

WATER FORUM

HOW A PARADIGM CHANGE COULD RESOLVE THE LEAD AND COPPER CRISIS DRINKING WATER

A paradigm shift is needed to resolve the lead (Pb) and copper (Cu) potable water hazardous metal crisis in the United States. This commentary proposes a shift towards an industrial water treatment evaluation approach rather than a governmental compliance-centered evaluation. Industry represents technology, economics, results, and safety driven in its approach to tackling water challenges. Government represents laws, regulation, and compliance-driven approaches, and rarely shall the twain meet.

It should be noted that this problem not only affects drinking water, but touches industries that use municipal drinking supplies in their applications—particularly those whose products are used by humans, of which the food and beverage, and life sciences would be two examples.

Two situations contrast the approaches: water changes in Flint, MI, and Savannah, GA:

- In Flint, government-mandated chemistry targets would not indicate a major problem. State-of-the-art technology driven evaluations predict the crisis.
- In Savannah, a technology driven study evaluated the change in water chemistry, allowing for a successful change. The U.S. Army Corps of Engineers, and major consulting firms handled the actual evaluations in the manner industry addresses a potential water challenge or opportunity (1).

By **Robert J. Ferguson**
(French Creek Software Inc.)

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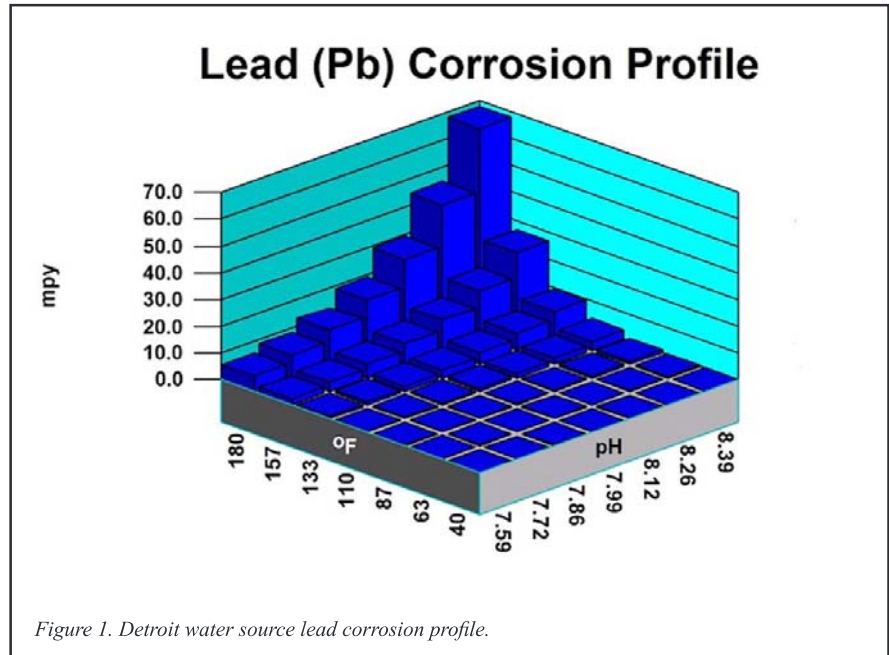


Figure 1. Detroit water source lead corrosion profile.

The Problem and Source

Lead and copper in drinking water present a health hazard that has been addressed legislatively by the Lead and Copper Rule (2) and through various laws at the state level. The federal laws mandate action limits for the metals. The U.S. Environmental Protection Agency (EPA) provides guidelines for limiting the corrosion source. State laws typically reflect the guidelines.

Guidelines may include adjusting indices such as the Langelier Saturation Index and Calcium Carbonate Precipitation Potential so that particular quality water might be expected. Adjusting the water chemistry towards the formation of calcium carbonate scale is believed to minimize corrosion. Prior to the availability of more accurate and direct prediction methods, the calcium carbonate indices were used as an indication of water's corrosivity towards metal as in piping, tubes, and fittings. The legislative approach has relied in many cases upon these simple indices from the early days of municipal and industrial water treatment.

Lead and copper contamination of municipal water can come from:

- The original water source;
- *In situ* corrosion of copper and lead pipe, solder and fittings; and
- Corrosion product deposits containing lead and/or copper.

Corrosion as a metal source. The levels encountered vary throughout the system. For example, in higher-flow areas, hazardous metal levels are much less likely to reach "action levels" than in low-flow or stagnant areas. In the high-flow area, the soluble lead or copper leaches from the corrosion site source. In the case of a stagnant area, metal levels form corrosion can build up to the maximum solubility of the Pb or Cu for that water chemistry.

This is the reason it is a good idea to run your water for a few minutes before drinking (to flush the soluble corrosion product). Conversely, water samples for testing are typically from the "first draw" of the day, so that accumulated soluble Pb and Cu are at their maximum, before they are flushed by use, and their

Maximum Lead Solubility

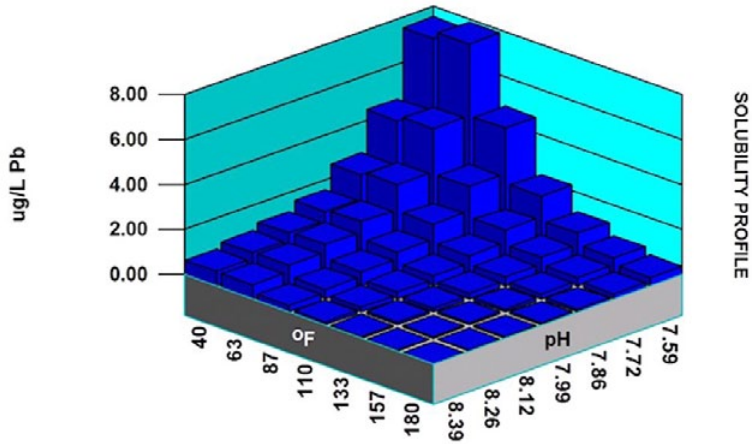


Figure 2. Detroit water source maximum lead solubility.

Lead (Pb) Corrosion Profile

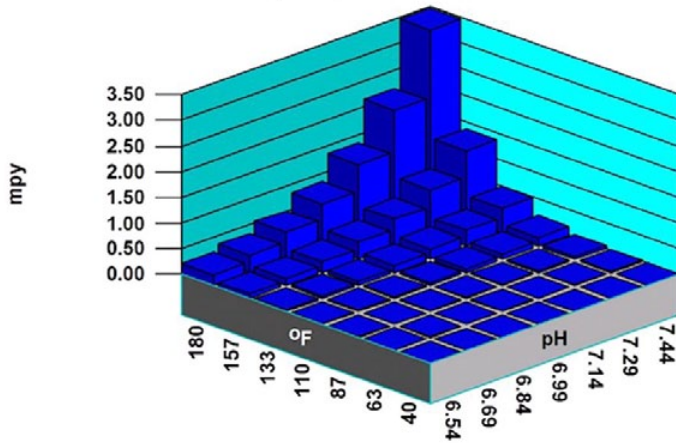


Figure 3. Flint, MI, maximum lead corrosion.

Maximum Lead Solubility

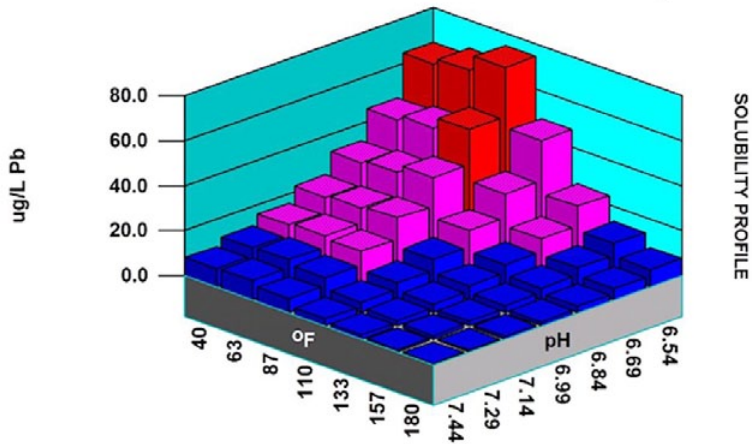


Figure 4. Flint, MI, lead solubility profile.

concentration(s) decreased. The legislative approach has emphasized corrosion control as the means to limit lead and copper contamination of a municipal water supply.

Deposits as a metal source. Pb and Cu from corrosion will deposit as carbonates, hydroxides, and phosphate precipitates. These deposits will not be measured in routine drinking water tests but they accumulate a reservoir of solid Pb or Cu, until conditions allow for its dissolution. Changing water sources, temperature, parameters such as pH, or even anti-corrosive treatments can influence the dissolution of the metal-containing corrosion product deposits, contaminating the water.

Expectations. Water with high corrosion rates for Pb and/or Cu metals, and a low maximum solubility for the metals and their typical deposits, would be expected to build up a reservoir of Cu and/or Pb deposits.

Water with high corrosion rates and high solubility would be expected to reach high, perhaps action level concentrations in stagnant areas.

As a point of reference, Detroit municipal water evaluated to relatively high corrosion rates for Pb (Figure 1) and low-Pb solubility (Figure 2), and would have been expected to build up appreciable lead-containing deposits. Flint River water was predicted to have lower lead corrosion rates (Figure 3), but a much higher solubility for Pb (Figure 4)...

Changing from long-term use of the Detroit municipal water to the Flint River source, would be expected to dissolve the deposits, with a release of soluble lead into the municipal water distribution system. The calculation methods used incorporate those used in industry for mission critical heat transfer equipment in cooling systems, and critical wells in petroleum production (3).

It should be noted that the graphs included are for example. The analysis used are from published data and represent only one point from each water source. A thorough analysis and evaluation would include all sampling points and profiles over the annual variations in chemistry.

Technology Driven Approach

A technology driven evaluation would incorporate currently available tools directly applicable to the problem. Here are some examples:

1. Generic corrosion rate models, and models developed from direct correlations of observed corrosion rates to water chemistry should be used to project the impact of water source, chemistry, and treatment changes upon corrosion.
2. Calculated values for maximum metal solubility should be used to predict the maximum soluble Pb and Cu that might be expected in the distribution system, and to infer the dissolution of existing metal-containing deposits. Please note that some anti-corrosive treatments may increase the solubility of Pb and Cu in the water. This interaction should be included in any modeling of maximum Pb and Cu solubility.
3. Profiles should be evaluated over the total operational parameter range for temperature (from reservoir temperature to that of hot water heaters and dishwashers), and pH (if variations is observed in the system).
4. Profiles should be run as water sources change because of seasonal variation, blending, or whenever they change.

Results from these modeling exercises should be verified by the compliance testing for observed Pb and Cu levels, and corrosion rates.

Recommendation

It is past the time for us to embrace a technology, rather than a compliance-driven approach to the evaluation and resolution of municipal potable water quality hazards. Part of this paradigm change would involve adopting or adapting the best available technologies from high technology areas of water treatment to address the problem of hazardous metal contamination of municipal potable water distribution systems. This is important not only to protect human health, but for industrial water users who often may rely on municipal water as their feed source (e.g., life sciences, food and beverage, and others).

References

1. U.S. Army Corps of Engineers, “Savannah (Georgia) Harbor Expansion Project” (work occurred from 2014 to 2015).
2. U.S. Environmental Protection Agency, 40 CFR Parts 141 and 142 [EPA-HQ-OW-2005-0034; FRL-8476-5] RIN 2040-AE83, “National Primary Drinking Water Regulations for Lead and Copper: Short-Term Regulatory Revisions and Clarifications”, *Federal Register* 72(195), Rules and Regulations, pp. 57782-57820, accessible at: <https://www.epa.gov/dwreginfo/lead-and-copper-rule> (Oct. 10, 2007).
3. Ferguson, R.J. “Modeling Lead and Copper Corrosion and Solubility”, presentation for the Cooling Technology Institute annual conference, New Orleans, LA. (Feb. 5-9, 2017).



Author Robert J. Ferguson is the president of French Creek Software, Inc., a company he co-founded in 1989.

His professional career includes positions with Nalco, Apollo, Mogul, Calgon, Chemlink, and Baker. Mr. Ferguson began modeling mineral scale formation and its control in 1974. Software he has developed is used for modeling cooling water, reverse osmosis, and oil field chemistry. He was educated at the U.S. Naval Academy and the University of Minnesota and received a BS in biochemistry and microbiology.

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