Water Well Chlorination using pH Adjustment and the "WellChlor" Calculator

Agriculture and Agri-Food Canada – Agri-Environment Services Branch (AAFC-AESB) has developed a step-by-step guide to disinfect your water well by means of chlorination. This methodology incorporates pH adjustment and is assisted by a calculator tool called "WellChlor".

Chlorination methods to date usually have manually calculated water volumes, chemical dosage volumes and concentrations, and pH adjustment requirements. The chlorination calculator tool, WelClor), has been developed to improve the ease and reliability of determining the volumes of chemical solution necessary for optimal disinfection

What is Well Chlorination?

Chlorination is a remedial or preventative strategy to disinfect water wells or distribution system in order to control or prevent the growth of unacceptable levels of micro-organisms. When chlorination is properly conducted, the entire well casing, pump, distribution plumbing, and some water system equipment should be disinfected.

When Should a Well be disinfected?

Disinfection should be undertaken when:

- the water has tested positive for coliform bacteria;
- the need arises to control taste or odour problems caused by nuisance organisms such as iron or sulphur-reducing bacteria. Regularly scheduled treatments will not eliminate nuisance bacteria but will reduce the incidence of organic tastes and odours in the water;
- the well has been affected by flooding;
- there have been construction, repairs or service to the well, pump, or plumbing system; or
- a seasonal well is restarted.

If there is a problem in the aquifer from which the well obtains groundwater, then chlorination will not be effective.

Use of Disinfection Chemicals

Chlorine

Chlorine is the most widely used well and water system disinfectant, since it is generally readily available, effective, easy to use and inexpensive. Some information on the most common chlorine products is provided below:

- common household bleach (5 to 5.25 % available chlorine). Do not use bleach that is scented, contains surfactants, foaming agents, or other additives. The shelf life of bleach is limited and the potency may decrease by 20-25% per month; therefore, store chlorine in a cool, dark environment to lower the rate of chemical decomposition;

- sodium hypochlorite (12 to 12.5 % available chlorine); and

- calcium hypochlorite (65 to 70% chlorine). This product is not generally recommended for water well disinfection because calcium hardness is often high in the groundwater and this product may cause calcite to be precipitated within the well resulting in plugging and reduced well yield. Avoid calcium hypochlorite swimming pool products that contain algaecides.

Chlorine concentrations for disinfection should be in the range of 50 to 250 ppm. Chlorine concentrations in excess of 500 ppm may damage fixtures and corrode metal surfaces within the water system. Such concentrations may also lead to oxidation of biofilms which may result in a hardening of the biofilm surface. In addition, higher chlorine concentrations require greater volumes of buffering agent to maintain the chlorine's biocidal effectiveness. It is better to repeat a treatment than to work with stronger chlorine solutions. In addition, longer contact times result in more effective treatment.

Organics and the presence of reducing agents such as hydrogen sulphide, iron and manganese, or high alkalinity, hardness, or turbidity can all interfere with, and reduce the effectiveness of chlorine.

pH-adjusted Chlorination

Chlorine works most effectively at a water pH of about 5.5. Chlorine products are highly alkaline, and, when mixed with the water directly in the well, will increase the pH of the groundwater. Therefore, an acid solution, such as household vinegar, must be added to maintain the pH at 5.5 and maximize the chlorine's performance. The addition of vinegar (5% acetic acid) will provide the necessary buffering and create the conditions for maximum biocidal efficiency.

To determine the volume of vinegar required, the total alkalinity must be measured by taking a standard chemical analysis of the groundwater. Alkalinity is a measurement of the capacity of the water to neutralize acids (or to resist change in pH). Waters with high total alkalinity are able to resist significant shifts in pH and, therefore, larger volumes of vinegar are required to achieve the desired shift. If the total alkalinity of the water is unknown, assume a value of 150 mg/L, when using the "WellChlor" calculator tool described below.

Safety Measures

Consider hiring a qualified well specialist to disinfect your well in the following situations:

- if you are unfamiliar with the water system, the electrical system, or chemical mixing;
- if you have concerns about gases in confined spaces;
- if hydrogen sulphide gas may be present in the groundwater; or
- if the well is located in a well pit.

Chlorine is strongly oxidizing and corrosive. To avoid skin and eye damage or irritation to mucous membrane when mixing or pouring disinfectant chemicals, wear personal protective equipment including: safety glasses with side skirts, disposable gloves (latex, rubber, nitrile or PVC), a waterproof apron, smock or coveralls, and rubber-soled and waterproof boots.

When mixing the chemical solution and, definitely, if the well is located in a pit, crawl space or basement, ensure that adequate ventilation is available. A fan may be used to improve air flow.

Chlorination Procedure for Drilled Wells

STEP 1 *Prepare equipment and supplies*

- Assemble the following: a clean tank large enough for the volume of mixed treatment solution, a garden hose, hand tools, containers of chlorine product and vinegar.
- Wear safety equipment and set-up a fan(s) if required.

STEP 2 *Store water*

- A sufficient quantity of water should be stored to meet the needs of occupants or farm for the period of treatment as described below.

STEP 3 *Isolate water system components*

- Turn off the well pump.
- Drain the distribution system as much as possible.
- For the disinfection of water system devices including the pressure tank, water filters, water softener, and automatic watering systems, follow the manufacturer's disinfection instructions and by-pass these devices as recommended.

STEP 4 *Flushing*

- Turn on the well pump.
- Pump the water well, regardless of its structure, at a maximum rate through one or more faucets to discharge several well casing volumes prior to initiating the disinfection process.

STEP 5 *Calculate chemical volumes using the "WellChlor" tool for drilled wells:*

- Enter the diameter and depth of the well and the depth to water in the well. The calculator will determine the volume of water in the well casing and screen and will calculate the volume of water required for the treatment solution in the tank (based upon a doubling of the volume of water in the well).
- Specify the chlorine product to be used and the desired chlorine disinfection concentration. The calculator will determine the volume of chlorine product for the disinfectant solution in the tank.
- Enter the total alkalinity of the groundwater as measured or estimated, and the calculator will determine the volume of vinegar required to bring the solution to a pH of 4.5.

STEP 6 *Preparing chemicals*

- Work in a well-ventilated area to disperse any fumes generated during chemical mixing.
- If using a tank to siphon the chemical solution into the well, place the solution tank at an elevation above the top of the well. If directly pouring the chemical into the well, place the solution tank near the well.
- Fill the tank with the designated volume of water as calculated in Step 5.
- Add the calculated volume of vinegar to the solution tank and mix thoroughly. Add in the calculated amount of chlorine product and mix.

STEP 7 *Adding chemicals to the well*

- Disconnect power to the well pump.
- Remove the well cap.
- Inspect and isolate the wiring at the top of the well and move it to the side.
- Siphon or pour the solution into the well.

STEP 8 *Recirculating the water*

- Connect one end of the water hose to a hydrant or nearby tap; place the other end in the well.
- Reconnect power to the well pump. Turn on the tap attached to the hose and recirculate the chlorinated water back into the well for a minimum of one hour until you can detect the odour of chlorine in the recirculated water. This will wash down the interior of the well casing, pressure tank, and associated water distribution system.
- In the event the water becomes very reddish or cloudy during this procedure, discharge this water to waste instead of recirculating it until the colour or cloudiness dissipates.

STEP 9 *Flushing chlorinated water through the plumbing system*

- With the recirculation complete, open each hot and cold water tap in the house individually, beginning with the one closest to the pressure tank and then close the tap when the smell of chlorine is detected. The water can also be run into the dishwasher, laundry tubs, showers, and hot water heater (follow the manufacturer's instructions for disinfecting the water system devices).
- Disconnect power to the well pump. Drain all the water from the pressure tank and water heater. Reconnect power to the well pump and completely fill both tanks with chlorine solution (subject to the manufacturer's instructions). After an hour, disconnect power to the pump and drain the water from the pressure tank. Reconnect the power and refill the tank to the original air to water volume necessary for pressuring the system.
- Leave the chlorine solution in the well and distribution system for at least 8 to12 hours if possible. If necessary, flush the toilets sparingly.

Avoid adding large quantities of chlorinated water to the septic system as this could disrupt the biological treatment activity in the system or hydraulically overload the system.

STEP 10 *Removing the chlorinated water and restarting your water supply*

- After completing the contact period, water should be purged by pumping from the well and draining the water onto the ground, away from sensitive vegetation and biota and the septic system. The distribution lines should be flushed until all the chlorine, turbidity and sediment have been removed. Flushing may take a considerable amount of time if the well is low-yielding, and it may be necessary to flush in intervals to allow the well to recover between pumping periods.
- Reconnect the water system treatment devices.

Chlorination Procedure for Large Diameter Bored Wells

The large volume of water in most bored wells precludes practical mixing of disinfectant and vinegar with water in a solution tank and achieving a doubling of the volume of water in the entire well water column. The best approach is to employ the well casing as the mixing tank, select a chlorine concentration no higher than 50 to 100 ppm, and mix in sufficient chemical to bring the chlorine concentration to the desired level within the column of water in the well.

STEP 1 to 4

- Follow steps 1 to 4 for drilled wells above.

STEP 5 *Calculate chemical volumes using the "WellChlor" Tool for Bored Wells*

- Enter the diameter and depth of the well and the depth to water in the well. The calculator will determine the volume of water contained in the well.
- Specify the chlorine product to be used and the desired chlorine disinfection concentration. The volume of chlorine product required for the disinfectant solution will be calculated.
- Enter the total alkalinity of the groundwater as measured or estimated, and the calculator will determine the volume of vinegar required to bring the solution to a pH of 4.5.

STEP 6 *Mixing the chemicals and adding them to the well*

- Disconnect power to the pump.
- Remove the well cover.
- As calculated in step 5 pour the volumes of chlorine product and vinegar into the well and mix. Ensure that there is adequate ventilation to disperse any fumes generated during chemical mixing.

STEP 7 to 11

- Follow steps 7 to 11 for drilled wells to disinfect the well and distribution system.
- If the pump intake is above the bottom of the well, some of the chlorine solution can be added directly to the bottom of the well to disinfect the entire well volume; this can be done by placing one end of a garden hose of sufficient length to the bottom of the well and using pump pressure to circulate the chlorine solution from a yard hydrant or house tap.

After Disinfection

Bacterial testing is required to ensure the well water is safe to drink. After disinfection, wait 5 days before taking a water sample. A 5-day waiting period is recommended to ensure that there is no chlorine residual which would cause an erroneous negative result.

Until the water sample results confirm that the water is safe to drink, water should not be used for human consumption unless it is brought to a rolling boil for 5 minutes before use; another option is to use an alternate supply of drinking water.

It is common for the water to be somewhat discoloured for a short period of time after chlorination, however, this should be a temporary condition.

In the event of heavy biofouling or water sample results indicating the presence of coliform or E.Coli bacteria, a repeat shock chlorination of the water well and distribution system may be necessary. In some instances, a more comprehensive well treatment and service work may be necessary, requiring the services of a qualified well specialist.