ENVIRONMENTAL Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Arsenic in New Hampshire Well Water

Wells drilled into New Hampshire's bedrock fractures have about a 1 in 5 probability of containing naturally occurring arsenic above 10 parts per billion. In addition, wells within short distances (~50 feet) can present very different water quality because of our highly fractured bedrock. Arsenic in water has **no color or odor**, even when present at elevated levels. Therefore, the only way to determine the arsenic level in your well water is by *testing*.

ARSENIC EXPOSURE

From 1975 until 2001, the federal maximum contaminant limit (MCL) for arsenic in water *supplied by public water systems* was 50 parts per billion, because the health effects of exposure to lower concentrations was not recognized. Based on an exhaustive review of the new information about arsenic's health effects, in January 2001 EPA established a goal of zero arsenic in drinking water. At the same time, EPA adopted an enforceable MCL of 10 parts per billion (ppb) based on balancing treatment costs and public health benefits. Studies have shown that chronic or repeated ingestion of water with arsenic over a person's lifetime is associated with increased risk of cancer (of the skin, bladder, lung, kidney, nasal passages, liver or prostate) and non-cancerous effects (diabetes, cardiovascular, immunological and neurological disorders). The same studies found that dermal absorption (skin exposure) of arsenic is not a significant exposure path; therefore, washing and bathing do not pose a known risk to human health. Additional information on health effects can be found in the DES fact sheet ARD-EHP-1, "Arsenic Health Effects Summary," which is available at www.des.nh.gov by searching for "ARD-EHP-1."

ARSENIC IN YOUR PRIVATE WELL

Water testing

DES recommends testing wells at least **annually** for potential acute contaminants such as bacteria and nitrates and **every 3 years** for chronic contaminants including arsenic, radon, uranium, lead and copper. If any parameter is found to be above the recommended levels, a confirmation sample should be collected *before* making any decisions regarding water treatment.

Arsenic III vs. V

Arsenic in natural waters is present predominantly as two types: Arsenic-III and Arsenic-V. The presence of these types can be important for the selection of treatment. At ambient water pH 6 to 9, the predominant forms are:

- As-III (Arsenite) present as Arsenious Acid H_3AsO_3 (no charge)
- As-V (Arsenate) present as anions $H_2AsO_4^-$ and $HAsO_4^{2-}$

Although some technologies can reduce both forms of arsenic, their efficiency for removal of Arsenic-III is drastically lower. For this reason, DES recommends testing for Arsenic-III before selecting a treatment system.

Commercial drinking water laboratories, including the state Public Health Laboratory, offer testing for Arsenic-III (speciation testing). At least one test is recommended to establish the relative ratios of Arsenic-III/V for your well water.

Arsenic III Oxidation
If raw water Arsenic-III levels are at or above 10 ppb (0.01 mg/L), a simple pre-oxidation step should be added to improve overall treatment efficiency. The following oxidants may be used (or not) for oxidation of Arsenic-III:

Effective = chlorine, ozone, permanganate, and solid manganese dioxide (pyrolusite) media
Not effective = Air, UV light, chlorine dioxide

REDUCING ARSENIC IN DRINKING WATER

Whole-House vs. Point-of-Use Treatment
Whole-house (or point-of-entry) treatment is when all of the water entering the home is treated. This is necessary when aesthetic parameters such as iron, manganese, hardness or sulfide are of concern, or for acute contaminants such as bacteria or nitrate and volatile contaminants such as radon, MtBE and other volatile organic compounds (VOCs). Whole-house treatment for arsenic is not necessary unless levels exceed 250 ppb (0.25 mg/L), because there is no skin absorption, and occasional accidental ingestion at these levels is not a concern.

Point-of-use treatment is when filters are installed at the kitchen sink or other dedicated faucet. These are used for contaminants such as arsenic or uranium where exposure via ingestion is the primary exposure route. When point-of-use treatment is used, all water for cooking, drinking and ice-making should be obtained from this tap. In the absence of other contaminants, point-of-use devices are recommended as the most cost effective and simplest solution for long-term treatment of arsenic in drinking water.

Point-of-Use Treatment Technologies
Common point-of-use devices for arsenic treatment are adsorption cartridges and reverse osmosis. Some of these devices are described below.

a) Point-of-Use Adsorption Cartridges
Commercial Point-of-Use adsorption cartridges are available online via a simple web search. If Arsenic-III is present, a pre-oxidation cartridge should be installed to extend the adsorption cartridge bedlife as much as three to five times longer.

Advantages of adsorption treatment are that it is selective to arsenic, based on arsenic's natural affinity to stick or adsorb to the iron filter media (or other metal-based media). Homeowners can determine the frequency of changing the cartridges by establishing quarterly testing at least for the first year of operation and by following the manufacturer's maintenance requirements. Disadvantages of adsorption treatment include the filter longevity, which is affected most notably by water pH, with longer longevity observed at pH 6.5 to 7.5, and shorter longevity for pH 8 and up. Current equipment costs begin at $150 with cartridge replacement costing less than $100 per cartridge.

b) Point-of-Use Reverse Osmosis
Reverse osmosis filtration retains the larger dissolved molecules by applying pressure on one side of a selective membrane, forcing purified water to pass to the other side. The "reject" water is disposed to the home septic system or drywell, while filtered water is stored in a small pressure tank and dispensed through a dedicated tap.

Advantages of point-of-use reserve osmosis are its widespread availability from home improvement stores, water treatment firms, and online. Disadvantages include high waste (three or more gallons waste for every 1 gallon treated), and its non-selective removal of the targeted contaminant. Current equipment costs begin at $150 plus installation costs.

Standard reverse ssmosis equipment includes one or more pre-filtration cartridges to protect the reverse osmosis membrane, as well as some post-filter cartridges. If As-III is present, DES recommends adding a pre-oxidation cartridge to improve removal of As-III, as it is typically 60 to 65 percent compared to greater than 98 percent removal of As-V.

Whole-House (or Point-of-Entry) Treatment Technologies
A family of four in a single-family home typically uses about 250 gallons of water per day for inside uses such as laundry, sanitation and cooking. **Whole-house treatment is applicable when arsenic levels are greater than 250 ppb** (0.25 mg/L), **or if iron removal is also necessary**. As noted, arsenic levels below 250 ppb do not require whole-house treatment because skin absorption at these levels is not a concern. Installation cost for a typical residential whole-house filtration system is on the order of $1,500 to $3,000 for a single filtration step, regardless of technology. Additional pre- and post-treatment needs such as iron, manganese, hardness, pH and/or radon will require additional equipment and cost. The principal differences between treatment methods relate to maintenance requirements and cost.

Applicable technologies for whole-house arsenic removal are described below.

a) Oxidation-Filtration (Iron-Arsenic)
When iron is present at 0.1 mg/L or more, iron-arsenic oxidation followed by particle filtration is the most cost-effective approach to reducing both contaminants on a whole-house basis. Manganese dioxide-based filter media such as Birm, Greensand and Filox are commonly used. This medium oxidizes iron and arsenic simultaneously so it inherently addresses both Arsenic-III and V. Removal relies on arsenic's natural preference to adsorb to iron particles. Optimal ratios are 20 parts iron to 1 part arsenic (for example, 0.4 mg/L iron to 20 ppb arsenic), and with pH 7 to 7.5. However, partial removal can be obtained for lower iron/arsenic ratios, reducing overall treatment maintenance costs for arsenic removal. As noted above, installation costs are $1,500 to $3,000, similar to other whole-house technologies. Maintenance costs would be about $100 per year for permanganate of chlorine pre-oxidant, if necessary.

b) Adsorptive Media
At least seven commercially available adsorptive media are actively marketed nationwide for arsenic removal from drinking water. Most are iron-based oxides but titanium- and zirconium-based media are also available.

Advantages of this technology are its simplicity and gradual contaminant breakthrough, which allow for more time between filter replacements. The main disadvantage of adsorptive media is its finite capacity, which is especially impacted by pH greater than 7.5 and the presence of Arsenic-III.

Single- or dual-filter installation costs range from $1,500 to $2,500, similar to other whole-house treatment. Maintenance costs consist of periodically replacing the filter media every one to three years, depending on water quality and water uses. Annual replacement costs are highly dependent on water quality and can be budgeted at $500 to $750 per year. Spent filter media must be disposed in a lined landfill or waste incinerator permitted to receive high metals waste and can be coordinated through your water treatment provider or your trash contractor, ensuring that final disposal is to a permitted facility.

c) Anion Exchange
Anion exchange is similar to conventional water softening except that it removes the negative ion Arsenic-V rather than the positive ions. Arsenic-III is not removed because it has no charge. Anion exchange replaces the target contaminant with the chloride anion.

Advantages of anion exchange are its ability to process high arsenic concentrations independent of raw water pH, and its low operating costs based on onsite regeneration with common salt pellets. Disadvantages are its potential for arsenic "dumping" if salt is not replenished, and its removal of water alkalinity requiring installation of a post-calcite filter to address corrosiveness. This technology is applicable for high arsenic loadings greater than 250 ppb and without iron or manganese co-occurrence.

Typical costs for whole-house anion exchange is approximately $1,500 to $2,500. Annual maintenance cost for salt is about $100 per year for regeneration once every 2 to 3 weeks, which is based on sulfate concentration rather than on arsenic level.

PERIODIC MAINTENANCE AND TESTING

The continued effectiveness of any treatment process should be monitored by periodic sampling and filter maintenance. DES recommends quarterly arsenic sampling for the first year of treatment, and semi-annually after that. If the treatment relies on pre-oxidant or salt regenerant, the feed tank should be checked weekly.

REFERENCES CITED

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EPA (2003b). Removal of Arsenic from Drinking Water with Adsorptive Media. EPA/600/R-03/019.

EPA (2001a). Technical Fact Sheet: Final Rule for Arsenic in Drinking Water. EPA/815/F-00/016.

EPA (2001b). Laboratory Study on the Oxidation of Arsenic III to Arsenic V. EPA/600/R-01/021.

FOR MORE INFORMATION

- DES Drinking Water and Groundwater Bureau's Arsenic page: search for "arsenic in drinking water" at www.des.nh.gov; technical staff are also available at (603) 271-3108 or dwgbinfo@des.nh.gov.
- DES Environmental Health Program staff (603) 271-4608
- DES additional drinking water and health effects fact sheets are available at www.des.nh.gov, choose "Publications/Fact Sheets" under "Quick Links."
- Dartmouth Toxic Metals Superfund Research Program: www.dartmouth.edu/~toxmetal
- USEPA "Arsenic in Drinking Water": http://water.epa.gov/lawsregs/rulesregs/sdwa/arsenic/index.cfm
- US CDC Agency for Toxic Substances and Disease Registry Arsenic Toxicological Profile, http://www.atsdr.cdc.gov/arsenic/
- USGS National Water Quality Assessment Program, Arsenic in Groundwater page http://water.usgs.gov/nawqa/trace/arsenic/

Note: This fact sheet is accurate as of April 2012. Statutory or regulatory changes or the availability of additional information after this date may render this information inaccurate or incomplete.