Irrigation Water Management for Farmers

Introduction

Nova Scotia has experienced an increased demand for irrigation in recent years due to more frequent growing season dry spells. There is also a greater awareness of water quality issues in relation to waterborne health risks. Both factors are leading to an increased sense of responsibility by the agriculture industry to meet irrigation water quality guidelines.

One issue related to irrigation is water contamination by various types of bacteria. Bacteria from the coliform group are frequently used as indicators of water quality because they are potential pathogens and it is relatively easy to test for them. The entire group of coliform bacteria is referred to as **total coliforms**, whereas **fecal coliforms** refer to coliforms originating in the intestine of warm blooded mammals. One specific type of fecal coliform is ***Escherichia coli*** **(*E. coli*)**.

The Nova Scotia Department of Environment and Labour (NSDEL) generally adheres to the Canadian Council of Ministers of the Environment (CCME) irrigation water quality guidelines. Currently the maximum acceptable limit of *E. coli* in these guidelines for irrigation water is 100 colony forming units (CFU)/100 mL. The total coliform limit is 1,000 CFU/100 mL. These guidelines do however, have limitations, including a lack of consideration for the risks associated with the type of crop grown, irrigation system being utilized and the timing of irrigation in relation to harvest.

Most Nova Scotia producers utilize surface water (e.g. Fig. 1) as their primary water source for irrigation, mainly due to lower operational costs. The challenge is that surface water is generally susceptible to microbial contamination, as it is inherently exposed to common sources of contamination. In addition, irrigation demand is often greatest when conditions of increased contamination risk exist. Irrigating crops with water exceeding CCME guidelines increases the risk of food borne illness. Therefore proper source water management is necessary. This factsheet will discuss *E. coli* management considerations related to irrigation and present several treatment options that farmers can consider to improve the microbial quality of water used for irrigation.

Figure 1: A typical surface water source, showing a withdrawal point for an irrigation system.

E. coli Survival in Farm Ponds

Many farms store irrigation water in ponds. This allows for water to be stored for use during drought. Often surface water may be collected during the winter and spring for later use. For more information related to ponding irrigation water collected from surface water sources refer to the factsheet titled “Harvesting Winter and Spring Stream Flows for Irrigation”.

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Conditions in clear, shallow farm ponds are not favourable for long-term *E. coli* survival. This is due to naturally occurring processes such as exposure to ultraviolet (UV) radiation. Ultraviolet radiation kills bacteria by distorting their genetic material, making them unable to reproduce. General water quality is important when considering *E. coli* survival in ponds. For example, the UV dose received by waters high in turbidity or suspended solids is reduced due reduced light penetration within the water column, and shielding of bacteria.

Recent Nova Scotia research has shown that water in farm ponds stored prior to irrigation experiences significant *E. coli* reductions. *E. coli* survival in the upper layer of shallow farm ponds was limited. Within 1 to 2 weeks *E. coli* levels dropped by at least 99% due to naturally occurring processes. Other research has shown that artificial aeration of farm ponds can further enhance *E. coli* reductions.

Due to significant natural decreases in *E. coli* in farm-ponds irrigation water treatment may not always be necessary. It is however important for farmers to routinely monitor the microbiological water quality. It is suggested that at least five water samples be tested within a 30 day period prior to irrigation. If the geometric mean of total coliforms or *E. coli* in samples exceeds CCME guidelines, treatment should be considered.

It should also be noted that following irrigation, rapid, natural die-off of bacteria can also occur. Hostile environmental conditions experienced by bacteria (e.g., UV radiation, dessication), are again responsible for this natural disinfection. Another recent Nova Scotia study with spinach found 80 to 90% reductions in *E. coli* 6 h after irrigating the crop with *E. coli* contaminated water. Within 3 days, *E. coli* were often below measurable levels.

Research findings demonstrate that if *E. coli* are present in source water, significant reductions can occur naturally without chemical or physical treatment. There are no harmful residual chemicals associated with natural disinfection. Natural disinfection is however, highly dependent on weather, water quality and water depth. It may therefore be necessary to consider a backup treatment to ensure water quality guidelines are consistently met.

Irrigation Water Treatment Options

A number of on-farm disinfection methods can be used to improve microbial irrigation water quality including:

- Chlorination
- Ultraviolet radiation
- Ozonation

Chlorination

Chlorination is a widely used technology for disinfecting water. Chlorine destroys or prevents bacteria from multiplying by damaging their membranes. Chlorine is available in gas, liquid, or powder forms. Liquid (sodium hypochlorite) is the most commonly used form of chlorine, and has been approved by the US Food and Drug Administration for disinfection. Chlorine is often injected into irrigation systems by a chemical metering pump that supplies the required chlorine dose, and can be adjusted to meet seasonal variations in water quality.

Treating water using chlorine is relatively inexpensive, partially due to the low doses required (2-3 mg/L). The capital cost of a chlorination unit is low compared to a UV system. Annual operation costs include power and chemicals. Its effectiveness is dependent on water quality (especially organic content in water), contact time, pH and temperature.

Chlorination requires the proper management of chemicals to prevent the discharge of chlorine into the environment. The CCME guideline for the protection of aquatic life for chlorine is 0.5 ppb for chlorine. To prevent the release of chlorine into source waters several preventative measures should be taken. It is important to follow manufacturer's procedures on the proper handling, storage and prevention of chlorine spills. Furthermore, backflow prevention equipment must also be installed within the existing irrigation system to prevent the backflow of chlorinated irrigation water into the source water.

A recent Nova Scotia study involved retrofitting a commercial fruit and vegetable farm's irrigation system with a chlorine injection system. The system consisted of a chemical injection pump (diaphragm pump) installed in a portable enclosure, chemical check valve, and an injection line connected to the pressure side of the irrigation system (Fig. 3).

The injection pump was calibrated to deliver chlorine dose of 3 mg/L. This was based on the type of sprinkler being used and the number of sprinklers. A residual concentration of less than 0.3 mg/L was typically measured at the sprinkler heads. Water samples collected from the source water and at the sprinklers were tested for *E. coli.* The chlorine system reduced *E. coli* levels by 99.9%. It was concluded that chlorination provided adequate *E. coli* disinfection for irrigation water and can be a cost effective treatment option.

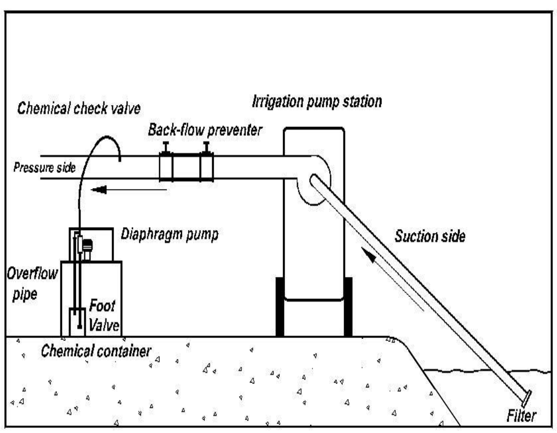

Figure 3: A chlorine injection system utilized at a fruit and vegetable operation.

Ultraviolet Radiation Systems

Ultraviolet radiation systems are frequently used for drinking water disinfection. Exposure to UV radiation inactivates bacteria by distorting their genetic material, making them unable to reproduce. The most common systems consist of cylindrical mercury arc lamps inside a cylindrical stainless steel chamber (e.g., Fig. 4). Lamps vary in length (30 to 173 cm), and energy output. Some UV systems include transparent sleeves that houses and protects the lamps. Water enters one end of the chamber, flows through the chamber around the lamps and exits the other end. The degree of inactivation is directly related to the applied UV dose, which is a product of UV radiation intensity and exposure time. Most UV systems are designed to provide a dose greater than 40 mJ/cm^2.

Nova Scotia researchers tested a pilot scale UV system (100 gpm flow capacity). It was installed in-line with 50 mm irrigation piping (Fig. 4). Water samples were collected from the river (water source) and at the sprinklers. *E. coli* levels were reduced by 99.9%. The pilot UV system provided adequate treatment for irrigation. From a cost perspective however, this technology is more expensive than chlorination.

Figure 4: A pilot scale UV disinfection system.

The effectiveness of UV systems depends on water quality, radiation intensity, exposure times, and reactor configuration. Ultraviolet systems are sensitive to high turbidity and organic matter content, both of which decrease UV transmittance, therefore reducing UV disinfection. Even water that appears transparent may still contain enough organic content or turbidity to interfere with the effectiveness of UV treatment. Therefore, water treated by this method should be monitored to ensure the quality meets manufacturer specifications. Pre-treatment by filtration to remove excess turbidity and organic matter is recommended to ensure UV transmittance greater than 75% for effective UV disinfection. Excessive hardness, iron and manganese tend to create a film on the sleeve, which can also decrease treatment effectiveness. Therefore, water that is hard or high in iron or manganese is not compatible with UV disinfection.

Ozonation

Ozonators are machines that produce ozone, a strong oxidizing agent that is effective at quickly destroying bacteria over a short period of time. Unlike chlorine, ozone does not protect the water after the initial dosing. Ozonation is often combined with activated carbon filtration to achieve more complete water treatment. Ozonation has the ability to achieve higher levels of disinfection than chlorination or UV radiation, however, this technology is complex, and requires testing in irrigation applications. The capital costs and maintenance expenditures of ozonation are not competitive with the treatment options outlined above.

Concluding Remarks

Disinfection of irrigation water is not meant to produce potable water, rather to ensure bacteria levels are below accepted guidelines. Natural reductions in *E. coli* levels due to UV radiation from the sun and environmental exposure can be effective at reducing bacteria levels, often making treatment unnecessary. If further treatment is necessary, chlorination and UV systems are effective systems that can be implemented into existing irrigation systems with relative ease. Source water quality is however, an important consideration for chlorination and UV systems. Ozonation is another technology currently in development that is most likely not suitable for typical farm operations, due to difficulties with implementation and high costs. Regardless of treatment that irrigation water may be receiving, continued monitoring is essential to ensure that crops are not receiving contaminated water. For additional information on irrigation water quality and on storing off-season water for irrigation please refer to the factsheets titled "*What You Should Know About Irrigation Water Quality Safety,*" and *"Harvesting Winter and Spring Stream Flows for Irrigation,"* respectively.