

## Drinking Water: Bacteria

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Bacteria in drinking water can endanger health. Learn how contamination occurs, how to have water tested, and which treatment to use. Viruses or other microbial organisms are not addressed.

The presence of pathogenic (disease-causing) organisms (bacterial or parasitic) in drinking water is a concern. Pathogenic organisms can cause flu-like symptoms, intestinal infections, dysentery, hepatitis, typhoid fever, cholera, and other illnesses.

### Sources of Bacteria in Drinking Water

Bacterial contamination of drinking water supplies, including groundwater, can result from a number of sources:

*Human and animal wastes.* Sources of this type of bacterial contamination include runoff from feedlots, pastures, dog runs, and other land areas where animal wastes are deposited. Additional sources include waste from improperly designed, located, installed, or maintained septic systems or residential lagoons.

Bacteria from these sources can enter wells, particularly wells that are open at the land surface, do not have watertight casings (linings) or caps, or do not have a grout seal in the annular space (the space between the wall of the drilled well and the outside of the well casing). Natural treatment occurs as water percolates downward through layers of soil, sand, and gravel. Due to this natural treatment process, bacteria are not likely to move into groundwater serving as the source of drinking water for deep, drilled wells with proper grout seals in the annular space. Bacteria could move into groundwater supplying drinking water in shallow wells; however, bacteria generally do not travel readily through geological formations in Nebraska.

*Insects, rodents, or animals entering the well.* Old wells were dug by hand and cased with rocks or bricks. These wells usually have large openings and casings that often are not sealed well. This makes it easy for insects, rodents, or animals to enter.

*Floodwaters that inundate or infiltrate a water supply.* Floodwaters commonly contain high levels of bacteria. Small depressions filled with floodwater provide an excellent breeding ground for bacteria. Whenever floodwaters or

surface runoff inundates a well, bacterial contamination is likely. Shallow wells and wells that do not have watertight casings can be contaminated by bacteria infiltrating with the water through the soil near the well, especially in coarse-textured soils.

Older water systems, especially dug wells, spring-fed, and cistern-type systems are most vulnerable to bacterial contamination. Any wells with casings or caps that are not watertight or lack a grout seal in the annular space are vulnerable. This is particularly true if the well is located such that surface runoff might be able to enter the well. Also, wells are vulnerable when located near a bacteria source in an area with sandy soil or shallow depth to groundwater. Domestic well construction standards in Nebraska have been in place since 1984. Updates and improvements have occurred since then to further protect new wells from bacterial contamination.

### Indications of Bacteria

Bacterial contamination cannot be detected by sight, smell, or taste. The only way to know if a water supply contains bacteria is to have it tested by a qualified laboratory.

All water has bacteria. The presence of bacteria does not mean the water is unsafe to drink. Only disease-causing bacteria known as pathogens lead to disease. Commonly tested bacteria include:

*Total coliform bacteria* is a group of different kinds of bacteria. Total coliform are commonly found in the environment, including soil, vegetation, and untreated surface water.

*Fecal coliform bacteria* is a subgroup of the total coliform group. They exist in great quantities in the intestines and feces of humans and other warm-blooded animals. The presence of fecal coliform in drinking water is a strong indication of recent sewage or animal waste contamination.

*Escherichia coli (E. coli)* bacteria is a subgroup of fecal coliform. *E. coli* outbreaks related to food contamination have received media attention. These outbreaks are often caused by a specific strain of *E. coli* known as Shiga toxin-producing *E. coli* (STEC). When a drinking water sample is reported as "*E. coli*

present,” it does not necessarily mean that this specific strain is present. However, it does indicate recent fecal contamination, which should be interpreted as an indication that there is a greater risk that pathogens are present.

*Heterotrophic bacteria* are non-coliform species of bacteria that use an organic substance for their development. Heterotrophic bacteria can be widespread throughout a water system. The presence of heterotrophic bacteria in drinking water is not an indication that the water presents a health risk. Rather, no specific significance or health standards are associated with these nonpathogenic, non-coliform bacteria.

### Potential Health Effects

Total coliform bacteria are generally not harmful. Fecal coliforms and *E. coli* bacteria indicate the water may be contaminated with human or animal wastes, and may contain additional microbes associated with fecal matter. Some microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. Infants, young children, some of the elderly, and people with severely compromised immune systems may be more susceptible than the general public. Other microbes can cause more severe illness, including intestinal infections, hepatitis, typhoid fever, and cholera.

### Testing

#### Testing Public Water Supplies

Testing a water sample for all individual pathogens is impractical and expensive. Instead, the Environmental Protection Agency (EPA) has designated total coliform bacteria as a standard method to determine the safety of water with respect to bacterial contamination.

Total coliform bacteria are found naturally in water, soil, and vegetation as well as in feces. Total coliform bacteria react to the natural environment and treatment processes in a manner and degree similar to pathogens. Due to this association, the bacterial safety of drinking water is monitored by testing for total coliform bacteria.

If test results for total coliform are positive, testing for *E. coli* bacteria is initiated. *E. coli* bacteria is the definitive indicator of recent fecal contamination of the water. *E. coli* bacteria is the only member of the total coliform group that is found in the feces of warm-blooded animals and humans, and not in the environment. The absence of *E. coli* in drinking water indicates that the water is free of intestinal disease-causing bacteria. In some cases, public water supplies may be tested simultaneously for total coliform bacteria and *E. coli* bacteria.

*The EPA requires that all public water suppliers regularly test for bacterial contamination and deliver water that meets the EPA standards.* How often testing occurs depends on the size of the population served. Bacteria test results are available from the water supplier. Public notice must be given by the water supplier if the water does not meet standards.

#### Testing Private Water Supplies

The quality of water from a private water supply in Nebraska is not regulated by federal or state statutes. Owners or users of private water supplies are responsible for having their water supply tested on a voluntary basis to ensure it is safe from bacterial contamination. Exceptions exist, such as when a residence is also a licensed child care facility or an approved foster home. Often, lending agencies require that private water supplies be tested for bacteria and nitrate

before home loans, including refinancing, will be approved. **It is recommended that private wells be tested for total coliform/*E. coli* and nitrate annually.**

Bacterial testing is provided confidentially and for a fee by the Nebraska Department of Health and Human Services (DHHS) Public Health Environmental Laboratory, some city/county health department laboratories, and some commercial water testing laboratories. See the NebGuide *Drinking Water: Approved Water Testing Laboratories in Nebraska* (G1614) for a list of certified laboratories in Nebraska that provide bacterial testing.

Many labs use an advanced technology, Colilert® Method, that allows water samples to be tested simultaneously for the presence or absence of total coliform and *E. coli*. Colilert test results are available after 24 hours. Some labs also offer the Colilert Quanti-Tray® testing method that takes 24 hours and produces a number measurement of total coliform and/or *E. coli*, if present. A few laboratories use membrane filter technology. Membrane filtration takes 24 hours to test if a negative result occurs, but up to an additional 48 hours to confirm positive test results for total coliform and *E. coli*. The membrane filtration method also provides a number measurement.

The Nebraska DHHS recommends use of the Colilert method because it has the fastest analysis time. In some cases, the use of a method (e.g., Quanti-Tray or membrane filtration) that provides a number measurement of total coliform or *E. coli* may be helpful. For example, when tests confirm the presence of bacteria after shock chlorination of a well, tests that provide a number measurement can tell if progress is being made in eliminating bacteria.

Private well owners/water users can contact their laboratory of choice to obtain a confidential drinking water bacterial purity test kit. The kit will contain a sterilized sampling bottle, an information form, sampling instructions, and a return mailing box. Using the bacterial test kit is necessary to help ensure the test is accurate. The bottle in the kit is completely sterilized to assure the sample is not contaminated by bacteria in the bottle. Using any other container could significantly skew results or could result in the water not being tested.

Generally, private water supplies should be tested for bacterial safety:

- at least once a year;
- when a new well is constructed;
- when an existing well that has not been used is returned to service;
- any time a component of the water system is opened for repair — the water system includes the well, pump, pressure tank, piping, and any other components the water will contact;
- whenever the well is inundated by flood waters or surface runoff;
- whenever bacterial contamination is suspected, as might be indicated by continuing illness; and
- when a laboratory test indicates high nitrate and human or livestock waste is suspected.

The test kit contains detailed instructions on how to collect the water sample. Instructions must be followed carefully to avoid outside contamination and to obtain a good representative sample. To avoid unnecessary delays and possibly a need for resampling, the sample should be mailed or carried to the laboratory immediately. The sample must be received at the

laboratory within 30 hours after collection or it will not be tested. Samples should not be mailed when they may be delayed over a weekend or a holiday. In most cases, samples need to arrive at the laboratory Monday through Thursday.

The form accompanying the sample must be accurate and complete. If there is no date or time of collection on the form, it will be assumed the sample is more than 30 hours old. If there is no return address, test results cannot be delivered.

## Interpreting Test Results

### Public Water Supply Test Results

The EPA establishes standards for public drinking water that fall into two categories — *Primary Standards* and *Secondary Standards*.

*Primary Standards* are based on health considerations and are designed to protect people from three classes of toxic pollutants: pathogens, radioactive elements, and toxic chemicals. Primary standards are enforced.

*Secondary Standards* are based on aesthetic factors such as taste, color, odor, corrosivity, foaming, and staining properties. Secondary standards are not enforced.

Bacterial contamination falls under the Primary Standards category of pathogens. The EPA Maximum Contaminant Level (MCL) for total coliform bacteria in drinking water is zero (or no) total coliform per 100 milliliters of water. Testing is always performed for total coliform and *E. coli* bacteria. A water sample testing positive for total coliform bacteria is not necessarily unsafe for consumption. A water sample testing positive for *E. coli* indicates recent fecal contamination, an indication that there is a risk that pathogens are present. The water is considered unsafe for human consumption, and a “boil water” advisory will be issued to the public by the water supplier.

Current regulations for management of public drinking water supplies for bacteria were enacted in 1989. The EPA revised the rule in 2012. However, the 1989 standards summarized in this publication remain effective through March 31, 2016.

### Private Water Supply Test Results

Depending upon the methodology, water test results may be reported as “present or absent” to indicate whether or not bacteria was detected or as a number to indicate the bacteria count detected. A “present or absent” designation might be given for total coliform, fecal coliform, *E. coli*, or a combination. The presence of total coliform in drinking water can be attributed to natural environmental presence, and is generally not harmful. The presence of fecal coliform or *E. coli* in drinking water is a strong indication of recent sewage or animal waste contamination.

While EPA and Nebraska regulations do not apply to private drinking water wells, users of private drinking water supplies may voluntarily compare test results to the EPA guidelines in assessing the risk associated with their water supply.

## Options

### Options for Public Water Supplies

The EPA requires that all public water suppliers provide water that meets the EPA standard for bacteria. Public notification is made if total coliform and/or *E. coli* are present. The water supplier must immediately implement steps to provide safe water. If a “boil water” advisory is issued, water users should boil water for drinking and food preparation and follow

the directions provided by the local public health department or water utility.

### Options for Private Water Supplies

If total coliform and/or *E. coli* bacteria are present (i.e., any positive detection or number above zero), an effort should be made to (1) reduce the risk of bacterial contamination and (2) provide safe water until the source has been addressed. Both issues are discussed below.

### Reducing the Risk of Bacterial Contamination

When test results indicate the presence of bacteria, attempts should be made to identify and eliminate contributing factors. Both well location and well construction should be evaluated.

#### Well Location

The location of a well is a crucial safety factor. A well downhill from a source of bacterial contamination has a greater risk of contamination from surface runoff than a well on the uphill side of the pollution source. Good well location is encouraged by requiring minimum separation distances from sources of potential contamination, thus using the natural protection provided by soil. Separation distances reduce the risk for bacterial contamination, as well as the risk from contamination from viruses or other microbial organisms. The following separation distances reflect Nebraska standards and are based on typical Nebraska geology.

The well should be located:

- at least 50 feet from a septic tank or any non-watertight sewer line;
- at least 100 feet from any drainfield, seepage pit, cesspool, or other wastewater subsurface disposal system;
- at least 100 feet away from any feedlot, manure pit, or manure or sewage lagoon; and
- uphill from potential sources of bacterial contamination.

#### Well Construction

Proper well design reduces the risk of pollution from bacteria, and also viruses or other microbial organisms, by sealing the well from contaminants that might enter from the surface. The way in which a well was constructed and is maintained, even if the design was sound, affects its ability to keep out contaminants. The following well construction checklist is based on Nebraska water well standards.

- The well should have a watertight casing, preferably of heavy-gauge metal or NSF (formerly National Sanitation Foundation) approved plastic.
- All joints in the well casing should be screwed, welded, or otherwise properly sealed.
- The well casing should extend at least 12 inches above the grade of the land surface.
- A sanitary well cap should be used on the casing and should be tightly secured.
- Pitless installation should be used, or if pit installation of pumping and storage equipment is used, the pit should be at least 10 feet away from the well.
- The ground surface should slope/drain away from the well.
- The well casing depth should be at least 10 feet below the static water level or at least 25 feet deep in sand and gravel, 30 feet in sandstone, or 40 feet in bedrock, whichever is deeper.

Driven (also called sandpoint) wells are not acceptable or legal. Driven wells are those constructed by driving assembled lengths of pipe into the ground in loose soil such as sand. These wells are normally 2 inches or less in diameter and less than 50 feet deep. Poor design and vulnerable aquifers associated with driven wells make them susceptible to contamination. Industry professionals may be able to correct problems and/or possible “weak links” regarding well location or construction.

### What to Do if Bacteria Is Present

After addressing contributing contamination sources and well location and construction, the entire water system should be disinfected using shock chlorination. Shock chlorination involves placing a strong chlorine solution in the well and the complete distribution system to kill nuisance and disease-causing organisms. After shock chlorination, another water sample should be submitted for testing. The water should test negative before use. More than one shock chlorination treatment may be needed to effectively treat the entire water supply. For more information, see the NebGuide *Drinking Water Treatment: Shock Chlorination* (G1761).

If the source of bacterial contamination or well construction errors cannot be identified and eliminated, continuous disinfection of the water supply may be necessary. Options include: continuous chlorination, ultraviolet radiation, distillation, and ozone treatment. Chlorination is the most common disinfection method. For more information on continuous chlorination, see the NebGuide *Drinking Water Treatment: Continuous Chlorination* (G1496).

### Providing Safe Water Until the Source Has Been Addressed

If laboratory tests confirm the presence of either total coliform or fecal bacteria (e.g., fecal coliform or *E. coli*) in a private water supply, an alternative water supply can be used, or the water supply can be disinfected for drinking and food preparation until further testing is negative for the presence of the bacterial contamination. Generally, untreated water can be used for showering and bathing as long as the water is not swallowed.

For short-term disinfection of water for drinking and food preparation, it is highly recommended to boil the water. Heat kills microorganisms and is the oldest effective means of disinfecting drinking water. Water must be brought to a vigorous rolling boil for 1 minute, which includes an adequate safety factor for Nebraska locations. Boiling any longer will concentrate other chemical contaminants that may be present, such as nitrate. Some publications may recommend boiling water for longer periods of time. The different time recommendations, if based on sound science, are due to different elevations being taken into account. Since water boils at a lower temperature as elevation increases, the Centers for Disease Control and Prevention recommends boiling for 3 minutes at altitudes above 6,562 feet (2,000 meters). The highest point in Nebraska is Panorama Point at 5,424 feet.

Household chlorine bleach that does not have scents or other additives can be used for disinfecting small amounts

of water used for dishwashing. Washed dishes should be air-dried. The percent sodium hypochlorite in the bleach should be between 4 and 6 percent. For clear water, six drops per gallon of water should be added using a medicine dropper. Very cloudy water should be strained through a clean cloth, and then a larger disinfectant dose of 16 drops per gallon (four drops per quart) should be added. The water should be stirred and left covered for 30 minutes. For adequate disinfection, the water should have a light chlorine odor after the 30-minute waiting period. If this odor is not present after 30 minutes, the dose should be repeated and the water should stand covered for another 15 minutes. While this water treatment method makes water safe for drinking and cooking purposes, heat treatment (boiling) may produce a more palatable product.

### Summary

Bacterial contamination of drinking water can be a problem. A water test is the only way to evaluate whether bacteria is present in a water supply. Public water suppliers must test water for bacteria and comply with the EPA standard of zero total coliform per 100 ml of water. Managing and testing a private water supply for bacteria is at the discretion of the well owner and/or water user. Properly locating and constructing a well are key to avoiding bacterial contamination of drinking water. If contamination is present in a private water supply, attempts should be made to identify and eliminate contributing factors. A contaminated water supply can be disinfected.

If site-specific recommendations provided by a water utility, state, or local public health department differ from the recommendations in this guide, the local information should be followed. These officials will be familiar with site- and event-specific conditions.

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