The Role of Reverse Osmosis in Reducing Arsenic Exposures

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Arsenic is considered a silent pollutant since it may be undetectable by the senses of sight smell or taste when present in water. Groundwater supplies are particularly vulnerable; their flows through mineral deposits effectively leach the contaminant into the water supply from weathering rocks and eroding materials. Many industrial applications also contribute to arsenic load in the environment, including discharge from semiconductor manufacturing, petroleum refining and glass manufacturing, as well as products used as wood preservatives, animal feed additives, herbicides and lead- or copper- based alloys. Although a product of nature, it is a poisonous agent at low levels, a regulated contaminant in US water supplies and a significant cause of morbidity and mortality worldwide.

Developing the arsenic standard

Formulation of the arsenic rule was a much-debated topic where the improved health benefits were necessarily balanced relative to the ability to achieve the standard based on the best available science. Public water supplies are required to monitor for arsenic and meet regulatory standards. The Maximum Contaminant Level Goal (MCLG) is zero parts per million, given that even a small dose of 0.5 ppb of arsenic in drinking water consumed over a lifetime results in an estimated cancer risk of one in 10,000 (typically the acceptable risk level on which regulatory decisions are made regarding a hazard).

Since 1942, the Maximum Contaminant Level (MCL) for arsenic in drinking water was set at 50 parts per billion (ppb). A series of reports released in 2001, including *The National Academy of Sciences Nation Research Council's Report*, *The National Drinking Water Advisory Council Report* and *The Science Advisory Board Report* indicated that the US EPA's arsenic standard imparted an unacceptable cancer risk. Subsequently, the enforceable MCL was reduced to 10 ppb with a compliance date of January 2006 for public utilities.[1]

According to the National Academy of Science,[3] the estimated lifetime risk of cancer from exposure to arsenic at 10 ppb is one in 500 compared to one in 100 with the 50 ppb limit. This additional regulation is estimated to protect an estimated 13 million Americans (the new arsenic standard was estimated to affect five percent of all community water systems in the US where corrective action was required. Arsenic levels in US well waters is reported to vary widely from one to 490 ppb, requiring analysis of individual source waters to estimate population exposures.[4]

Silent but deadly

Symptoms of chronic low-level exposures to arsenic may be delayed for years. Early warning signs may include stomach pain, nausea, vomiting, diarrhea, blindness and numbness in extremities. Some evidence also suggests that arsenic can affect the immune and respiratory systems. The effect of arsenic exposure depends on factors of ingested dose, exposure duration, immune status of those exposed and the form of the arsenic species. Arsenic poisoning may be acute following short-term, high concentrations of exposure (>60 mg/L) or chronic where low levels may be consumed over a period of years. Symptoms of arsenic exposure include skin damage, circulatory system problems, diabetes and increased cancer risk (especially of the bladder, skin, kidneys, nasal passages, prostate and lungs).

The predominant form of arsenic in environmental waters is the dissolved trivalent species, As (III). This form has a neutral charge in natural waters and is more toxic to humans compared to the pentavalent species, As(V), that is usually negatively charged and filterable. Much effort has been placed on the development of new arsenic removal technologies that are efficient and cost effective.[4] Many of these technologies focus on adsorption of arsenic by a variety of media (i.e., activated alumina, coconut husk carbon, iron oxide coated materials, etc.).

Many studies have been conducted in Bangladesh, where indigenous concentrations in groundwater are as high as 1,000 ppb. In 2003, more than 50 million people in Bangladesh were estimated to be consuming arsenic contaminated drinking water at levels higher than 50 ppb. In this region, where quality drinking water is scarce and resources limited, clay filters, rainwater harvesting and solar distillation minimize arsenic exposures.

Reducing your exposures

Private water sources are not regulated by federal or state agencies; however, households with well water supplies used for drinking water sources should consider the possibility of arsenic contamination and have their supplies tested periodically by a state-certified laboratory (lists are available from state extension offices). Water samples can be collected and analyzed for a fee of around $30 (US). If positive for arsenic, many affordable and reliable treatment devices are available for installation at the residential point of use (POU) or point of entry (POE).

Reverse osmosis (RO) and steam distillation are the most common methods used for treatment of arsenic contaminated drinking water at the POU. Water should be tested periodically to determine the presence of arsenic and the efficacy of the treatment system utilized. The use of carbon pre-filters before RO systems is standard in home treatment units to extend the life of the RO membrane and reduce membrane fouling. Proper maintenance of an RO system and the pre-filters are essential for reliable treatment, as treatment efficiency is known to decrease over time. The integrity of the RO membrane is typically monitored by measuring conductivity, since it is directly proportional to the dissolved solid content in water. A properly maintained residential RO system should remove >90 percent of dissolved solids.

While RO membranes have a typical life span of two to four years, their decreased efficiency is usually gradual, allowing the owner to react appropriately to signals of increased conductivity. A study conducted by the Montana University System Water Center demonstrated that conductivity in RO permeate increased to about 50 percent of the feed water before any substantial levels of arsenic was detected.[5] In the study, RO systems were determined effective for arsenic removal at the POU where initial concentrations were as high as 21 ppb. The researchers recommended, however, that the carbon filters were changed yearly, at which time the conductivity monitoring devices were checked and the entire unit disinfected. In addition, the RO membrane should be changed as needed based on conductivity monitoring.

Validated treatment options

There are many residential RO water treatment devices on the market, with components of varying quality. NSF International/American National Standards Institute (NSF/ANSI) certification assures that an accredited certification agency has verified that the product meets specific material safety and performance levels. Qualified certification agencies include Underwriters Laboratories Inc., Water Quality Association, NSF International and others. Consumers needing arsenic removal capabilities can find a list of verified technologies for arsenic removal at the website of the Environmental Technology Verification Program. This program began in 1995 and is designed to evaluate the performance of environmental technologies by facilitating the development of innovative and improved methods for the protection of public health and the environment. The program is funded through both public and private testing partnerships, allowing for objective analysis and introduction of new technologies from the private sector in a scientific and peer reviewed arena.

Conclusions

Arsenic is considered one of the world's most hazardous chemicals and is known to contaminate drinking water supplies around the globe. Many treatment options are available and effective for arsenic removal, especially when used in tandem. The choice of treatment depends on the scale, cost requirements and water quality characteristics. Consideration of treatment methods typically involves analysis of the concentration of arsenic and the basic chemistry of the water supply. For residential water treatment, RO remains a primary treatment option for arsenic removal.

References

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5. Moretti C. 2002. *Point-of-use reverse osmosis treatment for removal of arsenic from drinking water*. Montana Water Center. http://water.montana.edu

6. Environmental Technology Verification Program (ETV) website: www.epa.gov/etv/index.html

Certification agencies' websites: Underwriters Laboratories Inc. www.ul.com; Water Quality Association www.wqa.org; NSF International www.nsf.org

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