Good Agricultural Practices and Good Handling Practices: Water Use in Horticultural Systems
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Introduction

Good agricultural practices (GAPs) and good handling practices (GHPs) encompass management practices producers, growers and packers of fresh produce should follow to minimize contamination of their product. This publication covers those practices related to water use.

Water is of special concern in maintaining produce safety due to the ability of pathogens to survive long periods in water, the ability of water to transport pathogens over a large area and the number of ways in which water can contact fresh produce pre- and post-harvest. The application of contaminated water in pre- or post-harvest management has a high likelihood of reaching the consumer.

Water and Microbial Hazards

Anytime water comes into contact with fresh produce, its quality determines the potential for pathogen contamination, since water may carry many different microorganisms that are harmful to human health. Given that small amounts of microorganisms (usually as few as 10 to 100 cells) in water can cause foodborne illness, water use is one of the most important critical components of a food safety program. Water that is inadequate in quality has the potential to be a vehicle for larger areas of contamination in the field, packhouse or transportation environment.

Agricultural Water

Water quality is of particular importance when it comes into contact with the edible portion of the product, both pre- and post-harvest. All agricultural water must be safe and of adequate sanitary quality for its intended use (Food and Drug Administration, 2013). Agricultural water does not include indirect water application (noncrop contact), such as drip irrigation to an aboveground crop or furrow irrigation to fruit trees.

The quality of agricultural water will vary and is highly dependent upon the water’s source. Surface water has the highest probability of being contaminated, while groundwater is of moderate risk, and municipal water is considered low risk. Properly constructed, placed, protected and maintained wells will help to ensure high-quality water. Applications of water should always be appropriate for the intended use, whether it be for the crop or during post-harvest handling.

Pathogens in Agricultural Watersheds
Most waterborne pathogens are excreted or shed in the feces of vertebrates. Water contamination routes are typically agricultural runoff, storm water, septic tank or well head leakage, wild and domestic animals, and land application of manure. Pathogens tend to fluctuate seasonally due mainly to temperature and precipitation. In certain circumstances, such as where there are high animal densities in confined animal facilities or where large numbers of newborn animals are present, pathogens in the watershed can quickly increase (Natural Resources Conservation Service, 2012).

The survival of pathogens in agricultural watersheds is governed by water turbidity, temperature, pH, oxygen levels, presence of nutrients (especially nitrogen), organic matter content and level of solar radiation. However, certain pathogens can remain viable for long periods of time despite the chemical, physical and biological stresses of the environment through resistant forms, such as cysts. *Escherichia coli* and *Salmonella* spp. can overwinter in streambeds, and increased levels have been shown to be associated with larger rainfall events and higher temperatures (Haly, Cole and Lipp, 2009). Being aware of seasonal variation and land use in your watershed will help minimize the risk if microbial contamination on your farm.

Actively participating in a local watershed group can be a way to influence water quality in your watershed and educate others.

**Land Use and Mapping**

Awareness of current and historical land uses on your property and in your watershed will allow you to better manage your production system with food safety in mind. Feedlots, animal pastures and dairy operations in your area can be a source of contamination. As such, producers should know what is upstream and how seasonal variation may influence water quality.

Developing a map of water sources, distribution systems and associated potential sources of contamination, such as adjacent and upstream land uses, will allow for a more comprehensive approach to understanding water quality on your farm or ranch. Include a record of well placement and distances to points of contamination, such as chemical and fuel storage areas. Review your map initially to see what management changes will have the greatest impact on water quality, and periodically to assess your system. If necessary, erect barriers that reduce the potential for water contamination. Examples of barriers might include sod or grass waterways, fencing, and earthen dams or berms.

**Irrigation and Crop Protection Water**

Assessing access to water, crop water demands and food-safety issues related to water use are important parts of fruit and vegetable production. Water that is of good quality, free of pathogenic microorganisms, is critical for on-farm food safety. Regularly inspect, especially at the onset of the growing season, and maintain water sources that are under your control.

The method and timing of irrigation has an effect on the potential to contaminate produce. Drip irrigation is a method that prevents contamination from product contact and soil splash. Avoiding irrigation one week before harvest can help minimize contamination of produce. In general, maximize the time between irrigation and harvest to reduce contamination due to dryness and exposure to solar radiation, which increases the rate of inactivation or death of pathogens (NRCS, 2012). Putting into place practices that protect water sources, such as grass waterways and fencing to exclude animals, will help to reduce contamination of your water source.
Water used in foliar sprays, including agricultural teas, frost protection and pesticide or fertilizer applications, should be from a pathogen-free source and potable as pathogens can persist and even grow in crop sprays. Avoid using surface water for irrigation immediately after storm events due to the chance of microbial loading into waterways. Irrigation water from a pond or lake that has had animals grazing in close proximity should not be used if it will come into direct contact with the crop or is untreated. Well water is less likely to be contaminated than surface water; however, wells should be properly located, maintained and constructed to reduce the chance of contamination.

Worker Hygiene

All water used for hand-washing must be potable. Workers must be trained and re-trained on proper hygiene, waste disposal and food-safety principles to reduce contamination. These trainings and related signage should be culturally sensitive and in the languages relevant to the operation.

Microbial Testing of Water

Testing water for generic *E. coli* may be required under the Food Safety Modernization Act of 2011, depending on your production practices, product and scale of operation. Being certified as following Good Agricultural Practices will require you to test the water used in production. Despite potential requirements, testing offers a “point in time” look at the quality of your water and is a good practice to follow to reduce contamination of your product.

Water quality can vary over time and should be tested to reflect seasonal fluctuations. Testing frequency should be conducted based on its source. In general, surface water should be tested once per month over the growing season, at planting, during peak use and just before harvest; well water should be tested once every three months; and municipal water is assumed safe but should be accompanied by tests from the municipality. All irrigation water that is tested should be collected as close to the field as possible.

Identification and quantification of all microbial pathogens in water is not practical due to the cost. However, methods are used that enumerate key organisms that serve as an indicator of water quality. Indicator bacteria may not be pathogenic but do indicate potential fecal contamination. Total coliform is a broad category that occurs in the environment, often in the absence of fecal contamination. Fecal coliform is a subgroup of total coliform and is commonly used as an indicator of fecal and bacterial contamination in watersheds (NRCS, 2013). Generic *E. coli* is a subgroup of the fecal coliform group found in high concentrations in mammalian fecal material. Water should be tested for generic *E. coli* at a close, reliable laboratory.

Microbial standards for water used for ice, agricultural teas, sprout or mushroom production, on food contact surfaces and hand-washing require that no detectable generic *E. coli* present per 100 milliliters of water. Irrigation water that comes into contact with the edible portion of the product (crop contact irrigation) should have no more than 235 colony forming units (CFU) of generic *E. coli* per 100 milliliters of any single water sample and a rolling geometric mean of five samples (n=5) of no more than 126 CFU/100 milliliters.

If standards are exceeded, stop using the water source and determine the cause of contamination (i.e. broken seal around well). Once you determine that you have exceeded allowable limits, document that you are addressing the issue and the corrective action taken such as replacing a seal around a well. Once you have
corrected the issue, reinspect your water supply and retest your water.

**Processing Water**

It is critical that water coming into contact with fresh produce during cleaning, cooling and other post-harvest activities must be potable. Water quality management throughout processing is essential to good sanitation, as reusing water can build up the amount of pathogens in the system with contamination spreading to larger volumes of product. In many instances, shelf life and safety are improved by not washing the product.

If water is used post-harvest, practices should be implemented that ensure that the water is of adequate quality at the start and end of all post-harvest processes (FDA, 1998). If water is being reused, water flow should be counter to the movement of produce through the different operations so that the most processed produce is always in contact with the cleanest water. Applying a regular treatment of disinfectant chemicals can be a good way to ensure water quality. Instillation of backflow devices is a necessary precautionary step to prevent contamination of clean water from contaminated water.

**Disinfectants**

The purpose of adding any disinfectant is to prevent cross-contamination and reduce microbial buildup. The addition of a disinfectant to wash water will not eliminate microbes from the product. There are many criteria to consider when selecting and incorporating a disinfectant into a processing system. Consult a university or industry expert to see what is appropriate for your system. Regardless of your selection, all sanitizers must be approved by the Environmental Protection Agency for use with fresh produce.

When using disinfectants, there are several tests that should be performed and recorded. Periodic testing of microbial loads and pH should be conducted to ensure continued efficacy of the wash treatment over time. Temperature monitoring is an essential component for some products due to the risk of water infiltration. Standard operating procedures (SOPs) should be developed that outline the use of sanitizers and water change schedules. Logs of temperature, pH and disinfectant levels should be maintained. Water contact surfaces must be cleaned and sanitized as necessary to keep produce safe.

**Product Cooling**

Produce is cooled to remove field heat and extend the life of the product. Many different methods are employed, including using water, ice and forced air. The method used depends on the product being cooled and operator preference. Water or ice used for cooling should be potable (no detectable generic *E. coli* per 100 milliliters). Good practices include:

- Cooling the product quickly and maintain temperatures to maximize produce quality.
- Considering the use of sanitizers in cooling water.
- Keeping water and ice clean and sanitary.
- Manufacturing, transporting and storing ice under sanitary conditions.
- Maintaining sanitary equipment.
- Preventing condensate from cold storage mechanisms from dripping onto produce.
- Storing similar commodities together to avoid cross-contamination (FDA, 1998).

**Conclusion**

Water is an important point of control for on-farm food safety. Pre- and post-harvest applications can easily contaminate large volumes of product. Water applications
should be of appropriate quality for their intended use. Assessing, monitoring and protecting your water source are important steps to take to reduce the risk to your operation and the consumer. Monitoring water quality for generic *E. coli* is a good practice that can help you understand the quality of your water source. All post-harvest water must be potable water. It is important to prevent cross-contamination via wash water or through other post-harvest processes. Always talk with a professional in the industry or at a university before selecting a sanitizer. It is also important to keep any records related to water use for a minimum of two years. Before implementing a water management plan, understand any potential buyer demands and regulatory requirements and meet those criteria.

**References**

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