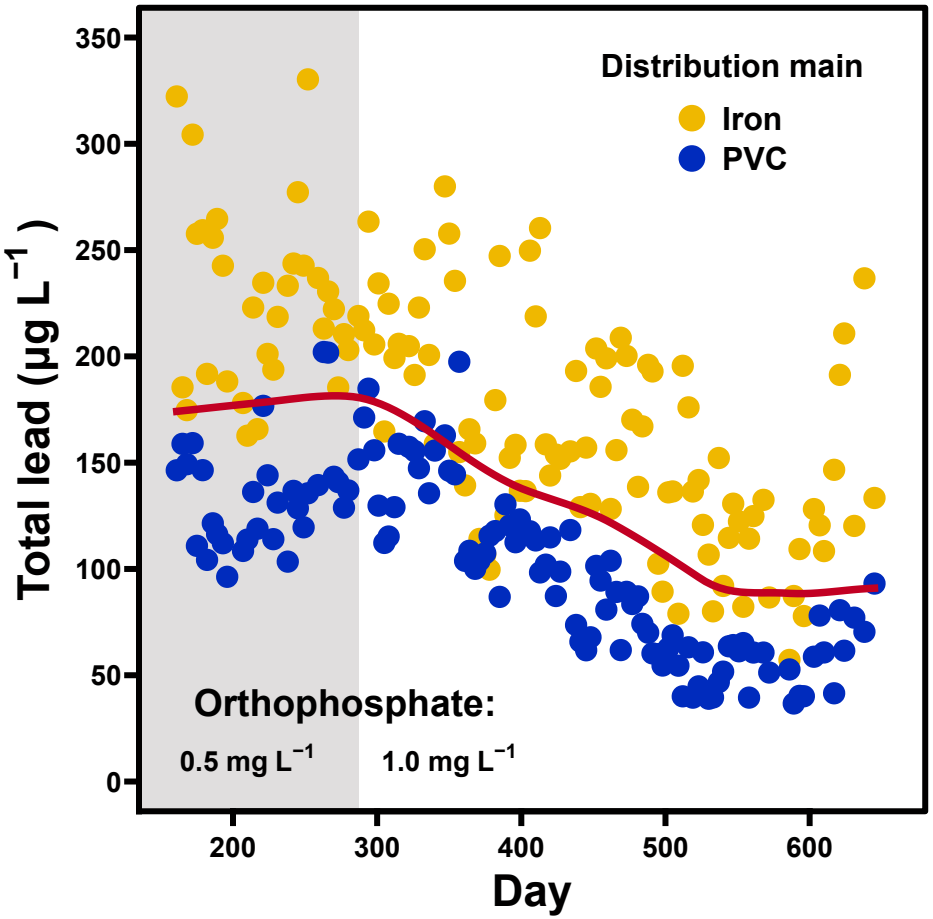


Figure source: Trueman & Gagnon. *Environ. Sci. Technol.* **2016**, *50*, 9053 – 9060.

Seasonality in lead release an important consideration

Available data in Hfx. show LSL lead release correlated with water temp. (R^2_{avg} = 0.79)

Other seasonally varying water quality parameters (NOM, coagulant residual) may be important

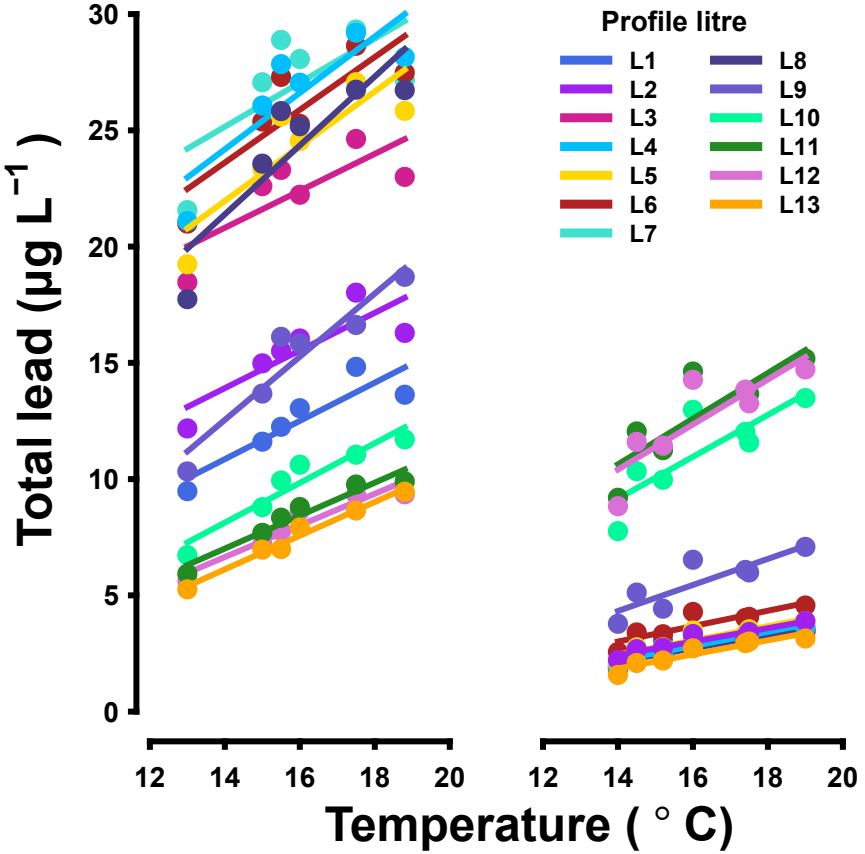


Figure source: Trueman *et al. Environ. Sci. Technol.* **2016,** 50, 7389−7396.

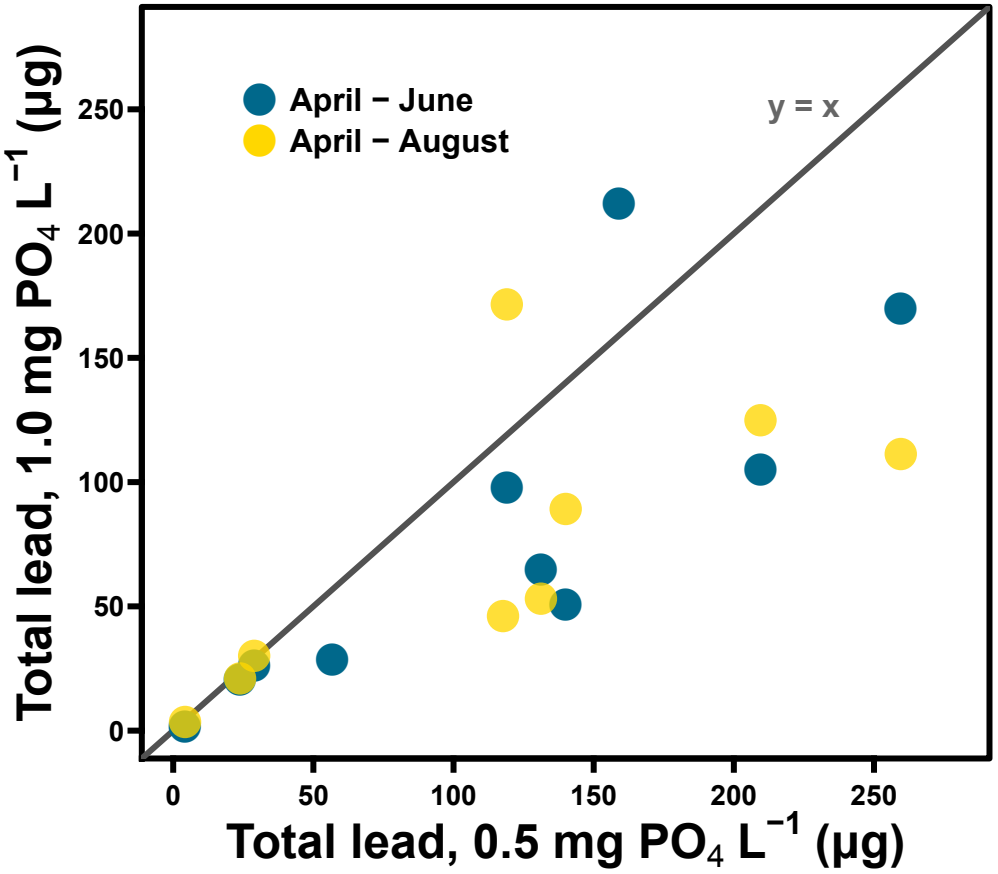
Effect of orthophosphate on lead release: preliminary residential data

Constant temperature comparison (summer 2015 vs. summer 2016) available for 1 residential site with an LSL:

—Total mass of lead released (over a 13 × 1L sample profile) was lower by 18% in 2016 (1.0 mg PO_4 L^{-1}) compared to 2015 (0.5 mg PO_4 L^{-1})

Effect of orthophosphate on lead release: preliminary residential data

Total mass of lead released[1] was lower by 35 – 36% following an increase in orthophosphate dose[2] (9 - 10 residential sites with full or partial LSLs)

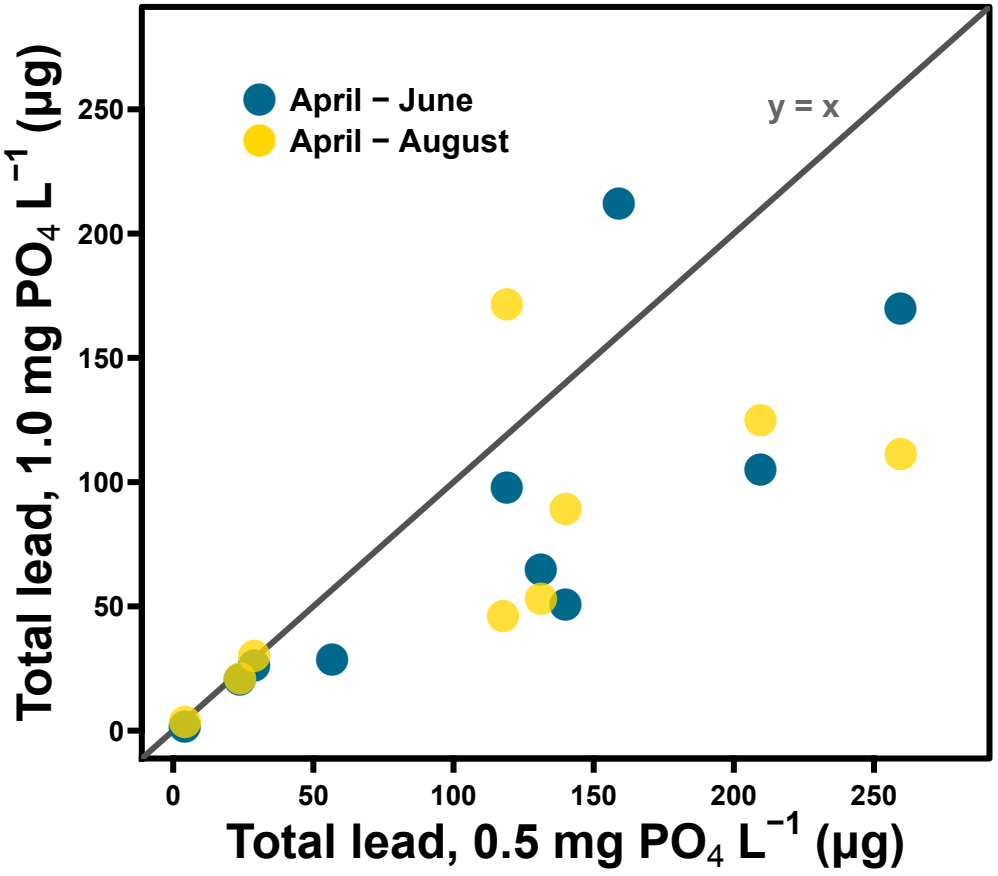


[1]over a 7 × 1L sample profile

[2]from 0.5 to 1.0 mg L^{-1} as PO_4

Effect of orthophosphate on lead release: preliminary residential data

Preliminary data do not take into account seasonality in lead release—more work is needed to understand the effect of phosphate



Summary thoughts:

(1) Data from Halifax study show that partial LSL replacement not reliable for lead reduction

(2) Corroded iron distribution mains play an important and complex role in lead release

—removing iron or preventing iron release could have significant benefits for lead exposure

(3) Preliminary data show promising results following a relatively small increase in phosphate

—seasonality is an important consideration in monitoring lead release to drinking water

Acknowledgements

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