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Research-Based Information That You Can Use

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Drinking Water Contaminants: Bacteria

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The presence of fecal 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.

Testing drinking water for fecal bacteria or E. coli is commonly used as an indicator of the presence of pathogenic microorganisms. The presence of pathogenic (disease-causing) microorganisms is a concern when considering the safety of drinking water. Pathogenic microorganisms can cause flu-like systems, 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 can be a source of bacteria in drinking water, including groundwater sources. These sources 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 either open at the land surface, or do not have watertight 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 for shallow wells. However, bacteria generally do not travel readily through geological formations in Nebraska.

Insects, rodents or animals entering the well are other sources of contamination. 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 the well.

Another way bacteria can enter a water supply is through inundation or infiltration by floodwaters. 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 lacking 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 an accredited laboratory.

The presence of bacteria in water 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 themselves. Fecal coliforms and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Human or animal wastes may contain not only pathogenic bacteria, but also pathogenic viruses and protozoan cysts. 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.

All water has a presence of bacteria. No specific sanitary significance or health standards have been indicated for the presence of non-pathogenic non-coliform bacteria in drinking water supplies.

Testing

Testing Public Water Supplies

Testing for all individual pathogens is impractical and expensive. Instead, the U.S. 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 feces. Total coliform bacteria react to the natural environment and treatment processes in a manner and degree similar to pathogens. Due to this association, 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 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. Frequency of testing 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 private water supplies be tested for bacteria and nitrate before home loans will be approved, including refinancing a loan.

Bacterial testing is provided on a confidential basis and for a fee, by the Nebraska Department of Health and Human Services Public Health Environmental Laboratory, some city/county health department laboratories, and some

commercial water testing laboratories. See the publication "*Drinking Water: Certified Water Testing Laboratories in Nebraska*" for a list of certified laboratories in Nebraska that provide bacterial testing for drinking water supplies. This means that recognized, standard test and quality control procedures are used. Most labs, including certified labs use an advanced technology (Colilert Method) that allows water samples to be tested for Total coliform and E. coli simultaneously. Test results are available after 24 hours. . It is recommended that private wells test for total coliform/E. coli and nitrate on an annual basis. The bacteria kit that a private well owner should request is Coliform by Quanti-tray. This test will give a number result rather than presence/absence. Having an actual count result is helpful in assessing the potential problem.

Contact the certified laboratory of your choice to obtain a confidential drinking water bacterial test kit. The kit will contain a sterilized sampling bottle, an information form, sampling instructions, and a return mailing box. Use of 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. The use of 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 as follows:

- when a new well is constructed;
- at least once a year post construction;
- 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 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, but may be adopted by some states.

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 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 2016.

Private Water Supply Test Results

Depending upon the methodology, water test results may be reported as "Present or Absent" or 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 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. In the event of a positive coliform result, repeat samples and an assessment is conducted to identify the possible presence of sanitary defects and defects in the distribution system's coliform monitoring practices. If a sample is positive for E. coli, repeat samples, assessment, and public notification of a boil water advisory is issued. The water supplier must immediately implement steps to provide safe water. If a "boil water" advisory is issued, water users should disinfect water for drinking and food preparation accordingly 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 water well construction standards and are based on Nebraska geology.

The well should be located:

- at least 50 feet from a septic tank or any non-water tight sewer line;
- at least 100 feet from any drain field, 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 potable water well construction standards.

- A well must not be located in a well pit.
- Protection: All water wells must be protected from surface drainage,
- flooding and seepage from sources of contamination and pollution by:
    - Locating the well site to promote drainage away from the well, and
    - Terminating the top of the well and vent above the 100 year flood plain, or
    - Locating on a berm and/or within a dike to protect the well from a 100 year flood, or
    - Plugging the vent and seal at the top of the well if yield is less than 50 GPM.
- The top of the well must extend at least 12 inches above the grade of

- the land surface. The earth surrounding the well must slope away from the well and
- must be firmly tamped to prevent water from seeping down the casing.
- 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.
- 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.

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 dis-infecting 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. Management of a private water supply for bacteria is a decision made by the well owner and/or water user. Proper well location and construction are keys 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.

This publication is a revision of Drinking Water, 2013, NebGuide G1826, by Sharon O. Skipton, Extension Water Quality Educator; Bruce I. Dvorak; Paul J. Jasa, Extension Engineer; David L. Varner, Extension Educator; DeLynn Hay, former Extension Water Resources Specialist; Wayne Woldt, former Extension Specialist; and Sherry Wirth, former Drinking Water Program Specialist, Nebraska Department of Health and Human Services .

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