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Drinking Water Treatment: Continuous Chlorination

Jodi Kocher, Extension Engineer; Bruce Dvorak, Extension Environmental Engineering Specialist; Sharon Skipton, Extension Educator

Continuous chlorination can be an effective method for disinfection of drinking water. It also can be one step in the process of removing iron, manganese or hydrogen sulfide. Continuous chlorination should not be a substitute for a sanitary water supply. Protecting the water supply from contamination should be the primary goal for assuring good water quality. Continuous chlorination can be a costly and complex treatment process and is often only considered after other options are exhausted. This guide discusses the principles, processes and requirements of continuous chlorination systems for the domestic (household) user.

What contaminants does continuous chlorination remove from water?

Purification of drinking water containing pathogenic (disease-causing) organisms requires disinfection treatment. Disinfection of drinking water destroys pathogenic bacteria, nuisance bacteria, viruses and other microorganisms, to produce a drinking water considered by public health officials to be essentially pathogen free. Chlorination is the most commonly used method for drinking water disinfection. Chlorine will oxidize iron and manganese so they can be filtered out and also oxidize hydrogen sulfide to reduce nuisance odors. For further information on iron and manganese removal see NebGuide G96-1279 *Drinking Water: Iron and Manganese*. For information on hydrogen sulfide see NebGuide G96-1275 *Drinking Water: Sulfates and Hydrogen Sulfide.*

Water used for drinking and cooking should be free of pathogenic organisms that can lead to illnesses such as typhoid fever, dysentery, infectious hepatitis and gastroenteritis. Pathogenic bacteria and viruses can be transmitted to humans by several routes, including contaminated drinking water supplies. Concentrated human and/or livestock populations near wells may result in contaminated water supplies. Contamination can also occur during or after well construction or repair, or flooding. Water can also be contaminated with naturally-occurring nuisance organisms such as iron bacteria, slime bacteria and sulfate-reducing bacteria.

Disinfection by a process such as continuous chlorination is necessary for surface water supplies. It also is used to treat ongoing bacterial contamination and the process is similar to that used by public water utilities. Shock chlorination is used for new wells or after well repairs and is recommended for treating non-recurring bacterial contamination. For information on this procedure see NebGuide G95-1255 *Shock Chlorination of Domestic Water Supplies.*

What contaminants are not removed by continuous chlorination?

Chlorine will not remove nitrate from water. Chlorination will not remove heavy metals, calcium and magnesium (hard water minerals), fluoride, and many other compounds. The concentration of chlorine typically applied for disinfection will not adequately destroy protozoan cysts such as Giardia and Cryptosporidium. These contaminants are not normally found in Nebraska groundwater but may be present in contaminated surface water. The effectiveness of removal or destruction of microbial contaminants by chlorination depends on numerous factors as discussed later in this guide under Treatment Principles. Often in Nebraska, chlorination is used to oxidize contaminants such as iron and manganese to form precipitates; then a filter is used for removal of these precipitates.

No one piece of treatment equipment manages all contaminants. All treatment methods have limitations and often situations require a combination of treatment processes to effectively treat the water. Refer to Extension Circular EC03-703 *Home Water Treatment: An Overview* for a discussion of possible water quality problems and appropriate treatments for these contaminants. Further information can be obtained from the appropriate treatment guide in the Drinking Water Treatment series (listed at the end of this publication).

Water Testing

Regardless of the water treatment system being considered, the water first should be tested to determine what substances are present. Public water systems routinely are tested for contaminants. Water utilities are required to publish Consumer Confidence Reports (CCRs), which inform consumers on the source of the water, contaminants that are present, potential health effects of those contaminants and methods of treatment used by the utility. Depending on the number of customers served by the utility, CCRs may be mailed, published in newspapers or posted on the Internet. A copy of the CCR can be obtained by contacting the local water utility. Public supplies must conform to federal standards established by the Safe Drinking Water Act. If contaminants exceed the Maximum Contaminant Level (MCL), the water must be treated to correct the problem and/or another source of water suitable for drinking must be provided.

In contrast, monitoring of private water systems is the responsibility of the homeowner. Therefore, contamination is more likely to go undetected in a private water supply. Knowledge of what contaminants may be present in the water should guide the testing, since it is not economically feasible to test for all possible contaminants. It is essential to know what contaminants are present, their quantities and reasons for their removal (i.e., to reduce contaminants posing health risks, to remove tastes or odors, etc.) before selecting treatment methods or equipment. Refer to NebGuide G89-907 *Testing for Drinking Water Quality* for testing information. Private well owners should have their drinking water tested for bacteriological contamination at least once each year and after any repair or improvements in the well.

Coliform bacteria testing is used to indicate the presence of disease-causing bacteria in drinking water. Coliform bacteria are organisms found in soil and in the intestinal tract of warm-blooded animals. Coliform bacteria are not necessarily pathogenic, but are indicators of possible contamination (For example, if the water is positive for coliform bacteria, it indicates the possibility of contamination by soil or waste from humans or animals, which may contain pathogenic organisms). Laboratory tests for coliform bacterial may be performed by use of the MPN (most probable number), MF (membrane filter) method, or Colilert® method. If no coliform bacteria are detected, results from the MPN method will be reported as "less than 2.2." Results from the MF method can be expressed as either text ("present" or "absent"), or as the detected number of bacteria. Results from the Colilert® method is expressed as either "present" or "absent."

Coliform presence in a drinking water sample does not necessarily mean the water is unsafe to drink. Since the test is a screening tool, a positive result should initiate additional testing, perhaps at different locations (well, pressure tank, etc.) in order to identify the source of the contamination. If the results reported show high coliform numbers, there is most likely considerable contamination and the water should not be consumed until the source of contamination is identified and eliminated, and/or the water is purified. In such situations, further water sample analysis for fecal coliform or E. coli should be initiated.

Treatment Principles

The *best* option for assuring good water quality is protecting the water source from contamination in the first place. If your water supply does become contaminated, removing the source of contamination is the ideal solution. Chlorination should not be a substitute for a sanitary water supply. Because of the cost and management requirements of continuous chlorination, many water treatment professionals will suggest drilling a new well (or in some cases moving the source of contamination, such as a septic tank) as a preferable option over continuous chlorination.

The disinfecting effectiveness of chlorine depends on the concentration in the water, the amount of time the available chlorine is in contact with the water prior to use (contact time), the water temperature, water pH and the characteristics of the contaminants and water supply. When chlorine is added to water it reacts with microorganisms, certain chemicals, plant material, and compounds that can cause taste, odor or color in the water. These components "tie up" some of the chlorine and this is called the chlorine demand. The chlorine that does not react with these contaminants is free, or residual, chlorine. The breakpoint is that concentration of chlorine that just meets the chlorine demand so that a higher concentration would allow for some residual chlorine. It is important to have enough chlorine in the water to meet the chlorine demand and allow for residual disinfection. Test kits are available from plumbing or water supply equipment dealers for testing chlorine in private systems; be certain the kit you purchase tests free chlorine, not total chlorine.

The concentration of free chlorine necessary for adequate disinfection is system-dependent; the chlorine concentration is depended on the amount and type of contamination present, water pH and temperature, etc. Consult your water treatment specialist for guidance on proper free chorine residual concentration for your situation. Household chlorination systems may provide a higher free chlorine concentration than the typical 0.3 - 0.5 ppm (parts per million) concentration used for chlorination of public water supplies. The distribution system of a public water system provides a much longer contact time than a household plumbing system so a lower concentration may be used for disinfection. Piping in home water systems generally provides very limited contact time for chlorination since the time between the pump and the nearest faucet is usually one minute or less. A coil of plastic pipe may be used to increase the contact time within the system. The length of pipe needed depends on the flow rate and the pipe diameter; consult a water treatment professional for determining the length needed for your system. Also, other features such as storage tanks with baffles or mixers may be installed by professionals to increase contact time so lower chlorine concentrations typical of public systems can be used. Other systems increase contact time by chlorinating the water in the well before it is pumped to the house. For information on different types of chlorination systems see the discussion on treatment equipment later in this guide.

The reaction of chlorine with trace concentration of naturally occurring organic matter can produce compounds such as trihalomethanes (THMs) as by-products. These disinfection by-products may increase the risk of certain cancers. The EPA mandates that public water systems have less than 80 parts per billion (ppb) of THMs in their treated water. Activated carbon filtration can be effective in removing chlorine and some disinfection by-products from drinking water. Activated carbon filters will need periodic replacement according to manufacturer's instructions. See NebGuide G03-1489 *Drinking Water Treatment: Activated Carbon Filtration* for further information on the activated carbon filtration process. THMs are primarily a concern for surface water supplies. Groundwater rarely has high levels of organic matter so exposure to THMs from chlorination of private well water is generally low. Also, exposure can vary with season, contact time and water chemistry. Though there is a risk associated with consuming THMs in chlorinated water, the health risks associated with consuming pathogen-contaminated water are far greater.

Chlorine concentrations used for disinfection in water are not toxic to humans or animals. The concentration can be high enough, however, to create a taste or odor that some people find objectionable. Activated carbon filtration following chlorination may be used to remove the taste and odor.

Equipment

Chlorine is available in dry form as either a powder or pellets (calcium hypochlorite) or in liquid form (sodium hypochlorite). Both forms of chlorine must be stored in accordance with the manufacturers' recommendations for safety purposes and to maintain the chemical integrity of the product. Chlorine gas as used by public utilities is too dangerous and costly for household use.

There are three common types of chlorinators for continuous chlorination of a home drinking water supply: a chemical feed pump, an injection device and a tablet chlorinator. Because the effectiveness of the disinfection is a function of contact time, in each type of chlorinator the chlorine should be introduced into the water as close to the source as possible. This will allow the chlorine a longer contact time with the water.

Figure 1 shows a chemical feed pump chlorinator. A fixed amount of chlorine solution is delivered with each pump discharge stroke. The amount delivered can be adjusted by changing the length of the discharge stroke, the speed of the pump, or the running time of the pump. The feed pump should be wired to the water pump pressure switch so that the chemical pump operates only when the water pump is operating. The system should also have a device to indicate when the chlorine solution supply is low or if the chemical pump fails.

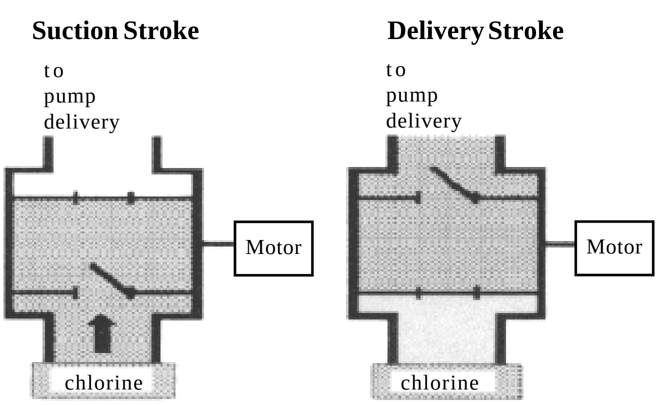

Figure 1. Chemical feed pump chlorinator (from *Chlorination of Drinking Water*, Wagenet, L, and Lemley, A., Cornell Cooperative Extension, New York State College of Human Ecology.)

Figure 2 shows a chlorine injection device. This device, also known as an aspirator, draws chlorine into the water supply system by jet action. The amount of chlorine drawn in can be adjusted by the feed screw.

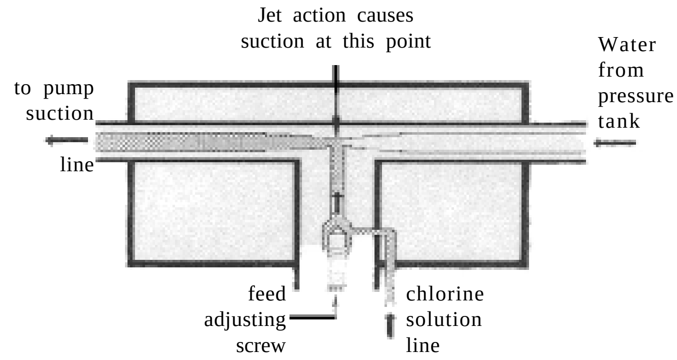

Figure 2. Injection type chlorinator (from *Chlorination of Drinking Water*, Wagenet, L, and Lemley, A., Cornell Cooperative Extension, New York State College of Human Ecology.)

Figure 3 shows two tablet type chlorinators. The tablet chlorinator in A) feeds dry chlorination pellets directly into the well casing so water is disinfected at the source prior to pumping. Water washes past the pellets, dissolves them, and flows to the pump inlet screen where it mixes with water from the bottom of the well. The tablet chlorinator in B) circulates a small amount of water through a container of tablets before re-entering the water supply system. The amount of water allowed to circulate through the tablet container determines the chlorine concentration and can be adjusted by the restrictor valve.

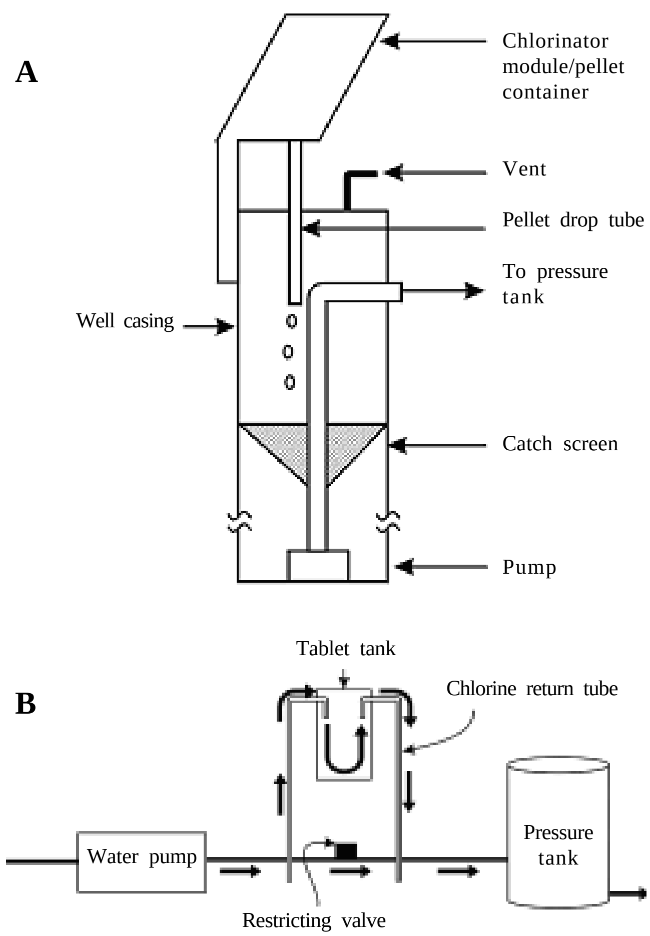

Figure 3. Tablet type chlorinators.

Selection Requirements

Federal, state or local laws do not regulate continuous chlorination home systems. The industry is self-regulated. The NSF (formerly known as the National Sanitation Foundation) and the Water Quality Association (WQA) evaluate performance, construction, advertising and operation manual information. The NSF program establishes performance standards that must be met for endorsement and certification. The WQA program uses the same NSF standards and provides equivalent American National Standards Institute (ANSI) accredited product certifications. WQA certified products carry the Water Quality Association Gold Seal. Though these certifications and validations should not be the only criteria for choosing a continuous chlorination system, they are helpful to ensure effectiveness of the system.

Other important guidelines for consumers purchasing drinking water treatment equipment are discussed in NebGuide G03-1488 *Drinking Water Treatment: What You Need to Know When Selecting Water Treatment Equipment.* Drinking water treatment NebGuides and guides on specific contaminants are listed at the end of this publication. The NebGuide series on drinking water treatment focuses on contaminants most likely to be encountered in Nebraska drinking water supplies.

Summary

Drinking water treatment using continuous chlorination disinfects a water supply. It destroys pathogenic bacteria, nuisance bacteria, viruses, some parasites and other microorganisms. It also oxidizes iron and manganese so they can be filtered out, and oxidizes hydrogen sulfide in order to reduce nuisance odors.

Continuous chlorination is a complex and relatively expensive treatment process. It requires continuous monitoring and knowledgeable management. Using continuous chlorination for control of bacteria should not be considered without consulting a professional and fully exploring other options such as drilling a new well or eliminating the source of contamination.

Related Drinking Water Treatment Publications

EC03-703	Drinking Water Treatment: An Overview
G03-1488	Drinking Water Treatment: What You Need to Know When Selecting Water Treatment Equipment
G03-1489	Drinking Water Treatment: Activated Carbon Filtration
G03-1490	Drinking Water Treatment: Reverse Osmosis
G03-1491	Drinking Water Treatment: Water Softening (Ion Exchange)
G03-1492	Drinking Water Treatment: Sediment Filtration
G03-1493	Drinking Water Treatment: Distillation
G03-1494	Drinking Water Treatment: Emergency Procedures
G95-1255	Shock Chlorination of Domestic Water Supplies

Related Drinking Water Contaminant Publications

G89-907	Testing for Drinking Water Quality
G90-989	Drinking Water: Bacteria
G03-1274	Drinking Water: Hard Water
G96-1275	Drinking Water: Sulfates and Hydrogen Sulfide
G96-1279	Drinking Water: Nitrate-Nitrogen
G96-1280	Drinking Water: Iron and Manganese
G96-1282	Drinking Water: Man-made Chemicals
G97-1333	Drinking Water: Lead
G98-1360	Drinking Water: Copper
G98-1376	Drinking Water: Fluoride
G98-1369	Drinking Water: Nitrate and Methemoglobinemia
G02-1448	Drinking Water: Bottled or Tap?
G03-1499	Drinking Water: Storing an Emergency Supply
NF02-505	Drinking Water: Chloramines Water Disinfection in Omaha Metropolitan Utilities District

Technical Review provided by: Joe Harrison, Water Quality Association; Mike Wentink, Nebraska Department of HHS Regulation and Licensure; Darrel Siekman, Cooperative Extension; John Wilson, Cooperative Extension; and Matt Morley, UNL Civil Engineering.

Views expressed in this publication are those of the authors and do not necessarily reflect the views of either the technical reviewers or the agencies they represent.

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"Water Treatment Notes: Chlorination of Drinking Water," Cornell Cooperative Extension, New York State College of Human Ecology

"Drinking Water Standards," www.epa.gov/safewater/mcl.html

"Understanding the New Consumer Confidence Report," www.awwa.org/Advocacy/bluethumb98/consumer.cfm

"Testing for Drinking Water Quality," NebGuide G89-907 Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

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