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Private Drinking Water Wells: Operation and Maintenance for a Safe Well

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This publication is one of six in a series designed to help rural families understand and manage their private drinking water wells.

Naturally Occurring Contaminants

Well water is never pure. Water naturally contains minerals and microorganisms from the rocks, soil, and air with which it comes in contact. Naturally occurring substances found in some Nebraska groundwater include hardness minerals such as calcium and magnesium, iron, manganese, fluoride, arsenic, and uranium.

Hard water minerals in drinking water are not a health risk. In fact, the National Research Council (National Academy of Sciences) states that hard drinking water generally contributes a small amount toward the total calcium and magnesium needed in the human diet. Hard water is a nuisance because of mineral buildup on plumbing fixtures and poor soap and/or detergent performance.

Iron and manganese in drinking water are not health risks. Of the two, iron is found more frequently in water supplies. Iron and manganese are nuisances because of mineral buildup on plumbing fixtures, reddish-brown (iron) and brownish-black (manganese) staining of laundry and dishes, and objectionable effects on the flavor and color of food and water. A problem that frequently results from iron or manganese in water is iron or manganese bacteria. These nonpathogenic (not health threatening) bacteria form red-brown (iron) or black-brown (manganese) slime as they feed on iron and manganese in water.

Fluoride exists in virtually all water sources. As with many substances, potential health effects are directly related to the concentration present in drinking water. Dental benefits from consuming water containing optimum levels of fluoride are well documented. The U.S. Public Health Service, Centers for Disease Control and Prevention, and the American Dental Association recommend an optimum level of 1.0 milligram per liter (mg/L), which also can be expressed as 1 part per million (ppm), to ensure potential benefits while minimizing or eliminating potential risks.

Varying amounts of arsenic are present in some groundwater sources. Arsenic exposure can cause a variety of adverse health effects. Studies summarized in a report by the National Research Council point to evidence that long-term ingestion of arsenic can increase the risk of skin, bladder, lung, kidney, liver, and prostate cancer. Noncancerous effects of ingesting arsenic may include cardiovascular, pulmonary, immunological, and neurological effects, as well as endocrine problems such as diabetes. The severity of the condition depends on how much arsenic is in the water, how much water is consumed, how long a person has been exposed to the water, and a person's general health. The U.S. Environmental Protection Agency (EPA) mandates a maximum contaminant level (MCL) for arsenic in public water supplies of 10 micrograms per liter (μg/L), which also can be expressed as 10 parts per billion (ppb). An MCL is the highest concentration of a contaminant allowed in water delivered to users of public drinking water supplies. If naturally occurring concentrations exceed the MCL, the water supplier must take action to reduce the concentration.

Uranium is a radioactive mineral present in certain types of rocks and soils found throughout the United States, including Nebraska. The health effects of uranium in drinking water depend on the concentration, how much water was consumed and for how long, as well as the age and general health of the individual. Studies suggest that ingesting high levels of uranium may be associated with an increased risk of kidney damage. The EPA mandates an MCL for uranium in public water supplies of 30 μg/L, which also can be expressed as 30 ppb.

Those who use water from private drinking water wells can have their water tested to determine if these or other naturally occurring contaminants are present in their water supply, and at what concentrations.

Also, see the following University of Nebraska–Lincoln Extension NebGuides

- Drinking Water: Arsenic
- Drinking Water: Fluoride
- Drinking Water: Hard Water (Calcium and Magnesium)

- Drinking Water: Iron and Manganese
- Drinking Water: Sulfur (Sulfates and Hydrogen Sulfide)
- Drinking Water: Uranium
- Drinking Water: Copper
- Drinking Water: Lead

Wellhead Protection

Human activities can add many more substances to water. The layers of soil, sand, and gravel above the aquifer provide some, but not complete, protection from contamination. Groundwater can be contaminated when pollution sources are not managed carefully. Two "introduced" contaminants of concern for private well water are nitrate and bacteria.

Nitrate in groundwater may result from point sources such as sewage treatment systems and livestock facilities, or from nonpoint sources such as fertilized cropland, parks, golf courses, lawns, and gardens. The EPA MCL for nitrate-nitrogen in a public water supply is 10 mg/L, which also can be expressed as 10 ppm. The acute health hazard associated with high nitrate in drinking water is the condition known as methemoglobinemia, sometimes referred to as "blue baby syndrome." In this condition, blood lacks the ability to carry sufficient oxygen to the individual body cells. Infants under one year of age have the highest risk of developing methemoglobinemia.

Bacterial contamination of drinking water supplies can result from animal waste in runoff from feedlots, dog runs, or other areas where animal wastes are deposited. Another source of bacterial contamination is human waste from failing septic systems or residential lagoons. Insects, rodents, or other animals entering the well serve as additional sources. Floodwaters that inundate or infiltrate a well commonly contain high levels of bacteria. Not all bacteria present a health risk. Those that are pathogenic can cause diarrhea, cramps, nausea, headaches, or other symptoms. It is not unusual for people to mistake a case of water-related disease for food poisoning or a "24-hour bug." While the EPA has designated total coliform bacteria as a standard to determine the safety of water with respect to bacterial contamination for public water supplies, *E. coli* bacteria is the definitive indicator of recent fecal contamination of water. An *E. coli* bacterium is the only member of the total coliform group that is found in the feces of warm-blooded animals, including humans.

For additional information, see the following UNL Extension NebGuides.

- Drinking Water: Bacteria
- Drinking Water: Nitrate-Nitrogen

Evaluating the activities around an acreage or farmstead and determining the location of potential contamination sources in relation to a drinking water well are both necessary to determine the potential risk to a water supply. The design and construction of structures and their location relative to a drinking water well, the condition of the well, and the storage and disposal of potential contaminants are important factors in assessing risks. By identifying contamination risks at an acreage or farmstead and taking action to reduce the risks, individuals can better protect drinking water from contamination from nitrate, bacteria, and other potential harmful substances.

For more information on what can be done to protect private drinking water supplies from contamination, see the UNL Extension NebGuide series on wellhead protection. The "Protecting Private Drinking Water Supplies" series helps individuals evaluate how acreage or farmstead activities might be affecting drinking water.

- Protecting Private Drinking Water Supplies: An Introduction
- Protecting Private Drinking Water Supplies: Water Well Location, Construction, Condition, and Management
- Protecting Private Drinking Water Supplies: Household Wastewater (Sewage) Treatment System Management
- Protecting Private Drinking Water Supplies: Hazardous Materials and Waste Management
- Protecting Private Drinking Water Supplies: Pesticide and Fertilizer Storage and Handling
- Protecting Private Drinking Water Supplies: Runoff Management

Water Testing

Testing a private water supply in Nebraska is not required by federal or state regulations. Regulatory exceptions occur where state licensing may be required for a specific activity. Local regulations may be more stringent than those issued by the state. Although not required, testing a private water supply is recommended. **There is no single test to determine the safety of drinking water.** Many naturally occurring or introduced contaminants can present a health risk if present in sufficient concentrations. Other contaminants, while not a health risk, can make water less desirable for domestic use. It would be costly, and in most cases unnecessary, to test private water supplies for all potential contaminants.

Users of private drinking water wells must decide which contaminants to test for and must order tests accordingly. A water testing laboratory only tests for specifically requested contaminant analysis. Reports will indicate if the contaminant is present in the water and at what concentration. Information will not be provided on contaminants for which analysis was not specifically requested.

Generally, private water supplies should be tested annually for nitrate and bacterial contamination. Consider requesting additional tests if contaminants have been found in neighbors' wells.

An initial nitrate test for any new water supply is recommended to determine the baseline concentration in the water source. Activities near a well potentially can contaminate the water supply, changing the nitrate concentration over time. Drinking water wells should be tested annually to monitor changes in nitrate concentration. In addition, a water test is recommended for households with infants, pregnant women, nursing mothers, or elderly people. These groups are believed to be the most susceptible to adverse health effects due to nitrate.

A variety of test kits and dip strips are available for nitrate testing outside of a laboratory environment. These might be used for preliminary screening. While an estimate of the nitrate concentration might be obtained, laboratory analysis is needed for an accurate and reliable nitrate measurement. A nitrate-testing kit can be obtained from a certified testing laboratory. The kit will usually include a sterilized sample bottle, an information form, and sampling instructions. The sample bottle for nitrate testing may contain a preservative to prevent any loss of nitrate in the sample. This sample bottle should not be rinsed before filling and should only be used for samples intended for nitrate analysis. It must be used within 90 days to ensure validity of the analysis. The sampling instructions provide information on how to collect the sample. Follow these instructions carefully to avoid contamination and to obtain a representative sample. Promptly mail or deliver the sample with the completed information form to the laboratory.

Coliform bacteria are most likely to be found during periods of wet weather when the soil is warm. Runoff and excess soil moisture carry contaminants into shallow groundwater sources or through well defects. Therefore, tests for bacteria should be conducted in the late spring or early summer during wet weather. Testing during extremely dry weather or when the ground is frozen may be less desirable. Lack of moisture migration through the soil reduces the likelihood of identifying contaminant risks.

A bacteria test kit can be obtained from a certified testing laboratory. The kit will usually include a sterilized sample bottle, an information form, and sampling instructions on how to collect the sample. Follow these instructions carefully to avoid contamination and to obtain a representative sample. Promptly mail or deliver the sample with the completed information form to the laboratory.

The best location to collect a water sample is at the tap used most frequently for drinking and cooking. If contaminants are found, inspect the water system for defects and, if necessary, collect additional samples at other locations to determine if the impurities are entering at the well or through defects in the plumbing system.

Take care when sampling for bacterial contaminants. Do not touch the inside of the bottle or lid when taking the sample. Most laboratories recommend removing the aerator from an interior faucet before collecting a bacteria water sample, and some recommend disinfecting the faucet with heat or chlorine before collection. Follow directions carefully or use the services of a professional.

Test for bacterial contamination any time users of the water supply experience recurring bouts of intestinal illness or when an infant, person with a compromised immune system, or elderly person starts using the water. In addition, test for bacterial contamination when repairs or alterations are made to the well or water system, when activating a well or water system that has not been used for an extended period of time, and following shock chlorination.

Testing for nitrate and bacteria does not guarantee the water is safe, as other contaminants could be present. Tests should be done for other suspected contaminants. Contaminants might be suspected as the result of a spill, backflow, use of product in close proximity to the well, or other such event. If any contaminant is detected in a nearby private or public well, wells in close proximity should be tested. For additional information, see the following UNL Extension NebGuides.

- Drinking Water: Testing for Quality
- Drinking Water: Certified Water Testing Laboratories in Nebraska

Managing Water Quality Problems

If water quality is less than desirable, consider options such as having a new well drilled, repairing the existing well, or removing the source of contamination. For example, the presence of bacteria in the water does not necessarily mean the groundwater is contaminated. There could be a problem with the well construction, operation, or maintenance allowing surface water and contaminants to enter the well. The problem may be correctable. If the water is contaminated with nitrate, a deeper well might produce water with nitrate of a lower concentration. Since the risk from nitrate is from ingestion, using bottled water for cooking and drinking might be another option. The well water still could be used for cleaning and bathing.

When drinking water contains contaminants making it either unsafe or aesthetically unacceptable, water treatment can often reduce or remove contaminants. When considering water treatment, realize that there is no one piece of treatment equipment that manages all contaminants. All treatment methods have limitations. The treatment system that is best for any particular household depends on the contaminant(s) present, the concentration(s) of each, the size of the household, the age and health of its occupants, and maintenance and operational requirements of the system. There also may be situations in which a combination of treatment methods is most effective. With any treatment system, regularly scheduled maintenance helps ensure proper performance of the system.

Treatment systems can be classified as either Point-of-Use (POU) or Point-of-Entry (POE). POU devices treat water at the point it is used, such as the faucet. This allows treatment of water used only for drinking and cooking. POE devices treat water as it enters the household; all water used within the house is treated. This is important if a contaminant can be absorbed through the skin or by inhalation during bathing, showering, or other times of water contact. It is also important when managing substances that may cause staining, mineral deposits, or other problems in the water distribution system. Choose a treatment option that will remove the specific contaminants of concern. Some common treatment options include sediment filters, activated carbon filters, oxidizing filters, and reverse osmosis, distillation, ion exchange, oxidizing-filtering, and chlorination units. Sediment filters are commonly used to remove suspended material such as sand, silt, loose scale, clay, or organic material from water. Sediment filters often are used in combination with another drinking water treatment method to remove contaminants such as dissolved iron, manganese, or hydrogen sulfide. Initial treatment oxidizes dissolved iron, manganese, or hydrogen sulfide into solid particles that are then trapped by the filter. Sediment filters also are used as pre-treatment for other processes such as activated carbon filtration and reverse osmosis in order to increase their effectiveness. Sediment filters can be POU or POE units.

Activated carbon (AC) filters are commonly used to improve the taste and odor of water. AC filters can reduce the levels of many organic chemicals such as solvents, pesticides, and industrial wastes. Only very specialized AC filters effectively adsorb heavy metals, such as lead. Radon, a radioactive decay product of natural uranium, can be removed by AC filtration, though removal rates for different types of AC equipment have not been established. AC filters can be POU or POE units.

Reverse osmosis (RO) membrane filters are commonly used to reduce the nitrate concentration in drinking water. RO units can effectively reduce total dissolved solids and many contaminants including arsenic and uranium. While RO units can remove microorganisms, they are not recommended for that use. Only coliform-free water should be fed to the system because bacteria may cause the membrane to deteriorate, and contamination may occur through pinhole leaks. RO units are POU.

Distillation can remove nearly all impurities from water. Compounds removed include sodium, hardness compounds such as calcium and magnesium, fluoride, nitrate, and other dissolved solids including iron and manganese. Operated properly, it effectively inactivates microorganisms such as bacteria, viruses, and protozoa. Distillation also can remove many organic compounds and heavy metals. Distillers are POU units.

Ion exchange water softeners can remove nearly all calcium and magnesium from source water. Softeners may also remove as much as 5-10 ppm of iron and manganese. Do not depend on a softener to remove large amounts of iron and manganese, as the increased use and backwashing may cause problems with a septic system. Consumers can check the manufacturer's rating for removal of these contaminants. Ion exchange water softeners are POE units.

Oxidizing filters and two-part oxidizing-filtration systems are commonly used to remove iron or hydrogen sulfide. Oxidizing filters and oxidizing-filtration systems are POE units.

Shock chlorination is the one-time introduction of a strong chlorine solution into the entire water distribution system (well, pump, distribution pipeline, hot water heater, etc.), allowing adequate disinfection contact time, and flushing the system to remove the chlorine. Shock chlorination is conducted by adding the appropriate amount of chlorine at the well.

Shock chlorination is an effective one-time treatment method to eliminate pathogenic bacteria in drinking water supplies. In addition, shock chlorination can be effective in managing iron, manganese, and/or sulfur bacteria. These nonpathogenic bacteria feed on the minerals in water.

Continuous chlorination involves the injection of chlorine into the drinking water supply over time with use of a chemical feed pump, an injection device, or a tablet chlorinator. With an adequate chlorine concentration and sufficient contact time, continuous chlorination can effectively disinfect drinking water containing pathogenic bacteria, viruses, and other microorganisms. It also can be used to manage nuisance bacteria such as iron, manganese, and/or sulfur bacteria. In addition, chlorine will oxidize iron and manganese so they can be filtered out, and will oxidize hydrogen sulfide to reduce nuisance odors. Continuous chlorination is POE treatment.

For additional information on some of these water treatment systems see the following UNL Extension NebGuides.

- Drinking Water Treatment: Sediment Filtration
- Drinking Water Treatment: Activated Carbon Filtration
- Drinking Water Treatment: Water Softening (Ion Exchange)
- Drinking Water Treatment: Reverse Osmosis
- Drinking Water Treatment: Continuous Chlorination
- Drinking Water Treatment: Shock Chlorination

Summary

Well water is never pure. Water can contain naturally occurring and introduced contaminants. Nuisance properties and potential health effects associated with a water source are directly related to the contaminants present and their concentrations. Potential sources of contamination should be identified and managed to reduce risk to the water supply. Although not required by federal or state regulations, testing a private water supply annually for bacteria and nitrate, and as needed for other suspected contaminants is recommended. Water quality problems might be managed by repairing an existing well, removing the source of contamination, drilling a new well, or utilizing appropriate water treatment.

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