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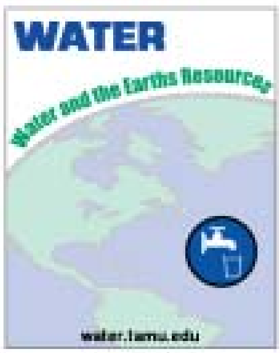
L-5468
10-05



Drinking Water Problems: Perchlorate

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Perchlorate is a chemical compound composed of one chlorine atom and four oxygen atoms. Perchlorate found in water systems can be either naturally occurring or the result of human activity. Perchlorate moves easily through water systems and can last for many decades under typical groundwater and surface water conditions. Sources of perchlorate contamination resulting from human activity include chemical fertilizers and various other chemical and industrial activities, such as the manufacture of ammonium perchlorate, an oxide component and the primary ingredient in solid propellant for rockets, missiles and fireworks. Perchlorate salts also are used on a large scale as a component of automobile airbag inflators.

Perchlorate was discovered at various manufacturing sites and in well-water and drinking-water supplies within several months following the April 1997 development of a low-level (4 ppb) detection method. Perchlorate releases have been confirmed in at least 25 states throughout the United States. The United States Environmental Protection Agency (EPA), other federal agencies, states, water suppliers and industry already are actively addressing perchlorate contamination through monitoring for its presence in drinking water and in source water. The full extent of perchlorate contamination is not known at this time. Figure 1 shows the results of a water-well sampling study Texas Tech University conducted on the Texas High Plains to identify perchlorate concentrations in groundwater (Figure 1).

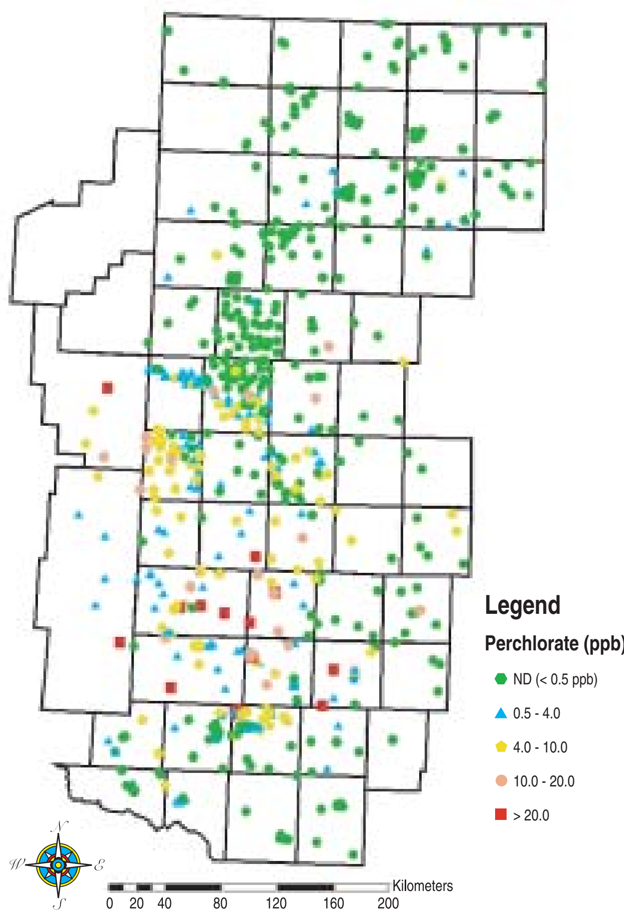

Figure 1. Distribution of perchlorate detections in water wells (Jackson, et. al. 2004).

Although the potential for perchlorate contamination has been estimated to affect drinking-water supplies of at least 12 million people in the United States, the effect of low-level, chronic exposure still is not fully understood. Currently, there is no National Primary Drinking Water Regulation (NPDWR) for perchlorate. Perchlorate was placed on the Office of Water Conta-minants' Candidate List in March 1998, with a note that additional research and information are required before regulatory determinations can be made.

What are the potential health effects of perchlorate?

Most people are exposed to perchlorate via their diets, because perchlorate is found in many agricultural products. For instance, the Food and Drug Administration (FDA) found iceberg lettuce grown in Belle Glade, Florida, to have 71.6 ppb of perchlorate. Some red leaf lettuce grown in California was found to contain 52 ppb of perchlorate.

Because some controversy surrounds the environmental and health effects of perchlorate, the National Research Council (NRC) was asked to assess potential adverse health effects of perchlorate ingestion. In a 2004 report, the NRC confirmed that perchlorate blocks iodide uptake by the thyroid. Iodide is an essential component in two hormones produced by the thyroid. These hormones are influential for growth and development in fetuses, infants and young children. This makes fetuses and newborns especially sensitive to perchlorate ingestion. People with compromised thyroid function resulting from conditions that reduce thyroid hormone production and people with iodide deficiencies also are considered to be populations potentially sensitive to perchlorate ingestion. Long-term change in the production of thyroid hormones can result in thyroid hypertrophy and hyperplasia and possibly in hypothyroidism in individuals who cannot compensate with an increasing thyroid iodide uptake. The NRC (2005) points out that fortunately the body has an efficient feedback-control mechanism to compensate for iodide deficiency, so it would probably take an iodide-uptake reduction of at least 75% for months or longer before adverse health effects would result. The NRC concluded ". . . *available epidemiological evidence is not consistent with a causal association between perchlorate and congenital hypothyroidism, changes in thyroid function in normal-birthweight, full-term newborns, or hypothyroidism or other thyroid disorders in adults.*"

Studies of thyroid health of both newborns and adults have concluded that present perchlorate environmental exposures levels do not appear to produce harmful effects. Regulatory agencies and other groups are now trying to determine a safe level of perchlorate in water. Following recommendations in the NRC (2005 report) report, the Environmental Protection Agency (EPA) has set a reference dose (RfD) of 0.0007 mg/kg per day. An RfD is an estimate of the maximum daily oral exposure that is likely to be without risk of adverse health effects to an individual during that individual's lifespan. The perchlorate RfD was derived from a study in which a maximum daily perchlorate dose of 0.007 mg/kg/day given to human volunteers did not inhibit iodide uptake. An uncertainty factor of 10 is applied to the dose to account for varying effects on sensitive population, resulting in a final RfD of 0.0007 mg/kg/day. This RfD could be used to figure action levels. For example, a person weighing 154 pounds (70 Kg) who drinks 2 liters of water per day could consume water containing up to 24.5 mg/L (ppb) of perchlorate without adverse effects. Texas' perchlorate advisory level was revised in 2005 to 17 ppb, although the prior advisory level of 4 ppb still is being used for public water systems.

For more information on this topic, see http://www.epa.gov/safewater/ccl

How can you remove perchlorate from well water?

Well owners can treat their water to remove perchlorate using reverse osmosis or ion exchange processes.

Reverse Osmosis (RO)

A reverse osmosis (RO) unit operates by passing water under pressure though a semi-permeable membrane. The membrane allows water to pass through but prevents perchlorate from doing so. Most RO units will have

- A prefilter to remove solids and extend membrane life;
- An activated carbon filter to remove odors, taste and chlorine;
- A semi-permeable membrane through which water flows under pressure;
- A tank to hold treated water; and
- A drain connection for discharging reject water produced.

However, RO units result in relatively poor water recovery. Most units are designed to recover 20 to 30 percent of the water processed. For example, if 100 gallons of water are treated, only 20 to 30 gallons will be useable; the rest of the water will be sent to a wastewater treatment system. Homeowners using on-site wastewater treatment should consider the impact this additional loading may have on their systems. Because of their inefficiency, RO units typically are used to treat only drinking and cooking water. Thus, system size should be based on the number of gallons to be used for these purposes each day. Typical RO unit production rates range from 5 to 15 gallons per day.

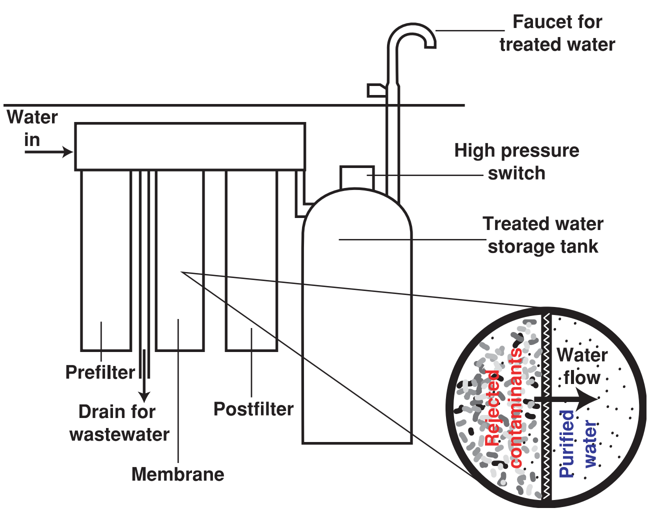

Figure 2. Reverse Osmosis Treatment Unit (Adapted from Kneen et al., 1995 and USEPA, 2003.

RO devices typically cost between $300 and $1,000. Unit installation takes from 30 to 60 minutes, assuming no significant plumbing modifications are necessary. The RO unit's semi-permeable membrane must be replaced according to its 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 life, cost of water production ranges from 5 to 10 cents/gallon, not accounting for costs of water wasted or costs, if any, of treating rejected water.

Ion Exchange

Ion (charged atom) exchange removes perchlorate from a water source by passing the water under pressure through one or more columns packed with a particular exchange resin. As perchlorate moves across the resin, an ion is released from the resin, and the perchlorate takes its place because the perchlorate ion is more strongly attracted to the resin exchange site than was the ion it replaced. Once all of the original ions have been replaced, the column is considered to be saturated and must be replaced. The used resin should be disposed of as a hazardous waste. It is not practical to attempt to regenerate the resin because it is extremely difficult to remove the perchlorate from it.

Resins designed for perchlorate removal are especially effective in ion-exchange units. Nitrate-selective-resins also effectively remove perchlorate. Selective resins can prevent perchlorate "dumping" as the ion-exchange-resin bed reaches saturation. Dumping refers to higher perchlorate concentrations being found in the effluent water than in the source water and occurs especially when source water contains sulfates. Resins developed for preferential nitrate exchange prevent sulfates from displacing or "dumping" nitrate or perchlorate as a resin bed reaches saturation.

For water sources containing large amounts of sulfates or of total dissolved solids (TDS), ion exchange may not be a good option for treating perchlorate. Presence of these constituents demands frequent resin replacement, dramatically increasing a system's operational costs. If source water requires treatment for nitrates as well as for perchlorate, a multiple-column system should be used. The first ion-exchange column will remove perchlorate, and the resin used will have to be replaced. Columns following the first in the series will remove nitrate, and these resin columns can be regenerated.

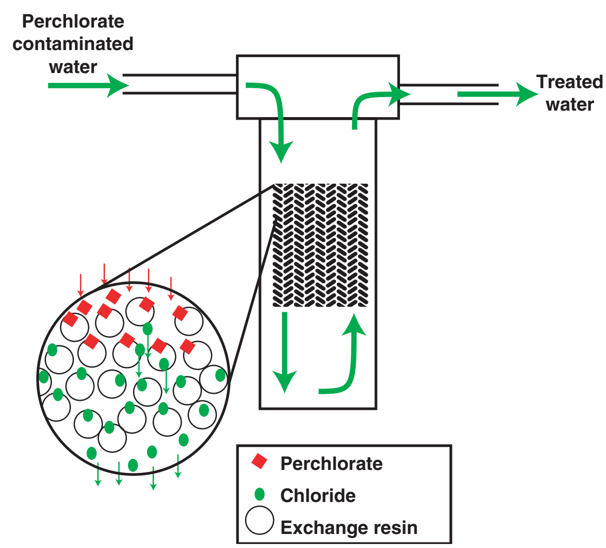

Figure 3. Ion Exchange Process (Adapted from Robillard et al., 2001).

An ion exchange unit costs between \$400 and \$1500. Operation and maintenance costs have been estimated to be \$0.02 per gallon of treated water.

How should a well owner select a treatment unit?

No single technology will treat all water contaminants. Before selecting a treatment option, well owners should test the water source, using a laboratory qualified to determine water quality. A list of labs certified by the Texas Commission on Environmental Quality (TCEQ) for testing drinking water can be found at: http://www.tnrcc.state.tx.us/permitting/waterperm/ pdw/chemlabs.pdf

Once you have established the constituents present in your water supply, research different products and find one suitable for treating these constituents. If you need multiple water treatment products to remove contaminants from your water, please remember to check how or if these different treatment products work together. For example, although the ion exchange process can be used to treat both nitrate and perchlorate, a system must be set up specifically to treat both. Compare initial costs, operation and maintenance costs and requirements, contaminant removal efficiency, warranties, life expectancy of the system and company reputation. Before making your final decision, also consider quantity of reject water 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 as to mechanical performance but not for ability to remove harmful contaminants. The National Sanitation Foundation (NSF) certifies products' ability to remove contaminants affecting health. A list of drinking-water treatment units with NSF certification can be found on the World Wide Web at: http://www.nsf.org /Certified/DWTU/. For questions regarding a particular product's certification, contact the NSF Consumer Hotline at 877-8-NSF-HELP or info@nsf.org or by writing to NSF International, P.O. Box 130140, 789 N. Dixboro Road, Ann Arbor, MI 48113-0140. An EPA registration number on a product indicates merely that the unit is registered with the EPA; this registration number does not imply EPA approval or certification.

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 and resin in ion exchange units must be replaced as necessary. All systems should be operated according to 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 treated water quality. Water output by treatment units should be tested regularly to ensure proper system operation.

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Acknowledgments

Guidance and assistance was provided by the Texas Groundwater Protection Committee and the Texas Commission on Environmental Quality. The effort was partially funded by the U. S. Environmental Protection Agency.

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This publication was funded by the Rio Grande Basin Initiative administered by the Texas Water Resources Institute of Texas Cooperative Extension, with funds provided through a grant from the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement No. 2005-45049-03209.

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