Virginia Cooperative Extension

PUBLICATION 442-657

Virginia Household Water Quality Program: Heavy Metals in Household Water

Erin James Ling, Water Quality Extension Associate, Biological Systems Engineering, Virginia Tech
Brian Benham, Associate Professor and Extension Specialist, Biological Systems Engineering, Virginia Tech
Scott Forrester, Graduate Student, Biological Systems Engineering, Virginia Tech

Private water sources, such as wells and springs, are not regulated by the U.S. Environmental Protection Agency (EPA). Although private well construction regulations exist in Virginia, private water supply owners are responsible for the maintenance of their water systems, for monitoring the quality of their drinking water, and for taking appropriate steps to address problems should they arise.

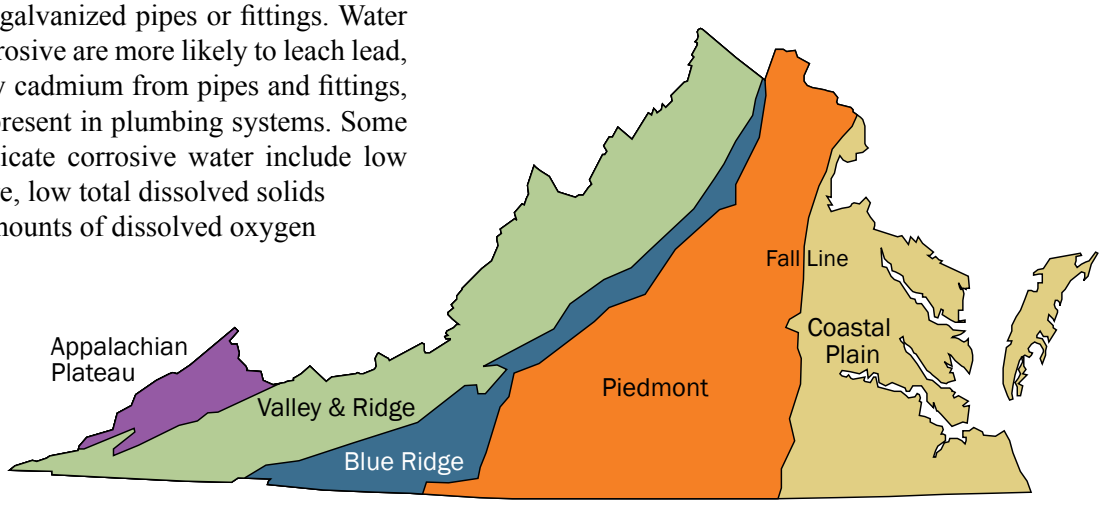
The EPA public drinking water standards are good guidelines for assessing your water quality. *Primary drinking water standards* apply to contaminants that can adversely affect health and are legally enforceable for public water systems. *Secondary drinking water standards* are non-regulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining.

Testing your water annually and routinely inspecting and maintaining your water supply system will help keep your water safe. For more information, visit the Virginia Household Water Quality Program website www.wellwater.bse.vt.edu.

Introduction

Heavy metals such as lead, copper, cadmium, arsenic, and mercury may be present in water supplies for a variety of reasons. Lead and copper most commonly leach into water supplies through corrosion of household plumbing fixtures, pipes, fittings, and solder, and cadmium contamination may occur as a result of impurities in the zinc of galvanized pipes or fittings. Water supplies that are corrosive are more likely to leach lead, copper, and possibly cadmium from pipes and fittings, if these metals are present in plumbing systems. Some factors that can indicate corrosive water include low pH, high temperature, low total dissolved solids content, and high amounts of dissolved oxygen or carbon dioxide.

Although found throughout Virginia, corrosive water is more commonly found in the Blue Ridge and parts of the Piedmont physiographic provinces, as seen in Figure 1. In some parts of far southwest Virginia, acid mine drainage may also reduce pH, increasing the corrosiveness of groundwater.



Based on material from: web.wm.edu/geology/virginia/?svr=www

Figure 1. Physiographic provinces of Virginia

www.ext.vt.edu

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2011

Other heavy metals may enter the water supply as groundwater dissolves rocks or soil or from runoff due to environmental contamination. In addition to potentially being present in zinc impurities in plumbing, cadmium may enter groundwater in fertilizer runoff, or runoff from waste batteries and paint. Arsenic may be naturally occurring in some rocks and soils, or can be found in water runoff from orchards as an ingredient in certain fungicides and pesticides. Mercury can be found in some natural deposits, and may be contained in runoff from batteries, light bulbs, or electrical equipment.

Problems Associated With Heavy Metals in Drinking Water

Consumption of heavy metals in drinking water is linked to many serious health concerns (Table 1). Lead is a cumulative poison, meaning it will accumulate in

Table 1. Summary of basic information on common heavy metals found in drinking water.

Pollutant	Water Quality Standard (for public water supplies)	Source	Health Effects
Lead	Zero (MCL) 0.015 ppm (Action Level)	Corrosion of household plumbing systems	Damage to the brain, kidneys, nervous system, and red blood cells. Stunting of mental and physical development in children
Arsenic	Zero (MCLG) 0.010 ppm (MCL)	Erosion of natural deposits, runoff from orchards	Cardiovascular, pulmonary, immunological, and neurological effects (acute). Skin, bladder, lung, kidney, liver, and prostate cancer (chronic)
Cadmium	0.005 ppm (MCL and MCLG)	Corrosion of galvanized pipes, runoff from waste batteries and paint	Nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure (acute). Kidney damage, osteoporosis (chronic)
Copper	1.3 ppm (MCL and MCLG); 1.0 ppm (SMCL)	Corrosion of household plumbing systems	Gastrointestinal distress, liver or kidney damage
Mercury	0.002 ppm (MCL and MCLG)	Erosion of natural deposits, discharge from refineries and factories, runoff from landfills, and runoff from croplands	Kidney damage

Source: http://water.epa.gov/drink/contaminants/index.cfm

Definitions:

Action Level: A level at which, if detected in public drinking water systems, triggers treatment or another requirement that a water system must follow. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps to educate the public and reduce the level.

MCL (Maximum Contaminant Level): The highest level of a contaminant that is allowed in drinking water, also known as primary drinking water standards. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

MCLG (Maximum Contaminant Level Goal): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

SMCL (Secondary Maximum Contaminant Level): Non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. Also known as secondary drinking water standards. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

The Virginia Household Water Quality Program, offered through Virginia Cooperative Extension (VCE), periodically conducts county-based household water sampling clinics where you can learn about the quality of your water supply, proper water supply system maintenance, and, if needed, possible water treatment options. Please contact your local Extension office or visit www.wellwater.bse.vt.edu for more information.

the body until it reaches toxic levels. High levels of lead can cause irreversible damage to the brain, kidneys, nervous system, and red blood cells. Because young children absorb lead more easily, they are more susceptible to lead poisoning. A child's mental and physical development can be irreversibly stunted by lead poisoning, which may lead to lower IQ levels, shortened attention spans, and behavioral problems.

Exposure to arsenic may have both short and long term effects. Short-term exposure in high doses can lead to cardiovascular, pulmonary, immunological, and neurological effects. Long-term exposure has been linked to skin, bladder, lung, kidney, liver, and prostate cancer. Acute, or short-term, doses of high levels of cadmium can cause nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure. Chronic, or long-term, exposure has been linked mainly to kidney disease and osteoporosis (loss of bone density). Copper can cause many of these same acute effects, as well as liver and kidney damage. Long-term exposure to mercury is linked to kidney damage. Table 1 shows a summary of heavy metals of concern in drinking water, potential sources of these metals, health effects, and water quality standards for each, based on the U.S. Environmental Protection Agency's standards for public drinking water supplies. As mentioned previously, these standards can be used as guidelines for private water supplies.

One should note that setting drinking water standards involves uncertainty. Data relating impacts on human health to chemicals in drinking water are limited, and predicting the human health effects of drinking small amounts of chemicals over a lifetime is difficult. In addition, regulatory decisions frequently incorporate economic, political, and social considerations. Therefore, it is important to understand that standards for drinking water contaminants do not guarantee that water with a contaminant level below the standard is risk free. Nor do the regulations mean that water with a contaminant level above the standard is automatically unsafe in all instances. Drinking water standards reflect the scientific judgment and expertise based on the available knowledge at the time the standard was established.

Other Problems and Indications of Metals in Well Water

Although most heavy metals do not noticeably affect the taste, smell, or color of water, there are nuisance or aesthetic problems associated with some of the metals listed above. These may include staining of fixtures or laundry, or other visible differences in the smell or taste of the water. The presence of lead may be associated with dull gray stains on tile, tubs, sinks, or laundry, and perhaps an "off" or metallic taste. Copper levels higher than 1 milligram per liter (mg/L) can cause blue-green staining on surfaces such as tile, sinks, and tubs. Since both lead and copper are often leached from plumbing systems due to corrosive water, symptoms of corrosion may also be present. These may include pitting, pinhole leaks, or other damage to pipes, fixtures, or metal components of water-using appliances. On the other hand, it is important to note that dangerous levels of metals in water may be undetectable by human senses, so testing with a certified laboratory is always recommended to determine if metals are present.

Certain characteristics of your household plumbing system may indicate that certain metals may be present.

Lead

- Homes built prior to 1930 may have lead pipes or fittings
- Homes built prior to 1986 may have lead solder
- New homes may have "lead-free" brass components, which, in all states except California, may still contain up to 8% lead.

Copper

- Presence of copper pipes

Testing for Heavy Metals

Because corrosive water often results in a greater chance of lead, copper, or cadmium leaching from plumbing materials, testing the water's pH and/or corrosivity is encouraged in addition to testing for individual metals. The EPA recommends that the pH of drinking water in public water systems be between 6.5 and 8.5, which is a good guideline for private water systems. A pH value lower than 6.5 is considered acidic and more likely to be corrosive. Other characteristics of your water, like the amount of dissolved oxygen, carbon dioxide, and hydrogen sulfide can affect corrosivity, the water's potential to corrode.

Who Should Sample?

Public water authorities test and treat public water supplies to detect and address heavy metal contamination. However, if you depend on a private water system, it is your responsibility to monitor your water supply. Private water systems should be tested for heavy metals if a problem is suspected and particularly if children, pregnant women, or anyone with a compromised immune system consumes the water. Procedures and materials for private water system testing can be obtained from certified water testing laboratories. It is important to carefully follow the sample collection and storage instructions provided by the laboratory. A list of certified water testing laboratories may be accessed at: www.wellwater.bse.vt.edu/resources.php.

When Should I Sample?

Generally, corrosive or acidic water that comes into contact with lead, copper, or cadmium in plumbing systems will leach metals that are present. Because of this, water will have the highest concentration of metals after sitting in pipes for an extended period (more than six or eight hours). Collecting what is called a "first draw" sample first thing in the morning, after the water has been sitting in the pipes for at least six hours, will reflect the effect that your plumbing system has on metals in the water. Often, a second sample is collected after the pipes have been "flushed" or the water is left running for at least 5 minutes. Collecting a flushed sample will allow the lab to test for the metals content that is more representative of the well water itself.

How Do I Interpret Sample Results?

In laboratory results, metal concentrations are usually reported in parts per billion (ppb), a measurement that is approximately equivalent to micrograms per liter (symbolized by µg/L). If concentrations are found that exceed the maximum contaminant levels for any metal (listed in Table 1) it is recommended that the private water supply user take action immediately to determine the source of the contamination and correct it. Consider using an alternative source of water in the meantime. If you are unsure of how to interpret the report, contact the laboratory, your local Virginia Cooperative Extension office (www.ext.vt.edu) or the Virginia Household Water Quality Program (www.wellwater.bse.vt.edu/resources.php).

Prevention of Heavy Metal Contamination and Treatment Options

If metals in your household water are a concern, it is important to determine the source. The potential for lead, cadmium, or copper contamination of water supplies can be greatly reduced by addressing low pH and/or corrosiveness of the water supply. Another very basic way to prevent heavy metal contamination is simply by removing plumbing materials that contain lead, copper, or galvanized steel. PVC piping provides a metal-free alternative for plumbing systems.

If lead or copper are present in the plumbing system, and pH is lower than 6.5, consider taking steps to increase pH. This may be accomplished by installing an acid neutralizing filter, which will add calcium carbonate or magnesium oxide to your water. After pH has been adjusted with an acid neutralizing filter, retest for pH and metals of concern to determine whether the treatment device is effectively preventing metals from dissolving into household water. In addition, corrosion of pipes can be greater if grounding wires are connected to them. A professional electrician should be called to establish whether this is a problem and to recommend steps to correct it**.**

Another option for addressing metals leached into water from plumbing materials is to flush pipes prior to drinking or cooking with water. The time needed for flushing depends on your plumbing system. A good rule of thumb is to let the water run until it becomes as cold as it will get (at least 5 minutes). You can conserve water by flushing the plumbing in the morning while showering or bathing or while doing laundry. Be sure to also flush the kitchen faucet, the one most typically used when preparing meals or beverages, and always use cold water for drinking and cooking. After flushing the system, fill a container with water, which can then be used for drinking and cooking throughout the day.

If metals continue to be a problem, or if metals in household water are originating from the groundwater itself, which may be the case with arsenic or mercury, there are several viable treatment options to remove or reduce heavy metal concentrations. Distillation, reverse osmosis, and activated carbon filters are best suited for treatment of small quantities of water.

Distillation involves boiling water and collecting the resulting steam and cooling it in a separate chamber.

One of the benefits of distillation is that is uses no chemicals. Distillation, however, takes longer to produce the processed water than other methods, units can be expensive to operate, and the length of time distilled water is stored may affect its quality. In addition, distilled water has a very "flat" taste because minerals naturally present in water, which help to impart taste, are removed during treatment.

Reverse osmosis (RO) involves forcing water molecules through a semi-permeable membrane. Water passes through the membrane but most contaminants are too large to pass through. Ten to twenty percent of the water entering the RO system exits as treated water, and the other 80 to 90 percent is wastewater, and is diverted to a drain. These systems work best with higher water pressure and often require pretreatment and post-treatment systems to work properly. They have an average lifetime of 3-5 years at which point the membrane must be replaced. These devices can be expensive to purchase and maintain.

Activated carbon filters work by adsorbing metals to a bed of activated carbon. These devices are best used to treat only water used for drinking and cooking. Use as directed and read information carefully to determine that the particular device selected will remove the metals that are present in your water supply. Also be sure to change filters regularly, according to manufacturer recommendation, or the filter will actually become a source of additional metals once the activated carbon is used up.

Because heavy metals present such serious health concerns, consider testing water after a treatment device has been installed to ensure it is working properly and metal concentrations are at safe levels. Another option is to purchase bottled water, or use water from another source known to be safe for drinking and cooking. A comprehensive water analysis for contaminants and/or the advice of a certified water treatment professional will help in selecting the specific treatment method appropriate for each application. Consumers should verify manufacturer claims before purchasing any water treatment device by contacting the National Sanitation Foundation (www.nsf.org) or the Water Quality Association (www.wqa.org).

If you are concerned about the health effects of heavy metal levels in your family's drinking water, consult your physician.

Additional Information

For more information on heavy metals in household water, see the Virginia Cooperative Extension publications listed here:

Virginia Household Water Quality Program website: http://www.wellwater.bse.vt.edu/resources.php

Virginia Cooperative Extension website: http://pubs.ext.vt.edu/category/home-water-quality.html

Acknowledgements

This publication is partly an adaptation of Virginia Cooperative Extension publication 356-483 (1999), "Household Water Quality: Lead in Household Water," by Blake Ross, Extension specialist, agricultural engineering; Kathleen Parrott, Extension specialist, housing; Amber Wilson, Extension associate, management, housing and consumer education; and Janice Woodard, retired Extension specialist, Virginia Tech. The authors wish to thank the following individuals who reviewed this publication: Bruce Dvorak, professor, biological systems engineering, University of Nebraska; David Nelms, district groundwater specialist, US. Geological Survey, Richmond, VA.; Scott Baker, agriculture and natural resources Extension agent, VCE Bedford County Office; Debbie Dillion, agriculture and natural resources Extension agent, VCE Loudon County Office.

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