How Not to Get the Lead Out—Lead Service Line Replacement Will Not Solve Our Drinking Water Crisis

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Published online: 20 May 2016
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Abstract Since the water crisis erupted in Flint, Michigan, over lead in the water, there have been numerous calls to replace lead pipes used to bring water into the home. This is likely to do little, if anything, to reduce the detection of lead in drinking water under EPA sampling protocols. The problem is that the standard 1-l sample draws only from the first 10 to 22 ft of the pipe, not enough to reach the service line. The lead most likely comes from interior plumbing. Unless we find the actual sources of the lead, we may be in the same crisis position years from now after spending billions of dollars.

Commentary

Since the water crisis erupted in Flint, Michigan, regarding lead in the water, there have been numerous calls to replace the lead pipes often used to bring water from the main in the street into the home. Replacing these service lines that bring water from the street into peoples' homes, schools, and workplaces is likely to do little, if anything, to reduce the detection of lead in drinking water. The reason is as follows: The water sampling that has catapulted this problem to national attention involves taking a 1-l sample from the tap after at least 6 h of standing time. The problem is that this draws only from the first 10 to 22 ft of the pipe, which is usually not enough to reach the service line. Commercial water sampling kits sold over-the-counter at large hardware stores sample even smaller volumes. They also can

cause consumers to sample at slower flow rates than they would use for actual consumption, which contradicts EPA guidance on sampling for lead in drinking water.

According to Civil Engineering Magazine [1] Jill Jonas, chair of the USEPA's National Drinking Water Advisory Council, "The Council considers that the driving proactive principle to improve public health protection is removing full lead service lines from contact with drinking water to the greatest degree possible and minimizing the risks of exposure to the remaining sources of lead in the meantime." Jim Taft, executive director of the Association of State Drinking Water Administrators is quoted as saying that replacement of lead service lines is the "only sure-fire, long-term solution to the problem." But is it?

Lead pipe was commonly used to link water mains in the street to the interior plumbing systems of homes, schools, and businesses from the late 1800s until the mid-twentieth century [2]. Although its use was declining, it continued to be used into the 1980s. Lead pipe has advantages over other materials such as iron due to its durability and malleability. The latter property makes installation easier, since lead pipe is easily bent around obstructions. But there are other sources of lead in plumbing systems—lead solder joints and brass fixtures such as faucets and water meters.

Effective 1987, the US Congress banned the use of solder or flux with more than 0.2 % lead (U.S. [3]). However, pipes and brass fixtures were allowed to contain up to 8 % lead. Such levels of lead were included in brass alloys to make them easier to machine. Congress later passed the Reduction of Lead in Drinking Water Act which required that, starting in January 2014, all wetted surfaces, including pipes and fixtures, could have no more than 0.25 % lead. Thus, any fixtures sold before that time and still in our homes and schools could have high lead levels. There are other reasons fixtures may contribute large amounts of lead. They have metal parts that move against

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each other, which could scrape off corrosion products that either shields the surface from further corrosion, or that contain lead corrosion products themselves. There is much more turbulence in fixtures than would be found in a service line, which could scour up particles containing lead. Fixtures and joints are in closer contact with dissimilar metals, creating the possibility of enhanced galvanic corrosion. Lead service lines are likely suspects because they may be made of nearly pure lead and have a large surface area. But the data collected under the EPA Lead and Copper Rule (U.S. [4]) is not adequate to determine the contribution from the service lines.

I conducted detailed spatial sampling in my own home and several others by drawing a series of one hundred consecutive 30-mL samples and plotting the results versus the length along the plumbing system [5]. I live in a small single-family home. The kitchen is not at an extreme distance from the point of entry, yet the volume of the plumbing system from the kitchen tap to this point is over 3 liters. A 1-l sample does not even come close to sampling the service line. The highest concentration I found in my system was 109 ppb, associated with solder joints in the system about 7 ft from the faucet. But the average concentration of the first liter of samples was only 8 ppb, well below the EPA's 15 ppb "action level." After the first dozen samples until 2.5 l were drawn, the lead was almost always undetectable. But the following 20 samples, which corresponded to the area of the water meter and piping near it, including part of the service line, I found lead levels consistently above the action level, at an average of 31 ppb. Sampling using the EPA protocol would not have revealed this source.

The crisis in Flint was mostly about residential homes. But the awareness of the seriousness of lead in drinking water that was generated by the Flint crisis has led other communities to realize that they had a problem in other places. The New York Times reported in February [6] that "Unsafe levels of lead have turned up in tap water in city after city," including in Ohio, Mississippi, North Carolina and South Carolina. Here, in New Jersey, lead was found above the action level in a hospital in Morristown. Employees and patients have been screened for blood lead levels as a result. Water from drinking fountains in 30 schools in Newark exceeded the action level, with concentrations as high as 558 ppb [7]. Newark expects to test 17,000 students for blood levels. Drinking fountains in schools and other large buildings can be expected to be much farther from the service lines than faucets in residences. The likely sources of lead in the samples include solder joints and brass fixtures. Unless we do testing that can discriminate between these sources, our remediation steps may target the wrong culprit. The results in Newark and many of these other cases reportedly go back years, but are only being taken seriously now. One can expect to see many more cases like these across the nation in the coming months.

Civil Engineering Magazine reports that there are an estimated 6 to 7 million lead service lines in the USA, and

replacement of all of them could cost from \$35 billion to \$50 billion. This would represent a significant diversion of funds needed for other critical needs in our water infrastructure, without proof that it will solve the problem.

Replacement of lead service lines has already begun in Flint. Since the problem has been identified using 1-l first-flush samples, this is not likely to result in a change in detection. Furthermore, not knowing the actual sources of contamination can result in other improper actions. For example, residents are often told that the problem can be minimized by flushing their tap water until the water runs cold. This simply means that the water in the interior plumbing has been flushed, and the residents are now using water from the service line! In my home, if I flushed 3 or 4 l before filling my pitcher, I would be drawing from the lead service line leading to my house.

To be clear, removal of lead service lines is likely to significantly reduce exposure to lead, but this will do little to reduce the detection of lead at the tap. We need both in-situ and ex-situ testing methods that can identify the actual sources of the contamination. Unless we find the actual parts of the plumbing systems that are causing the exposure, future measurements taken after replacement of lead service lines can be expected to show the same high values we are finding today. We may find ourselves in a repeat crisis years from now after spending billions of dollars that we thought would solve the problem.

Compliance with Ethical Standards

Conflict of Interest David A. Vaccari declares that he has no conflict of interest.

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