Lead in Drinking Water

Learn how to determine if your drinking water contains too much lead, and discover ways to reduce lead in your water.

Where Does Lead Come From?

The chemical symbol for lead of “Pb” comes from the Latin plumbum, the root for “plumbing”. Lead is an element so it does not break down into less harmful substances. Lead has been used as an ingredient of gasoline, paint, glassware, metal pipes, and food containers, all of which have contained varying amounts of lead. Therefore, even though lead has been banned from gasoline and most paint and is no longer used in food containers, some lead can be found in the food, paint, soil, dust, housewares, and drinking water of many American homes.

Lead paint and dust are the primary source of lead exposure, especially in older homes. Leaded gasoline, largely replaced by unleaded mixtures since the 1970s, has caused lead contamination of soil near roadways and in urban areas.

Drinking water is usually a smaller source of exposure to lead, but this varies greatly among homes, schools, and other buildings, and can add to other lead sources. Infants drinking formula can get half of their lead exposure from drinking water.

How Does Lead Get Into Water?

In rare instances lead gets into water as a result of pesticides that were used decades ago or industrial activity that contaminated soil and groundwater. But lead is much more likely to enter water from household plumbing. For this reason, lead is a potential concern for all homes whether on a public (municipal) or private (individual well or spring) water supply. Depending on its other chemical characteristics, the water itself dissolves lead from leaded solder or lead pipes in plumbing systems in a process called "corrosion".

Lead can also corrode from metal faucets and fixtures made from brass, an alloy of copper and zinc that often contains lead impurities, including chrome-plated brass fixtures. Brass fixtures can leach lead even in homes with plastic water lines. Solder is an alloy of tin with lead, antimony, or silver. Lead may also originate from the corrosion of brass fittings on certain types of submersible pumps used in groundwater wells through the mid 1990’s. Laws have restricted the amount of...
lead allowed in new pipes, fixtures, and solder but many homes contain older materials. Corrosive water also degrades copper plumbing, which may produce small leaks, blue-green stains, or metallic tastes, but these are not reliable indicators of the risk of lead in water.

The amount of lead corroded from metal plumbing generally increases as water corrosivity increases. Water corrosivity is controlled primarily by the water’s acidity and calcium carbonate content. In general, acidic water that has a pH less than 7 and that is low in calcium carbonate is more corrosive than water that has a pH higher than 7 and that is high in calcium carbonate.

In addition to acidity and calcium carbonate, many other factors can influence water’s corrosivity. Soft water (low in dissolved solids like calcium and magnesium) tends to be more corrosive than hard water (with high concentrations of calcium and magnesium), and warm water is more corrosive than cold water. The common practice of grounding electrical connections to water pipes also can increase lead corrosion. Despite these general rules, any kind of water—including hard, soft, acidic, or non-acidic—can contain dangerous amounts of lead.

Corrosive water is a common natural problem in Pennsylvania. For example, of the over 2,000 water samples (mostly from private water wells) that were tested by the Penn State Agricultural Analytical Services Laboratory, about 65% were found to be potentially corrosive. Groundwater and surface waters in Pennsylvania often originate from sandstone and shale rock types that naturally produce relatively acidic and soft water. Common exceptions are water supplies in limestone valleys. Here interaction with limestone produces less acidic water that is higher in calcium carbonate hardness and is relatively noncorrosive. Water from cisterns and some springs resembles rainwater, which is naturally corrosive. For more information on corrosive water, see the Penn State Extension fact sheet.

Corrosive water acts to dissolve lead from pipes and solder while the water is in contact with the plumbing. Therefore, lead concentrations in drinking water usually are the highest in the first water out of the tap; they decrease as the water is run. If lead pipes, leaded solder, or brass fixtures are present, even relatively noncorrosive water can dissolve dangerous amounts of lead if the water sits in contact with these materials for an hour or more.

Conversely, if your town’s water distribution system and your home plumbing system do not contain lead pipes, lead solder, or brass fixtures, your drinking water probably does not contain significant amounts of lead.

How Much Lead in Water is Too Much?

Guidance from the Centers for Disease Control suggests that blood lead concentrations over 5 micrograms per deciliter of blood (µg/dL) may indicate lead poisoning. Various studies have found that blood lead concentrations are positively and significantly related to the amount of lead in drinking water.

Accounting for other sources of lead exposure (e.g., food, dust), the U.S. EPA set the maximum allowable concentration of lead in public drinking water at 15 µg/L. (Many experts on lead toxicology believe the safe level should be 10 µg/L or less, but for purposes of this discussion we will use the EPA’s level of 15 µg/L.) Since lead serves no beneficial purpose in the human body, it is best if drinking water contains no lead. State drinking water standards must be at least as strict as the EPA drinking water standard of 15 µg/L.

How Common is Lead in Drinking Water?

In Pennsylvania, the prevalence of leaded plumbing components and corrosive sources of water suggests that lead contamination is a common problem.

A survey of private water supplies (individual homes using groundwater wells) across Pennsylvania in 2006 and 2007 found that 12 percent contained unsafe lead levels of above 15 µg/L. The survey also found that high lead levels could nearly always be explained by corrosion of lead from metal plumbing components.

Samples submitted to the Penn State Agricultural Analytical Services Laboratory are not a random sample of water supplies, but do indicate that lead in drinking water is a problem in the state. Of the 872 first-draw lead tests from 2007 through 2015, 16% exceeded the 15 µg/L drinking water standard. Of the 1,346 samples that were tested after the water had been run, only 3% exceeded the 15 µg/L level suggesting that most high lead levels were occurring due to corrosion of metal plumbing.

The prevalence of lead in public water supplies at the tap is difficult to know because it depends on how corrosive the source water is, whether lead distribution lines are used, and whether a particular building contains leaded plumbing materials. If your home is connected to a public water supply, you may wish to contact your water company or consult their annual customer report to determine if lead is a problem in your community. You also may want to have your tap water tested, especially if you live in an older home (metal plumbing installed prior to early 1990’s), have young children, or have signs of corrosive water discussed above.
How Should You Test Your Water for Lead?

Because lead is colorless, odorless, and tasteless in water, the only sure way to determine if your water contains lead is to have the water tested. Some labs calculate a corrosivity index from other test results including the pH of the water, but a specific lead test is needed to determine the actual concentration of lead in drinking water.

A list of state accredited water testing labs is available on the PA Department of Environmental Protection website. On that website, page down to “Search Environmental Laboratories” and click on the link for the Quick Reference List. You can sort the list by county and choose a Commercial or Academic water testing laboratory. Not all labs are equipped and certified to test for lead. Make sure to ask and pick up bottles and instructions for testing lead in drinking water. Costs for testing lead in water normally range from $15 to $100. It is best to have your water tested for “total lead” which includes particles rather than just “dissolved lead” which will ignore particulate lead in the water.

You should collect two water samples, including a “first-draw” or “first-flush” sample and a “running” sample. Collect the first-draw sample first thing in the morning from cold water that has sat in the plumbing system overnight. This sample determines if lead accumulates in your water as it sits in contact with the plumbing system.

Collect the running sample after allowing the cold water to run for one minute. Comparing the results helps you determine the source of a lead problem. A lead concentration that remains above 15 µg/L after the water has run for one to two minutes indicates that lead is probably present in the water before it enters the household plumbing. The lead may originate from water supply contamination, from corroding submersible pump parts, or from corroding lines in a public water system.

Laboratories sometimes use different units in their report. The most common units are µg/L (micrograms per liter, equal to parts per billion, or ppb) and mg/L (milligrams per liter, equal to parts per million, or ppm).

If your test result is reported in µg/L or ppb, then you should compare it with the safe drinking water standard of 15 µg/L. If your result is reported in mg/L or ppm, then the comparable drinking water standard is 0.015 mg/L.

What Regulations Control Lead in Drinking Water?

Public water suppliers are required under the federal Safe Drinking Water Act and its amendments (and related EPA and PA DEP regulations) to test their water for many contaminants including lead, and in some cases, to provide corrosion control to prevent lead from entering drinking water. These results are sent to customers in an annual report.

The federal Lead and Copper Rule (1991, revised in 2000 and 2007) requires that public water suppliers monitor tap water lead concentrations in high-risk homes they serve (e.g. older homes). If more than 10 percent of these homes exceed 15 µg/L of lead, the water supplier must provide public education on the lead problem, and the water must be treated at a treatment plant to make it less corrosive. In addition, the lead service lines owned by many water companies may have been replaced or may need to be replaced.

While these regulations help reduce drinking water lead concentrations in homes using public water supplies, they will not entirely eliminate the problem. The variability of household plumbing systems within communities may mean individual homes still contain dangerous drinking water lead concentrations, even while most of the community does not have a problem. Also, the regulations provide little protection for homeowners with private water systems such as drilled wells, springs, and cisterns.

In 1986, Section 1417 of the federal Safe Drinking Water Act was amended to limit the content of lead in pipes and other materials used in water supplies, defining “lead-free” as less than 8% lead in pipes or fixtures and less than 0.2% in solder. The 1989 Pennsylvania Plumbing System Lead Ban and Notification Act (effective in 1991) and the 1996 SDWA amendments extended lead regulations further including private water supplies by requiring “lead-free” pipe, fittings, and fixtures in new construction and replacement parts.

Since 1991, new homes to be served by public water suppliers must be certified lead-free before connecting to the system. Some mortgage programs may also check for lead-free plumbing. If your home plumbing system is made of copper pipe and was installed before January 1991, it is likely that lead solder was used.

The 2011 federal Reduction of Lead in Drinking Water Act redefined “lead-free” to up to 0.25% lead on surfaces in contact with drinking water for consumption, with solder still less than 0.2% lead. The PA Lead Ban Act was amended in 2014 to the same lead levels.

Some independent organizations test and certify products for lead content. For a current list of organizations and pictures of their certification marks see the National Sanitation Foundation publication on How to Identify Lead Free Certification Marks for Drinking Water System & Plumbing Products. The European Union term “RoHS-certified” appears on some product labels which have less than 0.1% lead.

Although regulations are in place to control lead in drinking water, only water testing of each home can determine the actual presence of lead. If you are concerned about lead in your drinking water, you should arrange for a water test from an accredited laboratory regardless of whether you use a public or a private water supply. Also, because of the large variability in lead levels among homes, you should have your water tested for lead no matter what the levels in neighboring houses.
What Can You do to Reduce Lead in Your Drinking Water?

If your first-draw water test result is greater than 15 µg/L, you should take corrective action. Lead can be removed from water through numerous treatment methods depending on the cost and effort you are willing to expend.

If your running water lead concentration is below 15 µg/L, the simplest and least expensive method is to flush your plumbing system by running the water for one to two minutes before drinking it. Flushing is usually only necessary if the water has been in contact with the plumbing for at least one hour. Letting the water run for 1-2 minutes is the easiest and cheapest way to reduce lead levels in drinking water in many homes.

Flushing your plumbing system is recommended only if the lead concentration in your running water sample was less than 15 µg/L. It may not be effective in apartment buildings with complex plumbing systems or in homes on public water sources where lead service lines are the source of the lead. In these cases, tap water concentrations of lead may exceed 15 µg/L even after several minutes of running the water.

If flushing proves effective, you can conserve water by flushing the plumbing system once in the morning and storing water in bottles for use during the rest of the day. Only flushed water from the cold water tap should be used for drinking and cooking, since hot water can dissolve lead more quickly than cold.

If excessive lead concentrations persist after flushing, or if flushing is an undesirable method, there are alternatives for reducing lead exposure. Homeowners who have a groundwater well with a submersible pump may want to have the pump checked. If some of the pump’s metal parts are corroding, they could be contaminating the groundwater with lead.

Acid-neutralizing filters can be installed to reduce water corrosivity by adding calcium and by increasing the pH of the water. Unlike other treatment options, these filters act to prevent lead from entering the water rather than removing it at the tap. In addition to reducing acidity, the added hardness produces a thin scale inside the pipes that reduces lead corrosion. These units normally cost over $1000 and may cause a noticeable increase in the hardness of your water.

Contrary to some claims, water softener are not recommended for lead removal. Softeners are inefficient lead removal devices, and they usually are installed in the plumbing system ahead of the piping and fixtures where most of the lead originates. Also, softened water is usually more corrosive than un-softened water.

Reverse osmosis units and activated alumina filters are very effective in removing lead once it is in the water. These units typically are attached to the kitchen tap and treat only the water from that tap. Costs vary from $300 to more than $1,000. Reverse osmosis units of this size can produce only a few gallons of treated water per day.

Distillation units, also normally placed on the kitchen counter, are effective in removing lead from drinking water. However, they are relatively expensive to operate and produce only a gallon or so of water per day, depending on their size.

Other treatment devices such as granular activated carbon (GAC) filters can remove lead, but their efficiency is questionable. GAC filters, for instance, are only efficient at removing lead when the water pH is near 7. Small, inexpensive counter-top filter units are being marketed for lead removal, but prospective buyers should beware of salespersons who will not substantiate their claims or who use devices that involve questionable treatment methods.

Furthermore, excessively small units are limited in the amount of time that the filter is effective in removing lead. A National Sanitation Foundation (NSF) seal on treatment equipment is one method of ensuring that the unit has been tested for adequate removal efficiency. A NSF seal does not guarantee, however, that the filter will be effective after many months of continuous use, and filter replacement is always required periodically.

The most effective and most expensive lead removal method is to replace the leaded components in the plumbing system with newer, non-leaded components. This procedure most often involves replacing copper pipes and lead solder with plastic PVC or PEX pipes. Only plastic PVC or PEX pipes approved for home plumbing use, as indicated by “NSF-61” or ”NSF-PW appearing on the side of the pipe, should be used for replacement.

Replacing home plumbing components will be effective only if the source of the lead is within the home plumbing system. If the lead originates from lead service lines within a public water system, this method may be of limited benefit.
A National Sanitation Foundation (NSF) seal on treatment equipment shows that the unit has been tested for adequate removal efficiency.

For More Information

Lead in drinking water presents a complex problem for consumers of public and private water supplies. If you have questions concerning testing and removal of lead from your drinking water, contact your local office of the Pennsylvania Department of Environmental Protection, your county office of Penn State Extension, or the county or state health department.

To learn more about lead in drinking water, consult the following references.

- U.S. Environmental Protection Agency - basic information on lead in drinking water.
- Centers for Disease Control, About Lead in Drinking Water.
- Drinking Water Test Summaries, Penn State Agricultural Analytical Services Laboratory, 2016.


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