FACTSHEET

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WATER TREATMENT TECHNOLOGY OPTIONS FOR WASHING VEGETABLES

Bridget Visser & Eric Rozema

Introduction

Water entering a washing facility must be of a certain quality before it can be used to achieve food safety standards. Water for primary washing should be of good quality whereas final rinse water must meet potable water status (Ontario Safe Drinking Water Act, 2002; HMGA Water Project Factsheet #012). Treatment is commonly necessary to meet these requirements. The sources of water could be from surface water, a well, a municipal system, or treated recycled washwater. Municipal water is treated prior to delivery and will not require further treatment unless there are issues within the plumbing system. Other sources will require varying levels of treatment depending where water is used in the washing process. Water intended for primary washing will need less treatment than for final rinses since such water must meet potable standards.

There are different treatment options, fine filtration and disinfection, to achieve the required water quality. The selection and order of the appropriate technologies, demonstrated in Figure 1, must consider the raw water source, incoming quality, and required treated quality.

Fine Filtration

Fine filtration encompasses several widely used technologies, some of which utilize membranes and pressure to remove small particles that can pass through other solid removal systems. Examples of fine filtration systems include microfiltration, ultrafiltration, and reverse osmosis. Fine filtration systems are best placed after initial solid removal technologies. Fine filtration systems target viruses, plant soluble compounds, and some dissolved solids.

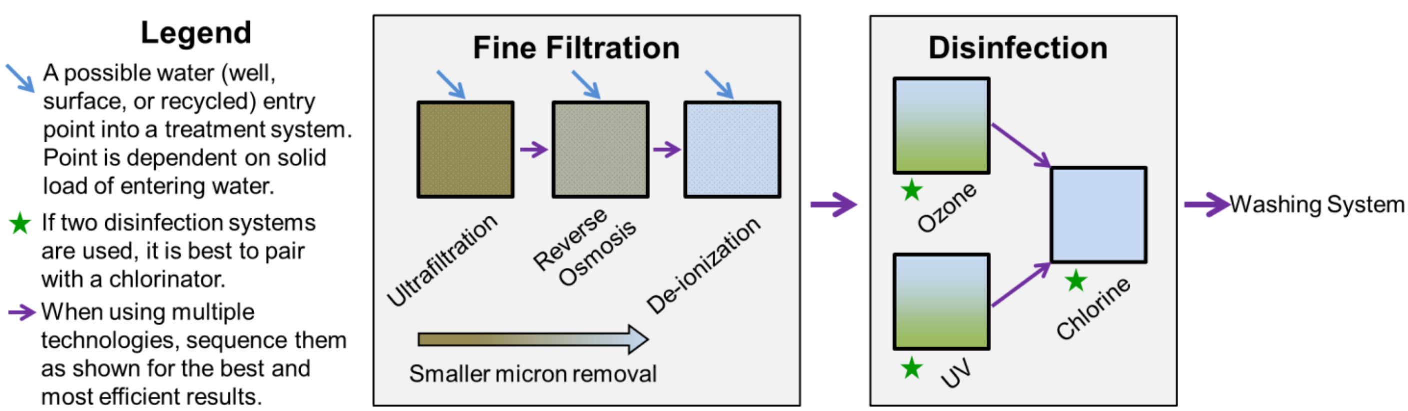

Figure 2: Suggested technology sequence with notes.

Microfiltration & Ultrafiltration

Microfiltration removes any particles that range from 0.1-10 micron or larger. Ultrafiltration (UF) primarily removes particles from 0.001-0.1 micron.

Washwater passes through specially designed membranes under pressure. The membranes allow water to pass through but capture unwanted material larger than the membrane pore size. These systems need regular cleaning to prevent fouling by solids that clog the filter membrane. Water is pumped back through the membrane to remove the solids and this backwash water is then disposed separately. Some systems will have automatic cleaning cycles that greatly reduce maintenance requirements.

Reverse Osmosis

Reverse Osmosis (RO) is a system that uses membranes with a pore size of approximately 0.0001 microns. After water passes through a RO unit it is essentially pure or potable water.

To understand how RO works, it is helpful to understand osmosis. Osmosis is a naturally occurring biological process where a membrane separates two solutions of differing concentrations of charged particles. The molecules travel through the membrane from the area of higher concentration to the lower concentration creating two sides of equal concentration. When the sides become unbalanced again, the process begins.

Like Osmosis, RO has two solutions of differing concentrations and a membrane present, however the goal is different. The membrane traps the molecules instead of allowing them through. Very high pressure is used to force water through the membrane from areas of high concentration to low concentration. The RO membrane will need to be replaced on a regular basis; the frequency will be based on the amount of solids in the washwater. Washwater with insufficient pre-treatment may cause the membrane to require replacement sooner than necessary.

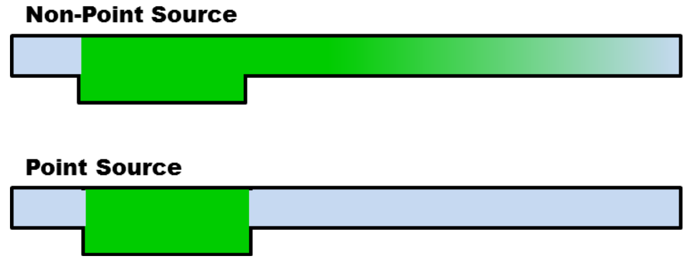

Figure 2: Area impacted by different disinfection methods as demonstrated by the green colour (HMGA Water Project)

De-ionization

Water is flushed through a unit containing negatively and positively charged electrodes. Dissolved ions such as phosphorus and nitrogen are attracted based on their own polarity and attach to the oppositely charged electrode where they are held (Voltea, n.d.). Clean water flows out of the unit. These units must be maintained by releasing the collected ions back into water by reversing the charge of the electrodes. The resulting backwash water is directed to a waste stream and is disposed.

Microbial Disinfection

Pathogenic microorganisms and viruses may be able to pass through primary treatment steps because of their small size and will need to be managed through a disinfection step. The efficacy of disinfection treatment is highly impacted by prior treatment. Disinfection is most effective when the majority of the other washwater contaminants, such as solids and nutrients, have been removed. This allows for the disinfection agents to more efficiently interact with the intended targets as desired.

There are several common methods of disinfection which can be either point or non-point source systems (Figure 2). A point source system provides primary disinfection at the point of contact only, whereas non-point source systems provide primary and secondary (on-going) disinfection. A disinfection process that provides primary disinfection treats the water as it passes through the treatment unit only and does not provide any residual disinfection. Secondary disinfection will continue to provide protection to water even after leaving the designated treatment area. It is recommended that water treated with only primary disinfection be used close to the disinfection point and in a timely manner.

Ultraviolet Disinfection

Ultraviolet (UV) disinfection is used to inactivate protozoa, bacteria, and viruses in water. Water is passed by a light bulb emitting ultraviolet radiation at 254 nm (Edstrom Industries, Inc.). The UV rays penetrate the outer membranes of the pathogens preventing reproduction by not disrupting the DNA (Edstrom Industries, Inc.). It is important to note that this process does not remove contaminants from water, rather it renders them inactive. It is a point source disinfection that only disinfects water as it passes through the UV unit. The addition of a small amount of a secondary disinfectant may be required for prolonged storage purposes. Solid particles and organic matter in the water can negatively impact UV disinfection as they reduce water clarity which is important for good UV transmittance. Organic matter will also absorb the UV energy and shield the pathogens from receiving treatment (Korshin et al., 1997; Gil et al., 2009).

Ozone

Ozone is a molecule made up of three oxygen atoms that can effectively oxidize pathogens causing them to be inactive. It is created on-site by passing clean air through an electrical field which produces gaseous ozone. During ozone treatment, the gas is diffused into water where the three-oxygen molecule breaks up into a stable two-oxygen molecule plus a free oxygen atom, known as a 'free radical' (B.F. Environmental Consultants). This free radical is very reactive and will quickly oxidize organic materials and pathogens in the water. Ozone is a non-point source treatment and water needs to be pre-treated to remove as much organic matter as possible prior to treatment; the clearer the water, the less required ozone dose. Too much ozone in the water can be a health and safety concern in the washing facility as the water releases the remaining free radicals as gas. Additional steps to treat the off-gases may be needed to manage residual ozone. Ozone is an effective disinfection method but it requires specialized equipment making it more costly than a chlorine dosing system (B.F. Environmental Consultants).

Chlorine

Chlorine dosing is a widely used disinfection technique. When added to water, chlorine forms compounds that act as oxidizing agents. These interact with protozoa, bacteria, and some viruses causing them to become non-functional (EPA, 1999), and unable to reproduce. Chlorine provides protection past the point of dosing. Chlorine is rendered less effective for treating water by the presence of organic matter as it will oxidize the chlorine thereby reducing its concentration and efficacy. The chlorine dose required is based on the water flow and quality, and the type of pathogen present in water. A metering pump and storage tank are used to ensure that water is consistently treated. Potable water has an aesthetic objective for chloride, an ion of chlorine, of 250 mg/L; an aesthetic objective is the maximum concentration suggested for visual appearance or taste. Too much chlorine could negatively impact water quality and additional steps may be needed to manage chlorine concentrations.

Technology Sequencing

It is important to arrange technologies in the proper order to ensure efficient treatment (Figure 1). For example, tannins or solids present in washwater can block UV rays or tie up ozone molecules thereby decreasing the effectiveness of microbial destruction. Therefore, solids removal must come before disinfection. If chlorine is used for disinfection before filtration steps, residual chlorine will be removed from the water. Therefore, fine filtration must occur before a disinfection stage.

RO will remove smaller material than ultrafiltration so it should be placed after an ultrafiltration system. De-ionization should be inserted after UF or RO as a final treatment step before disinfection

Within the disinfecting stages, chlorine should be used after a point source process completing primary disinfection, like UV or ozone, to allow on-going disinfection of the facility's water.

Conclusion

A washing facility commonly relies on one fine filtration and one disinfection system. The specific systems required by a facility will differ on a site by site basis and should be recommended by a qualified individual.

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More information on water testing to ensure washwater meets the appropriate water quality standards is available in Factsheet #012 'Water Quality Standards in Agriculture' which can be found at www.hmgawater.ca/factsheets.

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