NebGuide

University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

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G1826

Drinking Water: Bacteria

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University of Nebraska–Lincoln Extension and the Nebraska Department of Health and Human Services place a high priority on water quality and jointly sponsor this series of educational publications.

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) is a concern when considering the safety of drinking water. 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 water-tight casings 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. 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 lined (cased) with rocks or bricks. These wells usually have large openings and casings that often are not well sealed. 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 well 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 so 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 a presence of bacteria. The presence of bacteria does not mean the water is unsafe to drink. Only disease-causing bacteria known as pathogens lead to disease. The following definitions may prove helpful.

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 are a sub-group of the total coliform group. They exist in great quantities in the intestines and feces of humans and 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 sub-group of fecal coliform. *E. coli* outbreaks related to food contamination have received media attention. These outbreaks are caused by a specific strain of *E. coli* known as *E. coli* 0157:H7. 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 utilize an organic substance for its 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 non-pathogenic non-coliform bacteria.

Potential Health Effects

Total coliform bacteria are generally not harmful. Fecal coliforms and *E. coli* bacteria indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems.

Testing

Testing Public Water Supplies

Testing for all individual pathogens is impractical and expensive. Instead, the Environmental Protection Agency (EPA) has designated total coliform bacteria as a standard 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.

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.

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 is not regulated. Owners 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 publication *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.

Contact the laboratory of your 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 will result in the water not being tested.

The test kit contains detailed instructions on how to collect the water sample. Follow the instructions carefully to avoid outside contamination and to obtain a good representative sample. To avoid unnecessary delays and possibly a need for resampling, mail or carry the sample to the laboratory immediately. The sample must be received at the laboratory within 30 hours after collection or it will not be tested. Avoid mailing samples when they may be delayed over a weekend or a holiday. In most cases, samples need to arrive at the laboratory Monday through Thursday.

Be sure the form accompanying the sample is accurate and complete. If there is no date or time of collection on the form,

it will be assumed the sample is over 30 hours old. If there is no return address, tests results cannot be sent to you.

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 which 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;
- when a laboratory test indicates high nitrate and human or livestock waste is suspected.

Interpreting Test Results

Public Water Supply Test Results

The EPA establishes standards for public drinking water which 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.

Bacterial contamination falls under the 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.

Private Water Supply Test Results

Depending upon the methodology, water test results may be reported as "present or absent" or as a number to indicate whether or not bacteria was 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 environmental, 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 detected, an effort should be made to (1) identify and eliminate the source of contamination and to (2) provide safe water until the source has been addressed. Both issues are discussed below.

Identifying and Eliminating Source of Contamination

When test results indicate the presence of bacteria, attempt to identify and eliminate the source of contamination. Do so by evaluating both well location and well construction. Check the entire water distribution system for potential problem areas.

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 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.

To evaluate well location, ask the following questions. You should be able to answer "yes" to all of the following.

- Is the well located at least 50 feet from a septic tank or any nonwatertight sewer line?
- Is the well located at least 100 feet from any drainfield, seepage pit, cesspool, or other wastewater subsurface disposal system?
- Is the well located at least 100 feet away from any feedlot, manure pit, manure or sewage lagoon, or livestock lot?
- Is the well located uphill from potential sources of bacterial contamination?
- Is the well casing depth 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?

Proper well design reduces the risk of pollution from bacteria, as well as viruses or other microbial organisms, by sealing it 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.

To evaluate well construction ask the following questions which are based on Nebraska water well standards. You should be able to answer "yes" to all of the following.

- Does the well have a watertight casing, preferably of heavy-gauge metal or NSF (formerly National Sanitation Foundation) approved plastic?
- Are all joints in the well casing screwed, welded or otherwise properly sealed?
- Does the well casing extend at least 12 inches above the grade of the land surface?
- Is a sanitary well cap used on the casing?
- Is pitless installation used, or if pit installation of pumping and storage equipment is used, is the pit at least 10 feet away from the well?
- Does the ground surface slope/drain away from the well?

Driven and 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 vulnerable to contamination.

Consult an industry professional and, if possible, correct any problems and/or possible "weak links" regarding well location or construction.

After addressing the contamination source, disinfect the entire water system 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, submit another water sample 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.

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 your water supply, use an alternative water supply or disinfect your water supply 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. Bring water to a vigorous rolling boil for one minute, which includes an adequate safety factor. Any longer will concentrate other chemical contaminants that may be present, such as nitrate. Since water boils at a lower temperature as elevation increases, the Centers for Disease Control and Prevention recommends boiling for three minutes at altitudes above 6,562 feet (2,000 meters).

For disinfecting small amounts of water used for dishwashing you can use household chlorine bleach that does not have scents or other additives. After washing dishes, air dry utensils. The percent sodium hypochlorite in the bleach should be between 4 and 6 percent. For clear water, add six drops per gallon of water 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. Stir the water and let it stand covered for 30 minutes. For adequate disinfection, the water should have a light chlorine odor to it after the 30 minute waiting period. If this odor is not present after 30 minutes, repeat the dose and let it stand covered 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, attempt to identify and eliminate the source of the contamination. 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.

Acknowledgment

This revision is based on the original NebGuide by Sharon O. Skipton, Extension Water Quality Educator; Paul J. Jasa, Extension Engineer; David L. Varner, Extension Educator; and DeLynn Hay, former Extension Water Resources Specialist.

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