Healthy Drinking Waters

for

MASSACHUSETTS

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Arsenic in Private Drinking Water Wells

Private well owners are responsible for the quality of their drinking water. The U.S. Environmental Protection Agency (EPA) does not regulate private wells. Homeowners with private wells are generally not required to test their drinking water, although local Boards of Health or mortgage lenders may require well water testing. While there is also no state requirement to have your well water tested, the Massachusetts Department of Environmental Protection (MassDEP) recommends that all homeowners with private wells do so, and use a state certified testing laboratory. Homeowners can use the public drinking water standards as guidelines to ensure drinking water quality.

The standard that limits arsenic in public water supplies, called a maximum contaminant level (MCL), has been made more stringent in the last few years. The more stringent standard is 0.010 milligram per liter (mg/L). This standard may also be expressed as 10 parts per billion (ppb).

Summary

Arsenic occurs naturally in the soil and bedrock throughout many parts of the United States, including Massachusetts. Most arsenic in Massachusetts wells is believed to be naturally occurring. Arsenic in water has no smell, taste or coloration when dissolved in water, even at high concentrations. Where drinking water is rusty colored and has arsenic, the rusty particles may concentrate the arsenic. Therefore do not consume rusty colored water without having tested for arsenic.

- Arsenic also occurs in the environment as a result of industrial land use activities and arsenic's use as both a wood preservative and a pesticide.
- Arsenic is a health concern in drinking water and a known human carcinogen.
- A water test is the only way to determine the presence and amount of arsenic in well water.

If arsenic is present in well water, several types of home treatment systems are available for removing or reducing the amount of arsenic in water, including: absorptive media, reverse osmosis, anion exchange, and distillation.

Potential Health Effects

Arsenic is a toxic heavy metal and is also classified by EPA as a human carcinogen (cancer causing agent). Signs of arsenic poisoning

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include thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in the hands and feet, partial paralysis, and blindness. Most exposure to arsenic occurs through eating or drinking arsenic-contaminated food or water.

Chronic arsenic ingestion from elevated levels in drinking water may cause skin cancer and an increase risk for cancers of the bladder, lung, kidney, liver, colon, and prostate. It may also be associated with cardiovascular, pulmonary and other diseases and disorders. Various high-risk groups such as people suffering from malnutrition, protein deficiency, and hepatitis B infection may be more sensitive to the effects of arsenic. Other factors such as genetics, age, metabolism, diet, and health status may also affect health risks due to arsenic exposure.

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Sources of Arsenic in Drinking Water

Arsenic is common in areas where there are metallic ore mining operations. Arsenic has also been used as a pesticide, a wood preservative, and in paints, dyes, metals, drugs, soaps, and semi-conductors.

Arsenic has been widely used throughout the United States and the Northeast as a pesticide on fruit orchards and on some other crops. Though use of arsenic as a pesticide has been widely discontinued, it is possible that a buildup of arsenic in the soil has occurred over the years. There are other historical or existing industrial sites that could result in release of arsenic to the environment including: manufacturing of metals and alloys, pharmaceuticals, pesticides, chemicals, and petroleum refining, waste incineration and the use of coal ash as fill material.

Testing for Arsenic in Private Drinking Water Wells

To determine if arsenic is present, arrange to test your drinking water at a state certified laboratory. Carefully follow laboratory instructions to avoid contamination and to obtain a representative sample. If testing indicates that arsenic is present and treatment is required, other water quality characteristics can effect arsenic treatment and should be tested for, including pH, hardness, iron, manganese, nitrate, nitrite, and sulfate. If any of these are present, pre-treatment may be required.

If you have a bedrock well, you should test for arsenic. Also, if you suspect your property may have been located in or adjacent to an existing or former fruit orchard, it is recommended that private well water be tested for arsenic. This may also apply for those living near existing or former industrial manufacturing operations that have used or currently use arsenic in their processes. Water treatment for arsenic removal is generally feasible, depending on the levels found. Soil testing for arsenic levels is also recommended in these areas.

Reducing Arsenic in Your Water Supply

There are at least three approaches to reducing exposure to arsenic from drinking water: connect to a municipal water system, construct a new well, or install water treatment. Additional considerations for each option are discussed below.

Municipal Water

In most cases, municipal water is not available or is too costly to extend to all areas where arsenic concentrations are high. From the perspective of public health and real estate values, town water is preferable to one or more water treatment devices in the basement of a home. Where municipal water is a possibility, we suggest discussing the funding of a pipeline extension with your neighbors. A joint effort will reduce individual costs and provide an area-wide solution if arsenic or other contamination is extensive.

An important action before such discussions is to test all wells in the area for arsenic. Even if arsenic is not present, your neighbors may have other water quality problems, such as radon and other forms of radioactivity, fluoride, iron and manganese, hardness, and/or odor, which may influence their willingness to financially support a water main extension.

New Wells

A new dug well or point well installed in sand and gravel is much less likely to have a meaningful concentration of arsenic. Such a well typically requires a relatively shallow and stable water table. Unfortunately, in many areas of Massachusetts, the soil type and a year-round sustained water table are not favorable for shallow wells. Before drilling a new bedrock well, determine the water quality and arsenic levels of neighboring wells and evaluate alternate well types and locations. Other water quality concerns with bedrock wells can also include radioactivity and lead. Several types of treatment systems are available, including reverse osmosis, ion exchange, distillation, and absorptive media. Before choosing a treatment system, it is important to compare the amount of arsenic present in your water supply with the levels each system can effectively treat.

Arsenic Types

Before discussing treatment, a few words are necessary about arsenic chemistry. There are typically two variations, or species, of arsenic in water: "arsenic III" and "arsenic V." The numbers III and V describe the valence of the arsenic in the molecule when the arsenic compound is dissolved in water. This dissolved form of an element or compound in water is called an "ion." The form of the arsenic, III or V, is very important relative to the effectiveness of many treatment methods. Arsenic V is generally much easier to remove from water than arsenic III.

Determining the species of arsenic is normally a component of the sample collection step. As such, it noticeably adds to the complexity and possible expense of collecting a water sample for analysis. For arsenic speciation testing, two samples are collected in the field and then processed in the laboratory. The first sample is tested for total arsenic. The second sample is passed through a fine mesh anion exchange resin that removes only arsenic V. The water passing through the anion resin contains only arsenic in the valance III form. The difference between the total arsenic sample and the sample filtered by the anion resin, is the amount of arsenic V present in the water.

Arsenic Oxidation

If the well contains a significant level of arsenic III, oxidation pretreatment is recommended. Common oxidants include liquid chlorine (bleach), hydrogen peroxide (H2O2), ozone, or

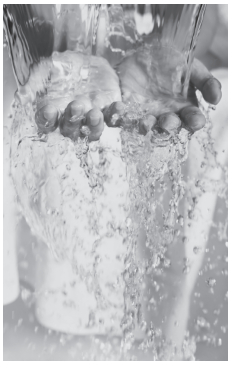
passing the well water through a cartridge of manganese dioxide media. Since the ratio of arsenic species may not be constant through out the year, many treatment equipment installers provide an oxidizer pretreatment rather than sampling for both species. Some wells may have varying amounts of arsenic III over the year.

Sizing of Treatment Devices: "Whole House" Vs. "Point-of-Use"

In-home water treatment devices come in two sizes: very small (often called under-the-sink or point-of-use), and whole house, where all water used within the home is treated to remove arsenic. Point-of-use (POU) devices produce only a few gallons of treated drinking water per day. This treated water is typically available at a new supplemental faucet placed near the kitchen sink. When using this POU option, drinking water and cooking water should be obtained from the separate treated faucet located near the kitchen sink. Household discipline is needed to ensure that most drinking water is taken from the treated water faucet, while water for dish washing can be obtained from the untreated faucet.

One concern with choosing point-of-use treatment is the level of arsenic absorption through the skin when the water is used for bathing. Point-of-use treatment is adequate if the arsenic concentration of the water used for bathing, laundry, dishwashing, and other non-consumptive uses is less than 0.500 mg/L (500 ppb). This assumes that inadvertent consumption of untreated water by infants, such as drinking bath water is kept to a minimum, particularly as arsenic concentrations rise.

If arsenic concentrations in well water are elevated, arsenic absorption through skin contact is of concern and whole house treatment (point-of-entry) is recommended.



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Types of Point-of-Use (POU) Treatment

POU treatment devices are generally the most cost effective method for treating arsenic in drinking water. A complete POU installation should have a water meter, pretreatment oxidizer, arsenic removal component, a possible second arsenic removal component in series and an accumulation tank. The water meter would identify the volume of water consumed and can be used to project the expected longevity of treatment components. In addition, the lower cost of POU can allow for a series configuration of two arsenic removal devices to assure complete treatment. In a series configuration, the first unit does the heavy removal and the second provides backup and polishing. POU systems normally produce approximately two to five gallons of treated water per day. Common POU treatment methods available for point-of-use arsenic treatment are adsorptive media, reverse osmosis, anion exchange cartridge, and distillation.

1. Adsorptive Media

Many new adsorptive media have been introduced into the market place over the last five years and packaged into various modular size cartridge products. These media have an affinity for a limited number of dissolved minerals including arsenic. In addition to arsenic, some of these media remove other contaminants including lead and uranium. Activated alumina used to reduce arsenic is an adsorptive media. Activated alumina is a granulated form of aluminum oxide. It is very porous and has a tremendous surface area for the removal of contaminants. In the treatment process, the water containing arsenic passes through a cartridge or canister of activated alumina. The alumina absorbs the arsenic and treated water continues to the faucet. An activated alumina cartridge combined with an activated carbon filter produces a good, broad-range water treatment. Minerals from the media are not released into the water. The activated alumina cartridge requires periodic maintenance to work properly. Activated alumina devices can accumulate bacteria, so a treatment system following the activated alumina system may be required to inactivate and/or remove bacteria.

Cost: The estimated installed cost of a single cartridge treatment configuration, with pre-oxidation cartridge, is approximately $600; a duplex media cartridge configuration costs approximately $800. Replacement adsorptive media cartridges cost in the range of $50-$200 depending on the media type and longevity. POU cartridges are typically sized for six months to one year before change-out.

Advantage/Disadvantages: Adsorptive media typically have the lowest initial installation cost. Some adsorptive media will remove arsenic III without pretreatment, however the longevity of the media for arsenic III is noticeably less than that for arsenic V. Adsorptive media can have higher flow rates than RO. Adsorptive media targets only those contaminants identified on the manufacture's label or brochures. When multiple health based contaminants are present, the one with the weakest affinity for the media will control the media replacement frequency. The release of low affinity contaminants is called "dumping" and should be evaluated when establishing a monitoring program to judge the effectiveness of overall treatment. Cartridge change-out should occur periodically based on the gallons processed and the results of performance samples.

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2. Reverse Osmosis (RO)

In the RO option, untreated water, under pressure, flows past a special membrane. The membrane allows water molecules to migrate through while retarding the passage of arsenic and many other contaminants. The contaminants remain on the untreated side of the membrane and are disposed of into a dry well, septic system or sewer. Treated water accumulates on the other side of the membrane and is held in a small pressure storage tank until needed.

Cost: A basic point-of-use RO device, with a pre-oxidation cartridge to address arsenic III, would cost approximately $950-$1,300. Annual maintenance consists of replacement of the pre-treatment sediment cartridge every three to six months, and membrane replacement every five to ten years. Annualized maintenance cost over a five year cycle would be approximately $100 per year.

Advantages/Disadvantages: RO provides broad-spectrum removal of nearly all mineral contaminants. One disadvantage of RO treatment is that the water can become somewhat more corrosive with the removal of the water's alkalinity. Thus, new plumbing fittings on the faucet and line from the treatment unit must be copper and lead free, preferably plastic.

3. Anion Exchange

Anion exchange treatment is explained below under "whole house treatment systems." Anion exchange modular cartridges are produced for small volume treatment, however, their relatively low capacity make them less likely to be chosen for point-of-use treatment.

4. Distillation

Distillation can also be used to produce a small amount of treated water. Distillation is not widely used however, due to its high operational cost and heat given off during summer months. Cost of distillation treatment, which is highly automated and directly connected to the plumbing, would be approximately $2,000 installed and warranted by others. The cost of a countertop, pour through distiller, would be approximately $1,000. Maintenance consists of cleaning residual minerals from the boiling chamber periodically. Annual operation and maintenance cost would be $200-$300 primarily for electricity.

Whole House Treatment Systems

A family of four in a single family home typically uses approximately 250 gallons of water per day for inside uses. As the amount of treated of water increases, the relative economics of some treatment methods may change.

1. Adsorptive Media

Adsorptive media is typically used for whole house treatment. Maintenance consists of replacing the media periodically--about every one to two years depending on the well's water quality. Adsorptive media whole house treatment for a typical family of four, with pre-oxidation by catalytic media, would cost approximately $2,400. The loose adsorptive media may be disposed of with your household trash since the arsenic is bound to the media. Annual operation and maintenance would consist of media replacement. Annual operational costs for replacing the media would be approximately $700-$1,200 depending on media type and water quality.

2. Anion Exchange

Anion exchange is similar to conventional water softening except it removes the negative ion (arsenate) rather than the positive ions. Anion "softening" exchanges the contaminant ions for less objectionable ions. In this case, chloride is added to the treated water as the negatively-charged arsenic ions are removed. Anion exchange increases water corrosivity by removing alkalinity. Use of a bicarbonate mineral as part of the salt regeneration solution decreases corrosivity. The retail cost of anion exchange is approximately $1,800. Annual operation, maintenance and cost for salt would be approximately $150 per year.

3. Reverse Osmosis

The cost an RO treatment system to produce 250 gallons of water per day would be approximately $5,000-$10,000. Annual maintenance cost would be approximately $300 per year. RO equipment of this size is generally not cost effective for whole home treatment.

4. Iron Treatment Systems

Iron is a very common water quality constituent that causes rusty brown staining of water fixtures and clothing. In cases where the oxidation-filtration method (birm, greensand) is being used to remove iron, arsenic will also be removed. The efficiency of arsenic removal in this option varies substantially with the water's iron quality and the precise type of treatment. Water quality tests are necessary to determine if there is significant arsenic removal for the particular iron oxidation/filtration treatment method used. Whole house treatment cost for oxidation filtration, assuming the presence of iron, costs approximately $2,300.

If water quality tests have shown that the water has both an elevated concentration of arsenic and iron, any rusty colored, untreated water is likely to have very high arsenic levels, and should not be consumed.

Other Considerations

Ensure the system you choose is installed and operated according to the manufacturer's instructions. After installation, retest both the raw water (prior to treatment) and the treated water at a state certified laboratory to ensure it is working properly and removing the contaminants. You should continue to test the quality of both the raw and treated water annually or more frequently (quarterly or semi-annually) if high levels of contaminants are present in the raw water. Frequent testing will also help you determine how well your treatment system is working and whether maintenance or replacement of components may be necessary.

When deciding on a treatment system, consider both the initial cost and the operating costs. Operating costs include the energy needed to operate the system, additional water that may be needed for flushing the system, consumable supplies and filters, repairs, and general maintenance.

Regardless of the quality of the equipment purchased, it will not perform satisfactorily unless maintained in accordance with the manufacturer's recommendations. Keep a logbook to record equipment maintenance and repairs. Equipment maintenance may include periodic cleaning and replacement of some components. Also consider any special installation requirements that may add to the equipment cost. For more information, refer to fact sheet *Questions to Ask When Purchasing Water Treatment Equipment*.

Product Certification

NFS International is a non-profit organization that sets performance standards for water treatment devices. Because companies can make unsubstantiated statements regarding product effectiveness, the consumer must evaluate test results of the device to determine if claims are realistic. Products that have been tested or evaluated by NSF and meet their minimum requirements are entitled to display the NSF listing mark on the products or in advertising literature for products. Manufacturers and models that meet NSF's standard are included in a listing published twice a year. For more information contact NSF at: 800-NSF-MARK or http://www.nsf.org/consumer/

Resources

US Environmental Protection Agency
http://www.epa.gov/safewater/arsenic/index.html

Agency for Toxic Substances and Disease Registry (ATSDR)
http://www.astsdr.cdc.gov/arsenic/index.html

Dartmouth University, Toxic Metals Research Program
http://www.dartmouth.edu/~toxmetal/TXQAas.shtml

UMass Extension
This fact sheet is one in a series on drinking water wells, testing, protection, common contaminants, and home water treatment methods available on-line at the University of Massachusetts website: http://www.umass.edu/nrec/watershed_water_quality/watershed_online_docs.html and Cape Cod Cooperative Extension: 508-375-6699 http://www.capecodextension.org

MA Dept. of Environmental Protection, Division of Environmental Analysis
Offers assistance, information on testing and state certified laboratories: 617-292-5770
For a listing of MassDEP certified private laboratories in Massachusetts: http://www.mass.gov/dep/service/compliance/wespub02.htm

U.S. Environmental Protection Agency, New England Office
Information and Education on: where drinking water comes from; drinking water testing and national laws; and how to prevent contamination: http://www.epa.gov/ne/eco/drinkwater

US Environmental Protection Agency
For a complete list of primary and secondary drinking water standards: http://www.epa.gov/safewater

MA Department of Conservation and Recreation, Division of Water Supply Protection
Maintains listing of registered well drillers, information on well location and construction: 617-626-1409, http://www.mass.gov/dcr/waterSupply/welldril/index.htm

NSF International
The NSF International has tested and certified treatment systems since 1965. For information on water treatment systems: 800-NSF-MARK http://www.nsf.org/consumer/

Water Quality Association
The Water Quality Association is a not-for-profit international trade association representing the household, commercial, industrial, and small community water treatment industry.
For information on water quality contaminants and treatment systems: http://www.wqa.org

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