

Water Treatment NOTES

Cornell Cooperative Extension, College of Human Ecology

Arsenic in Drinking Water

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Arsenic occurs naturally in the earth's crust. It is spread through volcanic activity, erosion and forest fires into the groundwater and can vary in concentration. In the US it appears in groundwater supplies all over the country, but mostly in New England, the Midwest and in the Western States (fig. 1). Arsenic can lead to several serious illnesses and has proven to be dangerous in water supplies, especially in Asian countries such as Bangladesh and China where concentrations can be very high.

This report will provide some basic knowledge about arsenic to better understand the threat it might pose and what measures can be taken.

Chemistry

Arsenic is a semi-metallic element that can be found in water in organic and inorganic forms. In the organic form it is mostly harmless and no threat to human health. In its inorganic form however, which is also the most abundant form, it can have serious health risks. Arsenic can be found in drinking water in two different inorganic forms: as arsenious acid (trivalent arsenic) or as arsenic acid (pentavalent arsenic). [2] They both have different properties in water, but trivalent arsenic is the more toxic variant.

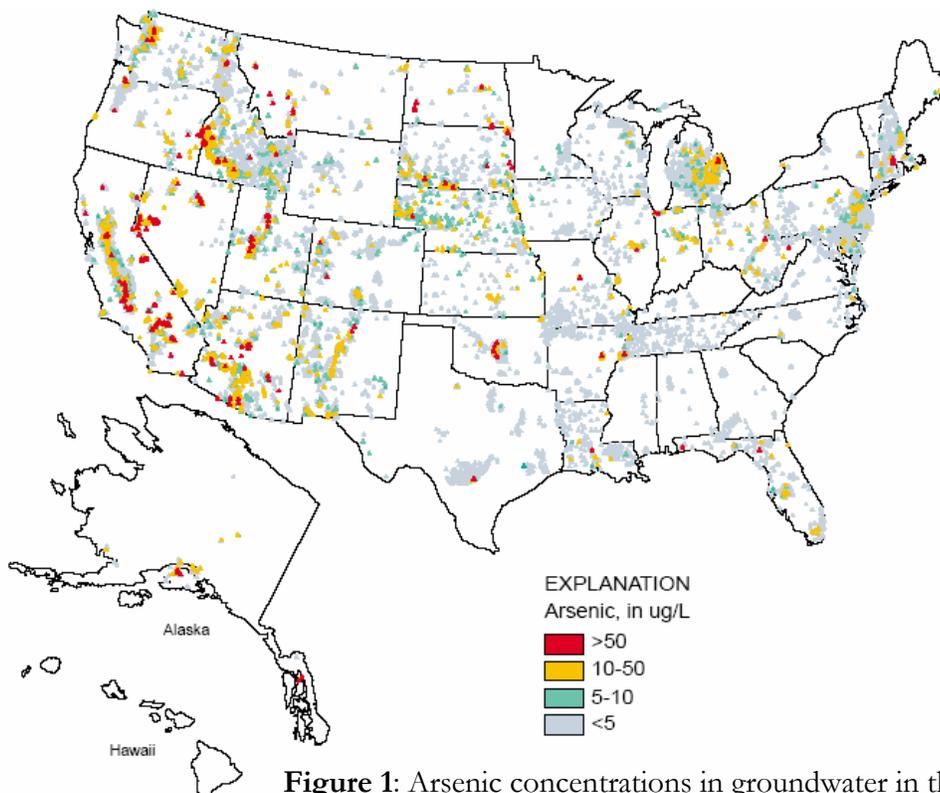


Figure 1: Arsenic concentrations in groundwater in the US. [1]

Health effects

A number of epidemiological studies [3] have shown the effects of long term exposure to high concentrations of arsenic. Chronic arsenic poisoning (arsenicosis) can cause skin lesions (change of pigmentation, keratosis of hands and feet), damage to internal organs and to the respiratory, digestive, circulatory, neural and renal systems. Such cases are mostly found in Far East countries such as China, Taiwan, India and Bangladesh where high arsenic concentrations are endemic.

Some effects can take over a decade to emerge, depending on the daily consumption of arsenic, sensitivity of the person in question and the form of arsenic (trivalent or pentavalent). Chronic exposure can also lead to a large variety of cancers. According to an NAS (National Academy of Sciences) report [4] it can lead to cancer of the bladder, lungs, skin, kidney, nasal passages, liver and prostate. This is the main reason why the EPA has lowered the drinking water standard for arsenic from 50 ppb to 10 ppb.

Regulation of Arsenic

The current US drinking water standard for arsenic is 10 parts per billion (ppb) [5]. It was lowered from 50 ppb in January 2006. This is also the recommended guideline of the World Health Organization (WHO), a United Nations agency. The first standard was established in 1942 by the US Public Health Service (50 ppb), but the EPA has been reevaluating this guideline since 1975. After a long period of discussion in Congress and reports by the EPA, the NAS and the NRC (National Research Council), a new arsenic standard was adopted in January 2001. [6] Due to further studies the national rules weren't updated until 2004, and made enforceable in 2006.

The EPA mandate drinking water standard applies only to public systems providing water to more than 25 individuals per day at least 60 days out of the year or having at least 15 service connections. So it does not apply to individual homeowners with private wells.[9] The measures they can take to make sure their water is safe, is addressed in the next section.

Water treatment

Trivalent arsenic is very difficult to remove from water and is therefore almost always oxidized to the pentavalent state. Adding pure oxygen does not work, because it reacts very slowly with trivalent arsenic. The oxidizing agent is often chlorine, because this is also used as a disinfectant. When chloramine (See FS 17) is the disinfectant, extra oxidizing reagents have to be added. Other options for oxidizing are ozone and manganese dioxide.[7] Both ozone and free chlorine can react with organic matter and might give undesirable by-products.

After oxidation, pentavalent arsenic can be removed from water with a variety of methods: adsorption, reverse osmosis, distillation, ion exchange, chemical precipitation and chemical coagulation.

These last two methods are used in municipal water treatment plants. For small water operators and private well owners it is hard to remove arsenic from water and also keep the costs low. NSF International, a not-for-profit standard setting organization, has Standards 53 and 58 for devices that can lower arsenic to 10 ppb.[8] A total arsenic test is necessary before purchase of water treatment equipment. It is important to know what kind of arsenic is in the water, what kind of pH the water has, and if there is iron present.

When to test for Arsenic? [9]

Water should be tested for Arsenic especially if:

- The water source is located in or near an area where arsenic is a known concern;
- There is an increased redness color in the water supply;
- The water has low pH levels;
- There is an increase in the levels of iron in water; or
- If the well or aquifer is located on an end moraine (the location where a glacier had ended).

Conclusion

Arsenic is a serious health threat and you should determine if it is in your water supply by testing because it is tasteless and odorless. Consumers on public water can contact their supplier because they have to monitor treated water for arsenic. Consumers with private water sources in an arsenic prevalent area (see fig.1) can do a total arsenic test which costs \$15-30 at a local certified laboratory. Depending on the results, water treatment appliances might be needed.

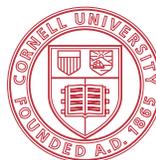
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