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Drinking Water Problems: Arsenic

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Arsenic can be released to the environment as a result of natural events, or its release can be caused by human activities. Through erosion, dissolution, and weathering, arsenic can be released from the Earth's crust into groundwater or surface water. Most agricultural uses of arsenic have been banned in the United States.

HOW CAN ARSENIC AFFECT HEALTH?

Exposure to elevated levels of arsenic can be harmful to the body. The Environmental Protection Agency (US EPA) maximum contaminant level (MCL) for arsenic is 10 micrograms per liter (10 parts per billion [ppb]) in the United States. Chronic ingestion of low levels of arsenic can lead to gastrointestinal symptoms, diabetes, anemia, cancer, liver disease, and various cardiovascular, pulmonary, and neurological effects. Arsenic levels are rarely high enough in drinking water supplies to result in acute poisoning.

WHERE HAVE HIGH LEVELS OF ARSENIC BEEN FOUND IN TEXAS?

Data on groundwater arsenic concentrations in Texas were compiled by Reedy and Scanlon (2018) from the Texas Water Development Board groundwater database and the Texas Commission on Environmental Quality (TCEQ) public water supply database for 10,489 wells sampled between 1992 and 2017. As shown in Figure 1, the highest concentrations are found in the southern Gulf Coast, southern High Plains, and the Trinity Aquifer. Previous studies have shown that arsenic hotspots in the southern High Plains and southern Gulf Coast aquifers originate from geologic sources.

WHERE TO TEST YOUR WELL WATER?

MCLs apply only to public water supplies; however, private water well owners can apply these or more rigorous standards to their own unregulated water supply. A list of labs certified by the TCEQ is available at https://www.tceq.texas.gov/goto/certified_labs.

WHAT CAN WATER WELL OWNERS DO ABOUT ARSENIC CONTAMINATION?

- **Purchase bottled water for drinking and cooking.** Unless their water source has arsenic levels greater than 500 micrograms per liter, they may safely use their well water for non-consumption activities such as showering, bathing, and washing clothes.
- **Connect to a public water system.** All community water supply systems are tested regularly for arsenic and other contaminants, and such systems must comply with EPA and state regulations.
- **Extend the existing well's casing or drill a new well into different water-bearing formations, possibly reducing arsenic levels.** Well designs may lower arsenic concentrations if they access a different aquifer or allow the mixing of water from different levels in an aquifer.
- **Purchase treatment systems.** Well owners choosing this option should test their water again to determine if other constituents dissolved in their water also exceed drinking water standards. Even if levels of other constituents are found to comply with drinking

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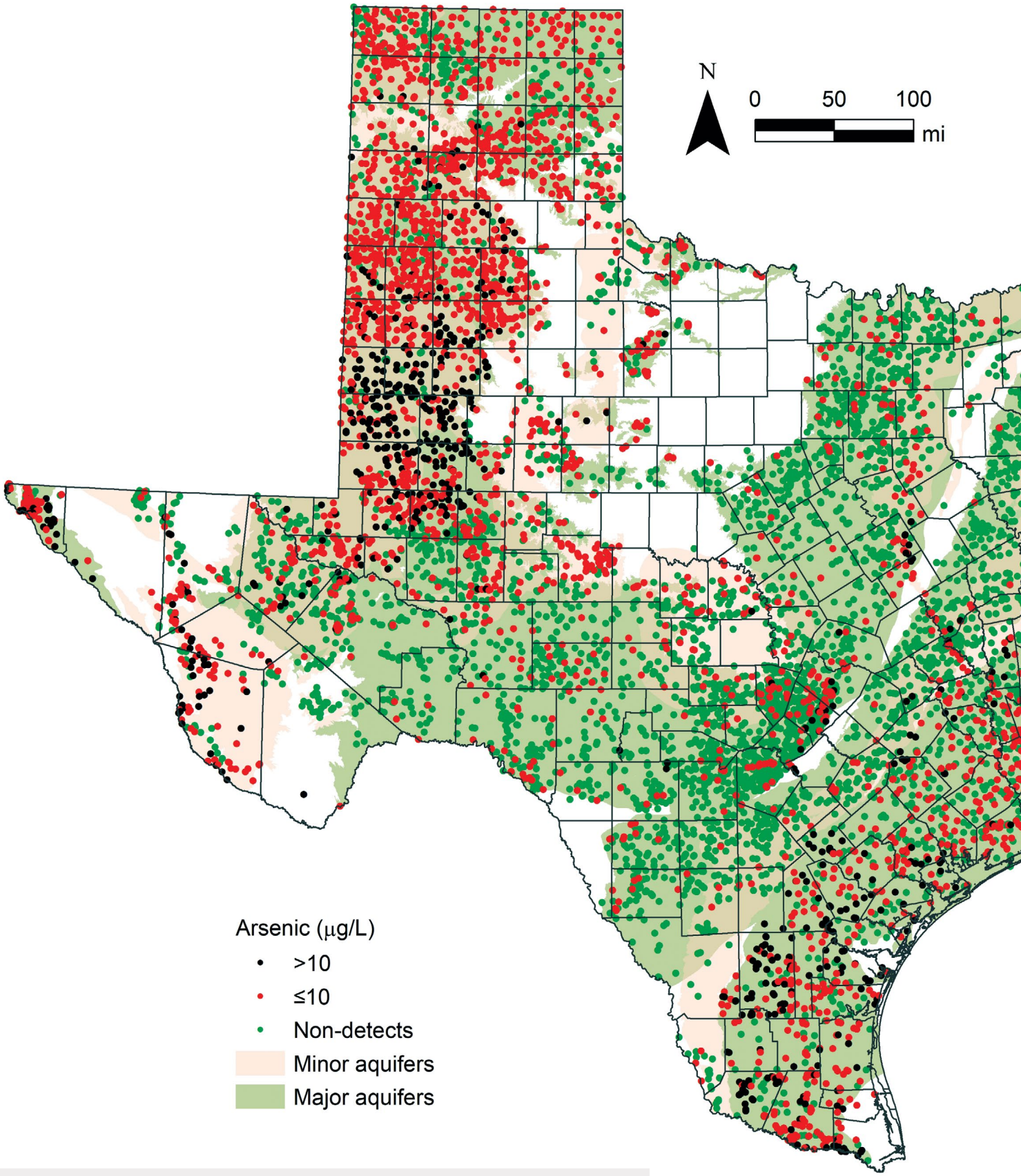
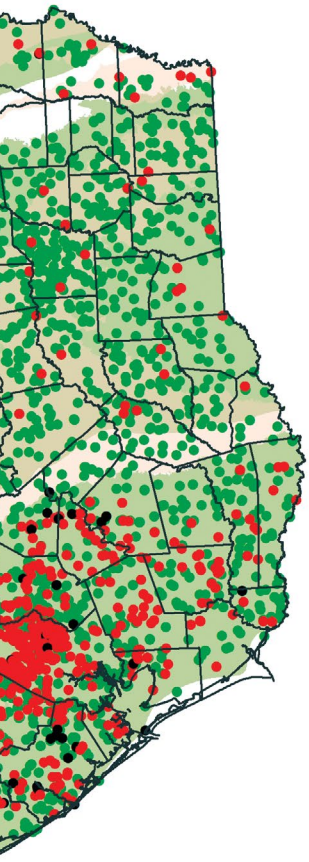


Figure 1. Arsenic content in groundwater sampled from 1992 to 2017 as recorded in the Texas Water Development Board groundwater database and the TCEQ public water supply database.



water standards, these constituents may interfere with proposed arsenic remediation systems. Iron and manganese, for example, hinder effective arsenic treatment and should be removed before arsenic treatment begins. Well owners also must consider whether treatment should occur at each tap (point of use) or before entry to the residence (point of entry), given the different treatment systems available for each option.

HOW SHOULD A WELL OWNER SELECT A TREATMENT UNIT?

Well owners should first test the water source using a laboratory qualified to determine water quality. A list of labs certified by the TCEQ for testing drinking water can be found at https://www.tceq.texas.gov/goto/certified_labs. Once you know the constituents present in your water supply, research different products and find one suitable for treating those constituents, or work with a licensed water treatment specialist to determine appropriate treatment options. Water treatment specialists licensed by the TCEQ may be located through https://www2.tceq.texas.gov/lic_dpa/index.cfm?fuseaction=licall.searchgp.

Compare initial costs, operation and maintenance costs and requirements, contaminant removal efficiency, warranties, the life expectancy of the system, and company reputation. Before making your final decision, also consider wastewater or solid wastes generated by a system.

Home water treatment systems are not regulated by federal or state laws, but some national organizations offer product certifications. The Water Quality Association (WQA) offers a validation program and advertising guidelines. Products that receive the WQA's Gold Seal Product Validations are certified for mechanical performance. NSF International certifies a product's ability to remove contaminants affecting health. A search engine for a list of drinking water treatment units with NSF certification can be found at http://info.nsf.org/Certified/PwsComponents/. An EPA registration number on a product merely indicates that the unit is registered with the EPA; this registration number does not imply EPA approval or certification.

WHAT TREATMENT METHODS ARE COMMONLY USED BY PRIVATE WELL OWNERS TO REMOVE ARSENIC?

Common treatment methods used to remove arsenic from well water include reverse osmosis (RO), adsorption columns, ion exchange, and distillation. Before installing a specific treatment system, well owners should be certain that it will meet their needs. They should work with reputable dealers who are familiar with the areas where their wells are located and find out the amount of arsenic a treatment system will remove, its maintenance requirements, and its costs. After well owners install a treatment system, they should test their water periodically to ensure that arsenic is being removed.

Reverse Osmosis

In Texas, RO treatment units are commonly recommended for removing arsenic, as Texas groundwater frequently also contains high levels of dissolved solids, sulfates, or phosphates. When operated at typical tap pressures, some RO devices remove 90 to 100 percent of arsenic present. An RO unit passes water under pressure through a semi-permeable membrane. This membrane allows water to pass through but prevents arsenic from doing so. Most units (Fig. 2) will have:

- A pre-filter to remove solids and extend membrane life;
- An activated carbon filter to remove odors, taste, and chlorine;
- A semi-permeable membrane;
- A tank to hold the treated water; or
- A drain connection for discharging wastewater generated.

However, RO units achieve relatively poor water recovery. Most units are designed to recover 20 to 30 percent of the water treated. For example, if 100 gallons are treated, only 20 to 30 gallons will

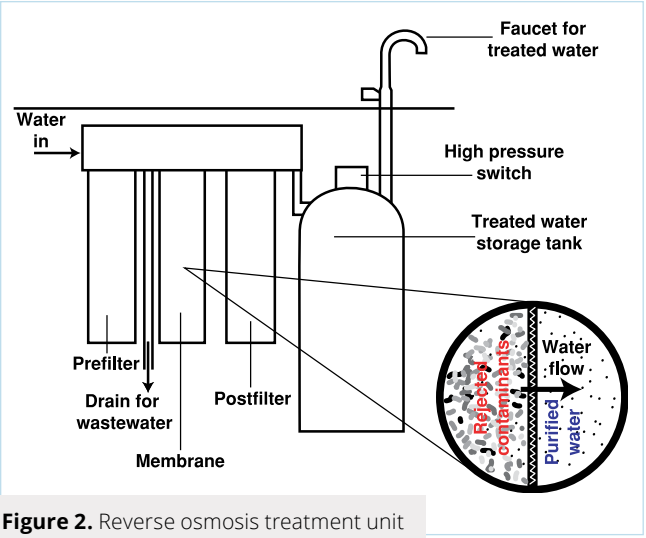


Figure 2. Reverse osmosis treatment unit
(Adapted from Kneen et al., 2005 and US EPA, 2003)

be useable—the rest of the water will be sent to the wastewater treatment system. Homeowners using onsite wastewater treatment systems should consider the impact additional loading from an RO unit may have on their septic systems. Because of RO systems' inefficiency, such units typically are used to treat only drinking and cooking water, so the system size should be based on the number of gallons used for these purposes each day. Typical treatment unit production rates range from 5 to 15 gallons of water per day.

The typical cost range of RO devices is from $300 to $1,000. The RO unit's membrane should be replaced according to the manufacturer's recommended schedule. New membranes cost about $150, and a carbon-based pre-filter typically costs between $15 and $50.

Depending on the system, based on a 10-year average, the cost of water production ranges from 5 to 10 cents per gallon, not including the cost of water wasted or the cost, if any, of treating wastewater from the RO unit.

Adsorption Column

Modified activated alumina and iron-based sorbents are among the adsorptive materials that can be used to remove arsenic from water (Fig. 3). The advantages of using an adsorption column operation include simple operation, low maintenance, a low relative cost depending upon cartridge replacement frequency, a small under-the-counter footprint, a high treatment capacity, and slow breakthrough kinetics (The New Hampshire Department of Environmental Sciences, 2019). To prevent untreated arsenic from leaking into drinking water, well owners can use metered cartridges that will shut off the system outlet once a designated volume of water has passed through the treatment unit.

Backwashing to regenerate activated alumina is typically not feasible for well owners because of handling and disposal of the resulting hazardous liquid waste. Well owners generally choose to use disposal or throwaway media cartridges. The frequency of periodic replacement of media depends primarily on the pH of the source water. The New Hampshire Department of Environmental Sciences (2012) states "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."

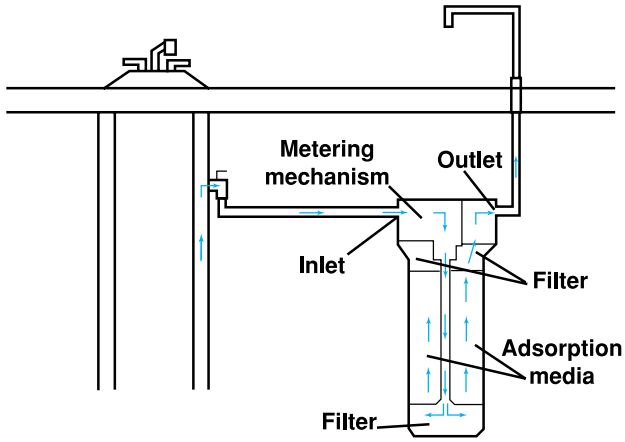


Figure 3. Adsorption treatment
(Adapted from US EPA, 2003)

Ion Exchange

If your water source contains iron, more than 500 milligrams per liter of total dissolved solids (TDS), more than 50 milligrams per liter of sulfate (SO_4), or high levels of nitrate, ion exchange (IE) most likely is not the best treatment option. Ions are charged particles. Because arsenic forms an anion, or a negatively charged ion, it can be removed from water through an ion exchange process. This process removes arsenic by passing the water under pressure through one or more columns packed with an exchange resin. The resin typically used for arsenic treatment is a strong-base ion exchange resin in either a chloride or a hydroxide form. As an arsenic ion moves across the resin, a chloride or a hydroxide ion is released from the resin, and the arsenic ion takes its place because the resin exchange site attracts the arsenic ion more strongly than the ion it replaced. Replacement of all the original ions saturates the resin column, and it must be regenerated or replaced. For treatment of arsenic, resin recharging can be done only at special facilities, making IE treatment expensive.

Because arsenic breakthrough events can occur very quickly with this treatment method, effluent from an IE unit should be monitored frequently to ensure the unit is operating properly.

In addition to ongoing costs of monitoring and for resin replacement, an IE unit initially costs somewhere between $400 and $1,500.

Distillation

Distillation is an effective method for removing arsenic from water; however, because operating energy costs are currently costly, this system is rarely selected by Texans. Distillation units can be purchased for between $300 and $1,200.

HOW CAN WELL OWNERS KEEP THEIR SYSTEMS WORKING?

No matter what treatment technology you use, maintenance is required to keep the system operating properly, and the first step to proper operation and maintenance is proper installation. Qualified installers:

- Carry liability insurance for property damage during installation;
- Are accessible for service calls;
- Accept responsibility for minor adjustments after installation; and
- Give a valid estimate of installation costs.

After system installation, water treatment units must be maintained properly. RO membranes, adsorption cartridges, and ion exchange resin units must be replaced as necessary. All systems should be operated according to the manufacturer's specifications. Treating more water in a certain period of time than a system is designed for may lower treatment effectiveness and adversely impact effluent water quality. Water output by treatment units should be tested regularly to ensure proper system operation.

USEFUL LINKS

TCEQ certified laboratory database at https://www.tceq.texas.gov/goto/certified_labs

Water treatment specialists licensed by the TCEQ may be located through https://www2.tceq.texas.gov/lic_dpa/index.cfm?fuseaction=licall.searchgp.

Texas Department of Licensing and Regulation (provides a list of licensed well drillers) https://www.tdlr.texas.gov/LicenseSearch/

Texas Water Development Board Groundwater Data Viewer https://www2.twdb.texas.gov/apps/WaterDataInteractive/GroundwaterDataViewer/?map=sdr

Texas Well Owner Network http://twon.tamu.edu/

Texas Groundwater Protection Committee https://tgpc.texas.gov/

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