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Arsenic in Drinking Water[1]

Arsenic is an important contaminant in New Hampshire's groundwater resources. Drinking water supplied from bedrock wells, also called drilled or artesian wells, and less frequently from dug wells may contain arsenic. The important question is, what is the concentration of arsenic?

WHERE DOES ARSENIC COME FROM?

Arsenic (chemical symbol As) occurs naturally in many parts of the United States, including New Hampshire and other areas of New England. In fact, arsenic was mined commercially in New Hampshire during the 1800s. Arsenic also occurs as a result of human activities. Activities that could have left arsenic residuals include, for example, apple orchard spraying and coal ash disposal. Arsenic may be either a residual of man past activities or naturally occurring. Generally is not possible to predict if a well will have elevated arsenic. Arsenic has no smell, taste or coloration when dissolved in water, even at high concentrations. Only water quality testing can determine its presence and concentration in well water.

HEALTH EFFECTS

Arsenic has been classified by the U.S. Environmental Protection Agency (EPA) as a human carcinogen (cancer causing agent.) Long term exposure to arsenic has been linked to cancer, cardiovascular disease, immunological disorders, diabetes and other medical issues. Specific health questions concerning arsenic should be directed to your personal physician. For general health information concerning arsenic call the Health Risk Assessment Bureau of the N.H. Department of Health and Human Services (DHHS) at 271 4664 or refer to their web site at **http://www.des.state.nh.us/factsheets/ehp/ard-ehp-1.htm**. Where drinking water is rusty colored and has arsenic, the rusty particles may concentrate the arsenic. Thus, do not consume rusty colored water.

HOW MUCH IS TOO MUCH?

The standard that limits arsenic in public water supplies, called a maximum contaminant level (MCL), has recently been made more stringent. There are 3 dates, noted below, that govern the effective date of this new arsenic requirement for public water systems.

US Environmental Protection Agency. On February 22, 2002 the new EPA rule for arsenic in drinking water became effective. This new MCL is 0.01 mg/L. This action completes an approximately one year review by the Bush Administration concerning the appropriate level of stringency for the drinking water arsenic MCL. This new rule although final, does not change the official MCL until January 2004 and public water systems have until January of 2006 to achieve compliance.

1. The material contained in this fact sheet was excerpted from the New Hampshire Department of Environmental Services web site: (http://www.des.state.nh.us/ws.htm).

State of New Hampshire. Recently DES adopted a revision to the state of New Hampshire's arsenic standard for public water systems. Like EPA, the new drinking water standard is 0.01 mg/L. Similarly this new MCL goes into effect in January 2004 and public water systems have until January 2006 to achieve compliance. Through 2004 the state of New Hampshire's legal standard for arsenic in PWSs is 0.050 mg/L.

FREQUENCY OF ARSENIC OCCURRENCE

Approximately 3 percent of New Hampshire wells exceed the current MCL of 0.05 mg/L. Approximately 13 percent of New Hampshire wells are projected to exceed the future DES standard of 0.01 mg/L. The statewide distribution of arsenic in drinking water wells is shown below.

Concentration	Percent of all bedrock wells
greater than 0.05 mg/L	3 %
0.025-0.049 "	5
0.010-0.024 "	5
0.005-0.009 "	6
less than 0.005 "	80

REDUCING ARSENIC IN YOUR WATER SUPPLY

There are at least three approaches that one could take to reduce exposure to arsenic from drinking water: connect to a municipal water system, construct a new well, or install water treatment. Additional considerations for each 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 with your neighbors 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, 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 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 New Hampshire, 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 type and locations.

Treatment

Before discussing in-home treatment types, a few words are necessary about arsenic chemistry. There are typically two variations, or species, of arsenic molecules in water: "arsenic III" and "arsenic V." The numbers III and V describe the valance 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 easier to remove from water than arsenic III.

Determining the species of arsenic begins in the field when a water sample is first collected and thus noticeably adds to the expense of the overall analysis. Arsenic species testing is discussed below.

> **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. The resin will remove only arsenic V. Thus the **treated** water sample passing through the anion resin should contain only that arsenic in the III form. The difference between the total arsenic sample and arsenic III sample is the amount of arsenic V present in the water.
>
> It is possible that species separation of arsenic III versus V can be processed in the laboratory without a change in valence taking place while in transit however, that change possibility has not yet been ruled out.

Arsenic Oxidation. Most arsenic seen in New Hampshire is arsenic V. Arsenic III can be transformed to arsenic V by the addition of a common oxidant to the water. Such 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 equipment installers provide an oxidizer pretreatment rather than identifying the species of arsenic.

Sizing of Treatment Devices: "Whole House" Versus "Under The Sink"
In-home water treatment devices come in two sizes: very small (often called under-the-sink or point-of-use) sized, and whole house, where all water used within the home is treated to remove arsenic. The point-of-use size produces only a few gallons of treated drinking water per day. This water is typically available at only the kitchen sink. When using this option, drinking water and cooking water would be obtained from a separate faucet located at the kitchen sink. Household discipline is needed to ensure that most drinking water is taken from this treated water faucet.

Skin Adsorption One concern with choosing a point-of-use treatment is the level of arsenic adsorption through the skin when the water is used for bathing. DHHS has concluded that point-of-use treatment is adequate if the arsenic concentration of the water used for bathing, laundry and dishwashing and other non-consumptive uses is less than 0.500 mg/L. This conclusion concerning point-of-use assumes that inadvertent consumption of untreated water by infants, such as drinking bath is keep to a minimum, particularly as arsenic concentrations rise.

Types of Point-of-Use Treatment

Point-of-use size treatment devices are generally the most cost effective method for treating arsenic in drinking water. A complete point-of-use installation should have a water meter to identify the water demand and to project the expected longevity of treatment components. In addition, the lower cost of point-of-use concept can allow for a series configuration of two devices to assure complete treatment. In a series configuration the first unit does the heavy removal and the second provides backup and polishing. Point-of-use systems normally produce approximately 2-5 gallons of treated water per day.

At least four treatment methods are available for point-of-use arsenic treatment; adsorptive medias, reverse osmosis, anion exchange, and distillation.

Adsorptive Media

Many new adsorptive media are being introduced into the market place and packaged into various modular size products. These media have an affinity for a limited number of minerals including arsenic. Activated alumina is an adsorptive media. In this process well water passes through the media. The arsenic V contaminant "stick" to the surface of the media by adsorption while the remaining water passes through the device. Minerals from the media are not released into the water.

In addition to arsenic, some of these medias remove other contaminants including fluoride and uranium. Fluoride, at appropriate concentration (1-2 mg/L), is beneficial in reducing tooth decay.

Cost of Adsorptive Media

The estimated installed cost of a single cartridge treatment configuration, with pre-oxidation cartridge, would be approximately $350; a duplex media cartridge configuration would cost approximately $500. Replacement adsorptive media cartridges may cost in the range of $50 each with the average cartridge longevity of approximately 6 months each.

Advantage/Disadvantages

Adsorptive medias typically have the lowest first cost. Some adsorptive media will remove arsenic III without pretreatment. Adsorptive media can have higher flow rates than RO. Adsorptive medias target only those contaminants identified on the manufactures label or brochures. When multiple contaminants are present, the one with the weakest affinity will control the media replacement. The release of low affinity contaminants is called "dumping" and should be evaluated for each water quality profile when establishing a monitoring program to judge the effectiveness of overall treatment. Cartridge change out will occur periodically based on performance samples.

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 leave the device as a concentrate to be "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 of RO

A basic point-of-use RO device, with a pre-oxidation cartridge to address arsenic III, would cost approximately $750-850. Annual maintenance consists of replacement of the pre-treatment sediment cartridge every 3-6 months and membrane replacement every 5-10 years. Annualized maintenance cost over a five year cycle would be approximately $100 per year.

RO Advantages/Disadvantages

RO provides very broad spectrum removal of nearly all mineral contaminants. One negative result of RO treatment is that the water becomes somewhat more corrosive with the removal of water's alkalinity. Thus new plumbing fittings on the faucet and line from the treatment unit must be lead free.

Anion Exchange

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

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 (kilowatts) and rejection of heat during summer months. Cost of distillation treatment, which is highly automated and is 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.

Whole House Size Treatment Systems

A family of 4 persons in a single family home would be expected to use 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.

Adsorptive Media

Adsorptive medias are typically used for whole house treatment. Maintenance consists of replacing the media periodically, about every year depending on water quality. The loose media may be disposed of with your household trash since the arsenic is not expected to leach out of the media once adsorbed. Adsorptive media whole house treatment cost, with oxidation by catalytic media, would cost approximately $2,200. Annual operation and maintenance would consist of media replacement. Annual operational costs for replacing the media would be approximately $750.

Reverse Osmosis

The cost an RO treatment system to produce 250 gallons of water per day would be approximately $5,000-10,000. RO equipment of this size is generally not available through the residential retail market in New Hampshire.

Anion Exchange

Anion exchange is another treatment process that would be typically used as a "whole house" treatment method. Anion exchange is similar to conventional water softening. Anion "softening" exchanges one contaminant for another. In this case, chloride is added to the treated water as the negatively charged arsenic molecules are removed. Anion exchange increases water corrosiveness by removing alkalinity. Thus, plumbing fittings should be lead free.

The retail cost of anion exchange is approximately $1,700. Annual operation and maintenance cost would be for salt usage at approximately $150 per year.

Iron Treatment Systems

Iron is a very common water quality constituent that causes staining of water use fixtures and clothing. In cases where the **oxidation-filtration method** (birm, greensand) is being used, some arsenic may also be removed. The efficiency of arsenic removal in this option varies substantially with the water's 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. Oxidation filtration, whole house treatment cost, assuming the presence of iron and with pH correction, costs approximately $2,300.

Drinking Rusty Water. 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.

PERIODIC MAINTENANCE, SAMPLING & LAYOUT

The effectiveness of a treatment process should be determined by periodic sampling. Once the treatment process has been proven and the longevity determined proven to be effective, sampling frequency can be reduced. Some New Hampshire water conditioning firms suggest adding a second arsenic removal method, in a series configuration, to capture any arsenic that escapes the first device.

TESTING YOUR WATER

EAI Analytical Labs will provide you with your free water testing kit containing: sample bottles, detailed sampling instructions and a tracking form. Bacteria samples bottles are distributed pre-sterilized and all sample bottles contain their necessary preservatives. Kits are available for pickup or they can be mailed to you. If you are interested or have any questions regarding the analysis of your water, please give us a call.