Sampling for Lead in Drinking Water

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Pb not present in drinking water right after treatment:

- Lead Service Lines (LSLs)
- Lead Goosenecks
- Leaded Solder
- Galvanized pipe downstream of leaded plumbing
- Leaded Brass (valves, fittings, faucets, water fountains)
Many factors affect lead release

- Plumbing materials, dimensions, configurations
- Water chemistry (corrosivity)
- Chemical and hydraulic changes/disturbances
- Water use patterns

- Spatial variability
- Temporal variability
- Particulate vs Dissolved lead

Pb Risk ???
Research tools

Lead Service Line (LSL) Removal

Lead Scale Carefully Harvested

Pipe Cut Open

Analysis of Lead Scale (XRD)

Plumbing inspection (Visual & XRF)
Research tools

Tap water collection

Analysis for lead and other metals (ICP-MS)

Morphology and elemental mapping of particles in faucet aerator (SEM/EDS)
Research tools

Lead in Tap Water → Biokinetic Model Prediction → Lead in Blood

Integrated Exposure Uptake Biokinetic Model for Lead in Children
Windows® version 1.1 Build9

IEUBK
Lead and IEUBK Technical Review Workgroup
IEUBK Model For Lead in Children

Air  Dust  Soil
Diet  Paint  Water

Lungs  GI Tract

Plasma Extra-Cellular Fluid

Red Blood Cells

Bone  Soft Tissue  Feces

Predict Blood Lead Levels (BLLs)

Modified from US EPA, 2002
Model Considerations

- **Most sensitive children:**
  - BLL variability in response to same lead dose due to genetics/diet
  - IEUBK predicts distribution of BLLs (including hypersensitive)

- **Most exposed children:**
  - Formula fed children consuming much higher water volumes
0-1 year old infant consuming baby formula

- IEUBK model predictions, hypothetical water lead levels
- 800 mL/day, Average water consumption
- Default exposures from other lead sources

<table>
<thead>
<tr>
<th>BLL Threshold (µg/dL)</th>
<th>Predicted Water Lead Required to Exceed BLL Threshold for</th>
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<tbody>
<tr>
<td></td>
<td>50%th Percentile</td>
</tr>
<tr>
<td>10</td>
<td>60 µg/L</td>
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<tr>
<td>5</td>
<td>18 µg/L</td>
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</table>

Triantafyllidou et al., 2012

For illustrative purposes. Different modeling assumptions would yield different results
5-6 year old child drinking tap water

- IEUBK model predictions, hypothetical water lead levels
- Default exposures from other lead sources

Triantafyllidou et al., 2014
Lead and Copper Rule Sampling, US

- Lead Action Level is not an MCL (Maximum Contaminant Level)
- Aimed at identifying system-wide problems rather than problems at outlets in individual buildings
- 90th percentile 15 µg/L action level is a trigger for corrosion control treatment rather than an exposure level

Always sample water in environmental assessments of lead-poisoned children, even in cities complying with LCR.
How do I know if my tap water is contaminated with lead?

The only way to know whether your tap water contains lead is to have it tested. You cannot see, taste, or smell lead in water. Therefore, you must ask your water provider whether your water has lead in it. For homes served by public water systems, information on lead in tap water may be available from your local water authority. If your water provider does not post this information, you should call and find out.

You should be particularly suspicious if:

- Your home has lead pipes (lead is a dull gray metal that is soft enough to be easily scratched with a house key)
- You see signs of decay (frequent leaks, rust colored water, stained dishes or laundry, or if your nonplastic plumbing is less than five years old)

* Taken from www.healthychildren.org
Small price to pay for piece of mind
By R Young on May 6, 2016
Verified Purchase

After hearing of several local schools that discovered high levels of lead in their water, I really started to worry about lead in the water at my workplace as the building is fairly old. I didn't want to spend a lot on an expensive test since it's my workplace and not my home, but I just wanted some piece of mind. This test did the trick.

The test itself was simple to use, fill the included dropper with water, put it in the provided vial, drop in the test stick and 10 minutes later you're done. It's really a breeze. I wish they mentioned in the instructions how little water is actually in the vial. I was second guessing myself that I didn't put enough, but one dropper did the trick.

After the 10 minutes, my test came back and my water tested negative for lead. Now I don't have to worry about it anymore.

The only thing I wish is that the test gave an amount of lead detected rather than just a TRUE or FALSE response, but tests that did that were way more expensive. For this price, it did the trick.

Testing your home's water

Start with your local water supplier -- some will come to your home and test for free. If that's not an option, you can buy a lead testing kit from home improvement stores to collect the testing samples.

If you do it yourself, be sure to follow directions carefully and only use "first-draw water," the very first water coming out of your pipes after sitting overnight. If your pipes are contaminated, that water will have the most accumulation of toxins.

Oct 13

The only way to tell if your water is safe is to test it at the tap. Let us give you peace of mind. https://www.leadsmart.com #BusinessOwners
How well we can answer that question hinges on many variables:

- Premise plumbing (volume, composition, configuration, age)
- LSL present?
- Individual household usage patterns

Need to ask more specific questions

- What is the general public’s exposure to lead in drinking water in this residence/neighborhood/town/distribution system?
- How effective is the current corrosion control treatment?
- What forms of lead are present in the drinking water (soluble vs. particulate)?
- Where is the lead coming from?
- Does the water meet regulatory standards for lead?
Current Sampling Approaches

- Regulatory/Compliance/Treatment Sampling
- Exposure Assessment Sampling
- Sampling for Lead Sources

No single universally applicable sampling approach for lead in drinking water exists

There are many protocols, but each has a specific use answering one of those many questions
What questions are you trying to answer?

- Does the water meet regulatory stand P?
- What is the general public’s exposure to Pb in water in this residence/neighborhood/town/distribution system?
- Lead regulatory compliance/corrosion control efficacy
- Lead exposure assessment
- Where is the Pb coming from?
- Lead plumbing sources determination or lead type identification
- How effective is the current corrosion control treatment for interior plumbing?
- What type of Pb is present (dissolved vs particulate)?
## Multiple Options Exist for Lead Sampling

<table>
<thead>
<tr>
<th><strong>OBJECTIVE</strong></th>
<th><strong>SAMPLE TYPE</strong></th>
<th><strong>PROTOCOL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead regulatory compliance/corrosion control efficacy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Draw, US</td>
<td>6+ hr stagnation</td>
<td></td>
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<tr>
<td></td>
<td>Collect 1 L</td>
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<tr>
<td>Random Daytime (RDT), UK</td>
<td>Random sample collection</td>
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<td></td>
<td>(variable stagnation)</td>
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<td></td>
<td>Collect 1 L</td>
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<tr>
<td>30 Min. Stagnation (30MS), Ontario Canada</td>
<td>2-5 min. flush</td>
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<td></td>
<td>30 min. stagnation</td>
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<tr>
<td></td>
<td>Collect first two liters</td>
<td></td>
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<tr>
<td>OBJECTIVE</td>
<td>SAMPLE TYPE</td>
<td>PROTOCOL</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
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<tr>
<td>Lead plumbing sources determination or lead type identification</td>
<td>Profile (or sequential) sampling (traditional)</td>
<td>Defined stagnation time 10-20 sequential samples of defined volume (125 mL, 250 mL, 1 L, etc.)</td>
</tr>
<tr>
<td></td>
<td>Profile sampling that stimulates particle release</td>
<td>Traditional profile sampling at increasingly high water flow rate (low, medium and high)</td>
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</tbody>
</table>
|                                 | 3T’s for schools guidance, US                    | Overnight stagnation  
Collect first 250 mL from all taps and fountains  
If sample > 20 ppb, take follow up samples |
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<tr>
<th>OBJECTIVE</th>
<th>SAMPLE TYPE</th>
<th>PROTOCOL</th>
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</thead>
<tbody>
<tr>
<td>Exposure Assessment</td>
<td>Voluntary monitoring</td>
<td>“Ad hoc”</td>
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<tr>
<td></td>
<td>Or</td>
<td></td>
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<td></td>
<td>Environmental assessments in homes of at-risk children</td>
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<tr>
<td></td>
<td>Composite proportional</td>
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</tbody>
</table>

- Captures actual water use
- A device collects 5% of every draw from the tap for consumption
- Used for 1 week

**Risk = Hazard x Exposure**
NHU = normal household use prior to stagnation
PF = flush of at least 5 minutes prior to stagnation
32 sites with LSLs (built between 1890-1960)

Del Toral et al. 2013
Regulatory Compliance Sampling

Does the water meet regulatory standards?

- US Lead and Copper Rule (90th Percentile Action Level ≥15 ppb)
  - 6+ hour stagnation and 1 L first draw sample
- Long stagnation time, allows sufficient lead amplification
- May also be used for corrosion control treatment evaluation
- Low flow rate, aerator removal, and pre-stagnation flushing have all been used to lower sample concentrations
- Differences in stagnation times can affect sample concentrations

1 L is often short of the volume required to reach the LSL and corresponding lead concentrations
1 L encompasses all of the plumbing components in the blue box (LSL is not reached)
Exposure Assessment Sampling

What is the general public’s exposure to lead in drinking water?

- RDT & 30 Minute Stagnation (MS)
  - Representative of the approximate inter-use stagnation time
  - Requires appropriate number of samples based on population size and variability within water system

- Composite Sampling Devices
  - Exposure reference method
  - Collects proportion of all lead consumed per week

These are the applicable sampling methods to use when a customer asks “Is my water safe to drink?”

*Reminder: LCR sampling does not assess exposure*
Automatic vs Manual Composite Sampling

- Collects lead under normal use conditions, capturing a range of flow rates, stagnation times, flow durations, and temperatures
  - Device is affixed to the tap & consumer operated
  - 5% of every draw meant for consumption is routed into holding tank
  - Does not collect all lead
  - Seen as inconvenient and cumbersome by residents
  - Of all water drawn for consumption the consumer pours a small volume into a collecting vessel
  - Creates a composite sample over a day's use, few days, week…

After a period of time the composite sample analyzed for lead → average lead concentration
Comparison

USEPA’s Home Plumbing Simulator (HPS) compares composite proportional sampling to LCR 1st Draw and RDT

- Shorter than typical LSL (7 ft. vs. ~60 ft.)
- LSL is 1.3 L away from faucet—not captured by LCR sampling
Sources of LEAD in Drinking Water

Where is the lead coming from?

Copper Pipe with Lead Solder: Solder made or installed before 1986 contained high lead levels.

Faucets: Fixtures inside your home may contain lead.

Lead Service Line: The service line is the pipe that runs from the water main to the home’s internal plumbing. Lead service lines can be a major source of lead contamination in water.

Galvanized Pipe: Lead particles can attach to the surface of galvanized pipes. Over time, the particles can enter your drinking water, causing elevated lead levels.

Lead Goose Necks: Goose necks and pigtails are shorter pipes that connect the lead service line to the main.
Sampling for Lead Sources

Where is the lead coming from?

- **Sequential Sampling**
  - Correspond high Pb and/or Zn, Cu, Sn, Fe samples to plumbing volumes

- **LSL Sampling**
  Option 1: Fully flushed (+short stagnation, 15-30 minutes) samples above ~3 µg/L can indicate a LSL is present (threshold depends on LSL length)
  Option 2: Allow water to sit motionless in the LSL for at least 6 hours, flush premise plumbing volume to sample LSL stagnation contribution (1 L sample)

- **3T’s**
  - 250 mL sample above 20 ppb after overnight stagnation indicates faucet or bubbler likely contributes lead (brass)

*250 mL is ~4 ft of plumbing at ½ inch ID (inside diameter)*
Sequential Sampling

- Series of samples taken after stagnation
- Correlate sample volumes to plumbing sections
- Useful for identifying lead sources and remedial actions—flushing & plumbing replacements
- Captures lead peaks from LSL or other plumbing that a 1 L sample may miss

Visual inspection of the plumbing network

- Estimate volumes of water within piping sections

Samples collected from cold-water kitchen tap

Courtesy: Kelsey Pieper, UNC
Sampling for Lead Type

What forms of lead are present in the drinking water?

- **Particulate**
  - Easy to miss with standard sampling protocols
  - High flow rate, hydraulic disturbances, & certain materials (brass especially) spur release
  - Harder to quantify with acidification

- **Soluble**
  - ~0.1-0.2 µm

- **Sampling Protocol** to disturb scale/generate particulate and protocol to filter samples for dissolved lead content
Choosing the correct protocol for the question being asked is extremely important.

Protocol Considerations:
- Sample volume
- Number of samples per site
- Number of sites
- Stagnation time
- First draw or flush
- Site choice
- Frequency of sampling

Sampling Variabilities:
- Flow rate
- Water temperature
- Time of year
- Pre-flushing
- Aerator removal
- Particulate release
- Accurate quantification
- Stagnation time differences
Summary

- Lead in water can be highly variable.
- Different sampling protocols produce different lead concentrations and sample different sources/forms of lead.
- The efficacy of a single protocol varies from building to building due to plumbing differences and other site variabilities.
- Choosing the correct protocol for the sampling purpose is crucial to producing meaningful data.
Contact Information

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Notice
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Schock, M. R.; Lytle, D. A. Internal Corrosion and Deposition Control; In Water Quality and Treatment: A Handbook of Community Water Supplies; Sixth ed. 2011.

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sampling Purpose</th>
<th>Protocol</th>
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<tbody>
<tr>
<td>First Draw</td>
<td>-Regulatory (US)</td>
<td>-6+ hr stagnation</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td>-Collect first liter</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td></td>
</tr>
<tr>
<td>Random Daytime Sampling (RDT)</td>
<td>-Regulatory (UK)</td>
<td>-Random sample collection (variable stagnation times)</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td>-Collect first liter</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td></td>
</tr>
<tr>
<td>Fixed Stagnation Time (30MS)</td>
<td>-Regulatory (Ontario)</td>
<td>-2-5 min. flush</td>
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<tr>
<td></td>
<td>-Treatment Assessment</td>
<td>-30 min stagnation</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td>-Collect first two liters</td>
</tr>
<tr>
<td>Fully Flushed</td>
<td>-Lead Source Assessment</td>
<td>-Several piping volumes flushed</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td>-Collect first liter</td>
</tr>
<tr>
<td>Sequential Sampling (Profile Sampling)</td>
<td>Lead Source Assessment</td>
<td>-Defined stagnation time</td>
</tr>
<tr>
<td></td>
<td>-Treatment Assessment</td>
<td>-Collect 10-20 samples of defined volume (125 mL, 250 mL, 1 L, etc.)</td>
</tr>
<tr>
<td>Composite Proportional</td>
<td>Exposure Assessment</td>
<td>-Normal water use patterns</td>
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<tr>
<td></td>
<td></td>
<td>-A device collects 5% of every draw from the tap for consumption</td>
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<tr>
<td></td>
<td></td>
<td>-Used for 1 week</td>
</tr>
<tr>
<td>Particle Stimulation Sampling</td>
<td>-Lead Type Assessment</td>
<td>-5 min stagnation</td>
</tr>
<tr>
<td></td>
<td>-Exposure Assessment</td>
<td>-Collect first liter and maximum flow rate, open and close tap five times, fill rest of bottle at normal flow rate.</td>
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<tr>
<td></td>
<td></td>
<td>-Collect second liter at a normal flow rate</td>
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<tr>
<td></td>
<td></td>
<td>-Collect third liter the same way as the first</td>
</tr>
<tr>
<td>Service Line Sampling (Second Draw)</td>
<td>Lead Source Assessment</td>
<td>-6+ hr stagnation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Volume between tap and LSL flushed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Collect 1 L</td>
</tr>
<tr>
<td>3T’s Sampling for Schools</td>
<td>-Lead Source Assessment</td>
<td>-Overnight stagnation</td>
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<td>-Collect first 250 mL from all taps and fountains</td>
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<tr>
<td></td>
<td></td>
<td>-Take follow up sample of overnight stagnation and 30 second flush if first sample&gt; 20 ppb</td>
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Sample Volumes Represent Where in the Plumbing You are Sampling From

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