Agricultural Extension Service
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Drinking Water Quality in Minnesota

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Drinking water quality is of particular concern to those with private water supplies. Nitrates and coliform organisms are two indicators of drinking water contamination, and sulfates and iron also can be troublesome. This publication will discuss recommended minimum levels of these substances as well as consequences of human consumption or use of water containing greater than minimum levels.

NITRATES

A nitrate (NO_3^-) is a chemical ion composed of one atom of nitrogen and three atoms of oxygen. Since the NO_3^- ion has a negative charge it must combine with a cation such as potassium (K), sodium (Na), or others to form a chemical compound.

HEALTH CONSIDERATIONS

Nitrates as such are not harmful. When they are acted on by microorganisms in the digestive tract, however, they tend to change from the nitrate form to the nitrite form and become much more toxic. After being absorbed into the blood they make the hemoglobin (red oxygen-carrying blood pigment) incapable of carrying oxygen, and symptoms of asphyxiation (lack of oxygen) appear. The change in the blood is described as a change from hemoglobin to methemoglobin. This term is the origin of the condition called methemoglobinemia, commonly referred to as "blue baby disease" when it occurs in infants.

Blood contains an enzyme capable of changing the methemoglobin back to hemoglobin. Because infants less than six months old seem to be less capable of making this reversal of the blood condition, nitrates are toxic at a lower level in infants than in others.

LEVELS OF TOXICITY

Nitrate levels greater than those listed in table 1 are considered significant. Amounts greater than 10 parts per million (ppm) of nitrate-nitrogen have caused methemoglobinemia in infants less than six months old. Death rarely occurs because the typical blue coloration is recognized by parents, who then seek medical assistance.

Nitrate-nitrogen toxicity for adults has not been firmly established. A Minnesota study reported in 1950 that many wells then in use supplied water containing in excess of 100 ppm of nitrate-nitrogen. The Minnesota Department of Health laboratory still examines some samples of water having concentrations a good deal higher than 100 ppm, but as far as is known by the Minnesota Department of Health, the consumption of such water by adults has not resulted in any reported illnesses.

Testing laboratories that report water unsafe to drink when nitrate-nitrogen levels exceed 10 ppm are following the 1962 U.S. Public Health Service Drinking Water Standards. That standard is based on the possible toxicity for infants less than six months of age. Adults apparently are able to consume water with much higher nitrate levels without any apparent ill effects.

Table 1. Limits of Nitrates

Persons affected	Expressed as Nitrate-Nitrogen (NO_3^--N)	Expressed as Nitrates (NO_3)
For infants less than 6 months of age	10 ppm[a]	45 ppm
For older children and adults	100 ppm[b]	450 ppm

[a] *US–EPA Drinking Water Standards*
[b] *No illnesses reported to Minnesota Department of Health by adult consumption of such water.*

NOTE: Methods of reporting nitrates levels

The standard method of reporting concentrations of nitrates is in levels of nitrate-nitrogen (NO_3^--N). Some laboratories may still use the old reporting method of total nitrates (NO_3^-). The quantity of nitrates may be reported in either ppm (parts per million) or mg/l (milligrams per liter).

The relationships among these methods of designating nitrates are as follows:

1. To change total nitrates (NO_3^-) to nitrate-nitrogen (NO_3^--N), multiply by 0.23.
2. To change nitrate-nitrogen (NO_3^--N) to nitrate (NO_3^-), multiply by 4.5.
3. Parts per million and mg/l are both used when reporting laboratory results. For all practical purposes these two quantities are equal. One part per million simply means one pound of a substance in a million pounds of water.

The terms nitrite-nitrogen (NO_2-N) and nitrites (NO_2) are sometimes referred to in literature, but are seldom reported by laboratories. Nitrites are much more harmful than nitrates, but only small amounts are ever found in the water itself. The changing of nitrates to nitrites in the digestive tract is what causes the health hazard and is explained in the text. When using the conversion numbers above do not confuse *nitrates* with *nitrites.*

Some Minnesota groundwaters are naturally high in nitrates, particularly in the southwestern part of the state. In some areas it is extremely difficult to obtain a water supply well with a nitrate-nitrogen level less than 10 ppm; however, as long as the water is free of bacteria, it can apparently be consumed by adults without ill effects. It may not be necessary to construct a new water supply as long as the water is not fed to infants less than six months old.

SOURCES OF NITRATES

Nitrates occur in the soil, animal excreta, crop residues, human wastes, some industrial wastes, and nitrogen fertilizers. All are possible sources of nitrates, which are soluble and move with surface and groundwaters.

Nitrogen stored in the soil and in crop residues normally does not leach downward in a loam or heavier textured soil. However, when nitrogen fertilizer is added to a sandy soil in amounts greater than the crop can utilize, leaching will occur and nitrate levels may increase in a shallow groundwater table. Onsite sewage treatment systems that are installed in coarse sand or gravel also may contribute nitrates to a shallow groundwater table. A shallow water supply well that penetrates only a short distance into the water table often will show increases in nitrate levels due to these two conditions.

Those nitrates that leach downward into a shallow groundwater table do not tend to mix in depth and will usually only be found in the top five feet of the water-bearing formation. Thus, a water supply well that penetrates to the bottom of a shallow water-bearing formation will usually produce water low in nitrates. Onsite sewage treatment systems should not be installed in soils where the percolation rate is faster than 0.1 minute per inch. (Refer to Extension Bulletin 304, *Town and Country Sewage Treatment*, for the proper method of installing a sewage treatment system to protect groundwater against contamination.)

In some areas of southwestern Minnesota, nitrates stored in the topsoil of the original prairie were released when the soil was plowed. Consequently, there are relatively high nitrate levels naturally occurring in shallow groundwater formations in those areas.

A deep well is no guarantee against the entrance of contamination from surface sources if the well is not properly constructed. But, if a deep well is properly constructed and still contains nitrates, the source of contamination may be a considerable distance away and difficult or impossible to locate. It is extremely unlikely, though, that a properly constructed deep well in Minnesota will contain nitrates.

COLIFORM ORGANISMS

Coliform bacteria are present in the colon and feces of warm-blooded animals or aerated surface soil. Because laboratory tests can identify coliform bacteria more easily than other types of bacteria, they are used as an indicator of water contamination.

Tests for the presence of coliform bacteria may be made by the most probable number (MPN) method or the membrane filter (MF) method. If no coliform bacteria are detected in a test, the MPN will be reported as *less than 2.2* and the MF as *zero*; these results indicate negative coliform. If any coliform are detected by the test, the number will be stated and the results will indicate positive coliform.

Presence of coliform organisms in your drinking water indicates that the well is contaminated by surface sources, usually in the immediate vicinity of the well itself. While well pits are not now allowed under the Minnesota Water Well Construction Code (1979), many of them still exist and serve as direct sources of contamination of the water supply well. Improper drainage allows surface water to drain into the well pit and along the well casing, carrying the bacteria-contaminated water into the groundwater.

To correct this improper construction and prevent further surface contamination of the well, a pitless underground discharge should be installed and the well pit filled with a tight clay soil. Several shock chlorinations are advisable to kill any bacteria in the well.

In some instances, water free of bacteria is pumped into an underground cistern for storage. Since cisterns constructed of concrete or masonry usually have some cracks, coliform organisms can enter the water supply. If you have a cistern in your water system and a sample taken from a faucet shows coliform organisms, collect a sample of the water as it is delivered from the well. This will determine whether the well is contaminated or whether cracks in the cistern allow coliform organisms to enter the water supply at that point.

Some aquifers in fractured bedrock with a shallow soil cover are contaminated from surface sources such as incorrectly installed sewage systems or livestock waste lagoons. If continuous contamination exists in a well in such a formation, it will be necessary to drill to a deeper and uncontaminated aquifer.

WATER TESTING

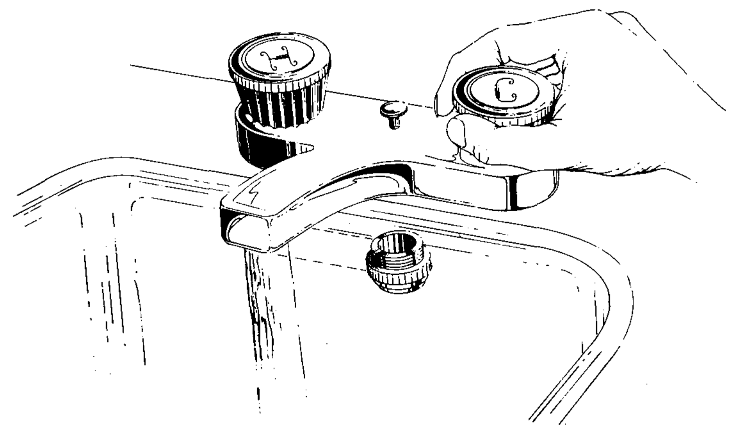
As provided by the Community Health Services Act, most Minnesota counties now have local laboratories that perform water testing. The laboratory may be county operated or under contract by the county, and may or may not charge for the service. Check with your local Community Health Services Administrator or your local County Extension office for information and a list of water testing laboratories.

Water samples for nitrate and bacteriological analysis should be collected in special sample bottles available from your laboratory or Community Health Service office. Special sampling procedures are not necessary for nitrate samples; however, when testing for nitrates, bacteriological testing should also be done. The two forms of contamination are somewhat related and are often found together, although it is not unusual to have bacteriologically safe water with nitrate-nitrogen higher than 10 ppm, or bacteriologically unsafe water with no nitrate-nitrogen.

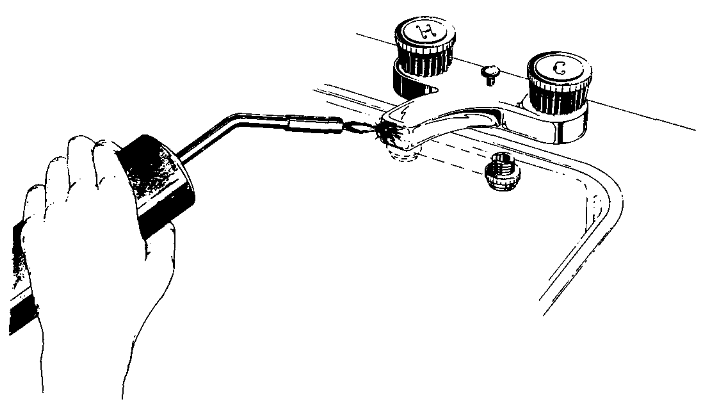
Collect your water sample from a single, cold hard-water faucet. Do not use the swing-type faucet commonly found on kitchen sinks and laundry tubs. Remove the aerator if one is present, and allow the water to run for several minutes to be sure a fresh sample is being drawn from the well. Turn the water off and flame the faucet with a small propane torch. Heat the faucet

Collecting a Water Sample for Testing

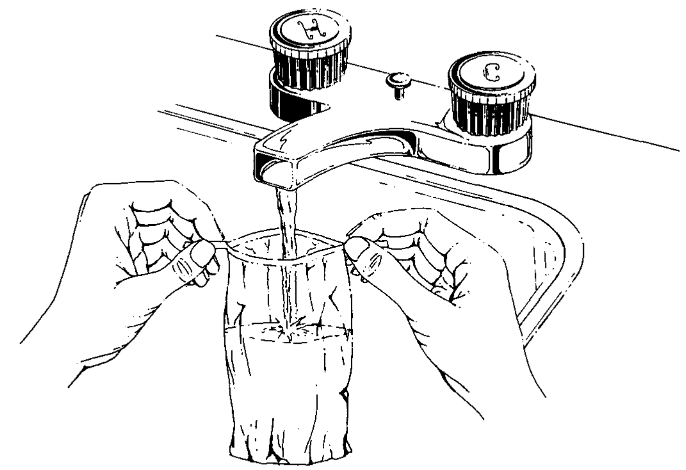
1. Remove the aerator and let the water run for several minutes.



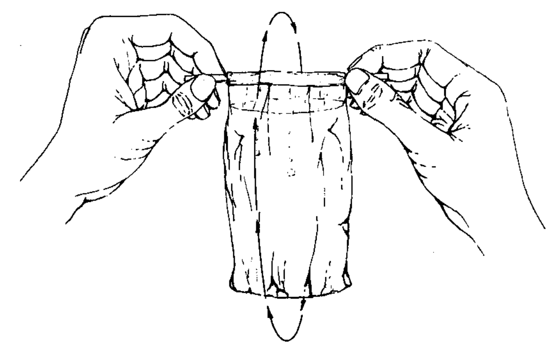
2. Flame the faucet with a propane torch until a layer of condensation appears and then disappears.



3. Fill the sample bag 2/3 to 3/4 full of water.



4. Whirl the bag 5 complete revolutions and turn the ends of the wires inward against the opposite face to seal the bag.



until a layer of condensation appears and then disappears. Turn the faucet on and allow it to run for approximately five minutes to assure that a fresh sample of water from the well is being collected. Collect the sample in the container provided, and be careful not to place your fingers inside of the sample container.

Nitrate levels have been known to fluctuate depending on local conditions. When nitrate levels are higher than the recommended limits, determine if there are any nearby sources of nitrates. Check to be sure that surface drainage is away from the well location. Determine the location and depth of the sewage treatment system, particularly a seepage pit or cesspool. Eliminate any source of nitrates if possible and continue to take samples at two-month intervals before deciding to change your water supply. If nitrate levels are higher than the recommended limits, drinking water should be obtained from another source during the test period.

RECOMMENDED CONTROL ACTIONS

Nitrate levels can be reduced by distillation, reverse osmosis, or mixed bed ion exchange (not water softeners). The per-gallon cost of these processes must be weighed against the total amount of water needed, the availability of another water source, and the cost of purchasing water.

It is important to note that filtration does not remove nitrates, nor does allowing the water to stand in a container. Boiling the water makes the situation worse, since nitrates are not removed and the remaining water contains a greater concentration of nitrates than before boiling.

While chlorination is highly effective in killing bacteria found in water, it does not remove nitrates. (Refer to M-Sheet 156, *Chlorination of Private Water Supplies*, for information on chlorination.)

OTHER COMMON WATER PROBLEMS

Since water is a solvent, it dissolves many different materials as it percolates downward to the groundwater table. Two of the most common minerals found in Minnesota waters are sulfates and iron. Neither of these is likely to cause health problems, but either one may be a nuisance in the use of the water. If there is any question concerning health problems for any minerals contained in water, your personal physician should be consulted.

SULFATES

Laxative effects are commonly experienced with water having sulfate concentrations of 600 to 1,000 ppm, particularly if much sodium or magnesium is present. Sodium sulfate (Glaubers salt) or magnesium sulfate (Epsom salt) are both well-known laxatives, and the laxative dose for either is approximately two grams. This requires the consumption of approximately two quarts of water having 300 ppm of Glauber salt or 390 ppm of Epsom salt. The laxative effect is commonly noted by newcomers or casual users of water high in sulfates. People who consume these waters on a constant basis usually become acclimated in a relatively short time against any laxative effects.

The U.S. Public Health Service recommends that waters containing more than 250 ppm of chlorides or sulfates and 500 ppm of dissolved solids not be used if other less mineralized supplies are available. However, these levels are recommended primarily by considerations of taste. The U.S. Public Health Service states that "a considerable number of supplies with dissolved solids in excess of the recommended limits are used without any obvious ill effects."

IRON

The presence of iron may impart a taste to drinking water that some describe as bitter and astringent. Individuals vary considerably in their perception of taste, but a study by the Public Health Service indicates that the taste of iron may be readily detected by 1.8 ppm in spring water.

Iron also appreciably affects the taste of beverages such as coffee, tea, and alcoholic beverages mixed with water. Iron in quantities greater than 0.3 ppm will impart a brownish color to laundered goods. The U.S. Public Health Service recommended limit of iron in water is 0.3 ppm. Iron in drinking water usually constitutes only a small fraction of the amount of iron normally consumed with foods and is not likely to have any toxicologic significance.

(For complete information on the removal of iron in domestic water, refer to M-154, *Iron in Drinking Water.*)

MANGANESE

Manganese produces a brownish color on laundry and affects the flavor of beverages such as coffee or tea. The U.S. Public Health Service recommended limit of manganese is 0.05 ppm. Manganese can be removed by the same techniques used for iron removal.

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