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Minimizing Risks: Use of Surface Water in Pre-Harvest Agricultural Irrigation

Part I: Understanding Water Quality & Treatment Options

Jessica L. Dery, Natalie Brassill, and Channah M. Rock

Why treat agricultural irrigation water?

Irrigation water can act as a **vector**, or carrier, that can transport or spread pathogens to crops, where they have the potential to cause illness (CDC, 2018). Decisions to treat irrigation water can be driven by buyer requirements, for product marketing or branding, or because the water quality exceeds the FDA Food Safety Modernization Act (FSMA) regulations or the Leafy Green Marketing Agreement (LGMA) standards for generic *Escherichia coli (E. coli)*. For example, the quality of surface waters may be more impaired or have higher pathogen contamination compared to groundwater (FDA, 2018). This is because they are directly exposed to external influences and therefore may require treatment. To ensure irrigation water is at a quality sufficient to meet grower needs, it is important to understand how water quality affects treatment methods and associated challenges and solutions. If the quality of the water source is unknown, there are many labs recommended by the Arizona Department of Health Services that offer U.S. EPA approved testing methods. Links to testing labs, EPA registered sanitizers, and approved testing methods are provided at the bottom of this fact sheet. This publication is a general overview of water quality and common treatment methods.

It is the first of a series covering specific treatment options for pre-harvest agricultural irrigation such as chlorination, Ultra Violet (UV), and peroxyacetic acid.

Common treatment methods

Various water treatment methods or technologies can be used for agricultural irrigation based on the water quality parameter of concern (e.g. bacteria, sediment, etc.). Such methods include chemical treatment, physical treatment, and biological treatment, and are illustrated in Figure 1. It is important to remember each method has advantages

Irrigation Canal, Yuma, AZ Photo by Natalie Brassill

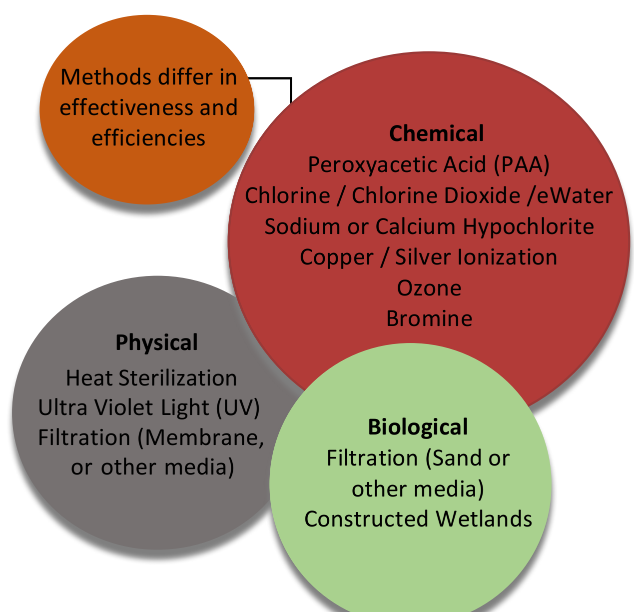

Figure 1. Common Treatment Methods for Pre-Harvest Agricultural Irrigation Water. For a list of EPA approved sanitizers, go to: https://producesafetyalliance.cornell.edu/resources/general-resource-listing/

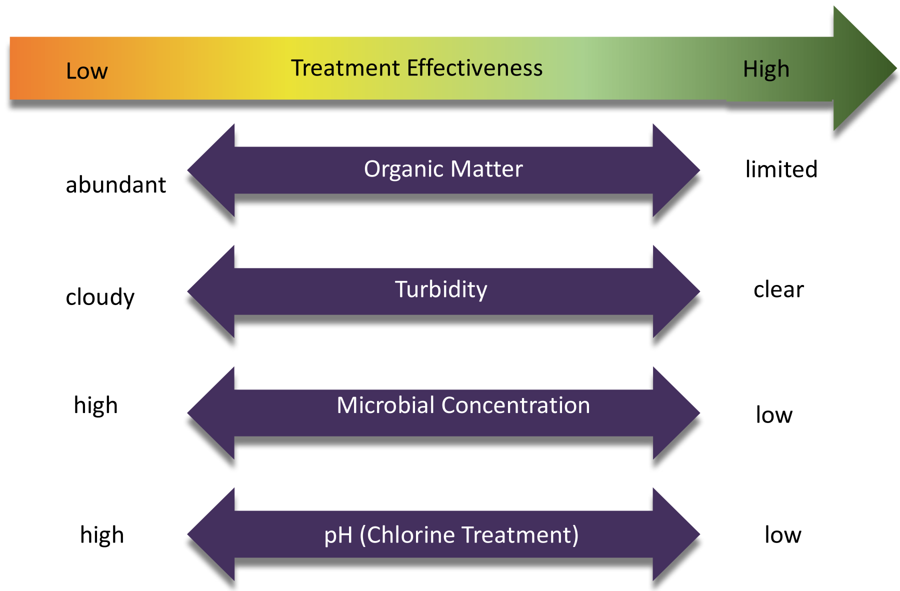

Figure 2. Factors affecting effectiveness of irrigation water treatment methods.

and disadvantages. Integrated approaches incorporating treatment technologies, sanitary surveys, and good agricultural practices (GAPs) should be implemented as a more effective and comprehensive way to mitigate risks to fresh produce.

What factors affect treatment effectiveness?

The effectiveness of treatment methods is influenced by the background quality of the irrigation water and includes physical, chemical, and biological parameters. In deciding which treatment method, or methods, to implement, your water's quality profile should be assessed. Each of these factors can impact which water treatment is best suited to meet your water quality needs.

Organic matter are organic substances broken down from plants, animals, microorganisms, and from geological origins that can be found in water sources, either settled or in suspension. Organic matter consumes disinfectants, requiring increased concentrations of the disinfectant to be effective. These organic substances also contribute to the **turbidity** of the water supply, which is a measure of the water's clarity, or how much light is scattered by the material in the water (USGS, 2018).

The more turbid a water source is, the more light is scattered, and the more difficult it is to see through. Turbidity provides food and a 'hiding' place for organisms and pathogens, shielding them from disinfection treatments such as ozone, UV, and chlorine (USGS, 2018; WRC, 2018a). This results in a need for increased concentrations of chemicals necessary to achieve the desired level of water quality, or inclusion of a 'pre-treatment' step, such as filtration, to remove sediment. The concentration of microbes in irrigation water, or the **microbial load** and the **characteristics of the microbes** can also affect treatment effectiveness. Different types of microbes may require different treatment methods, disinfection concentrations, or contact time (CT). **Temperature** is another important factor that can impact water treatment. Because chemical reactions often increase at higher temperatures, chlorine treatments, for example, are less effective at low temperatures (WHO, 2004). In addition, temperature affects other water quality parameters such as pH, or the measurement of how acidic or alkaline (basic) the water is. As the temperature of the irrigation water increases, pH decreases. The **pH** of the irrigation water also affects the efficiency of certain treatments. For example, ozone treatments require different dosages based on pH and chlorination is more effective in water with lower pH (EPA, 2018). Excess calcium and magnesium in a water source contribute to the **hardness** of water and can lead to scaling of irrigation lines. This buildup can decrease the effectiveness of water treatment

Factors affecting effectiveness of treatments include:

- Organic matter
- Turbidity
- Microbial loading
- Microbial Characteristics
- Temperature
- pH

processes such as UV, making it important to minimize scale deposits in the irrigation system. Because these factors affect treatment methods differently, they will be discussed in more detail for each treatment method in this series

How long does it take a disinfectant to work?

Disinfectants and sanitizers do not kill, or inactivate, microbes immediately upon contact. They take time to work. There are several factors influencing how fast a disinfectant works, known as the **inactivation rate.** This rate is dependent on the type of **pathogen**, as some microbes are more resistant to disinfection than others and may require increased disinfectant concentrations or contact time (CT). The chemical disinfectant **concentration (C)** and the **time (T)** in which the chemical disinfectant is in contact with the water is known as the **'contact time' (CT)**. This also affects this rate of inactivation. It is important to remember that an increase in chemical concentration can decrease the amount of contact time (CT) needed to kill or inactivate pathogens, and vice versa. When treating irrigation water with chlorine, it is important to understand **breakpoint disinfection**, or breakpoint chlorination. This occurs when there has been enough chlorine added to the irrigation water to satisfy the chlorine demand. At this point, the water begins to build up residual and free (available) chlorine, the form of chlorine with the most disinfecting power (Pa. DEP, 2016). This is an important concept for monitoring chlorine levels for maximum disinfection efficiency and will be further discussed in Part II of this series covering chlorination treatment.

Temperature and **pH** are also important in determining the rate of disinfection (WRC, 2018b). For example, ideal temperatures for chlorine treatment are between 65 and 99°F, and ideal pH is between 6-7.5 (Castle Chemicals; USDA NRCS; WHO, 2013). Figure 2 provides an example of factors that influence treatment effectiveness. Temperature is not included in this figure as the effects are variable between treatment methods.

Factors affecting inactivation rates of disinfectants:

- Organic matter
- The pathogen
- Chemical concentration, C (mg/l)
- Contact time, CT (minutes)
- Temperature of water
- pH of water

Types of irrigation water to be tested:

- Water that directly contacts the edible portion of harvested crop.
- Water used for sprout irrigation

Treating Agricultural Irrigation Water

When treating your irrigation water with sanitizers/disinfectants, it is important to follow specific guidelines and remember to:

- Use sanitizers and disinfectants approved by the EPA to determine if it will be effective (PSA, 2018).
- Sanitizers and disinfectants are to be used in accordance with label specifications and guidelines. Each sanitizer may have different specifications.
- Always remember to follow directions on all sanitizer labels.
- Consider environmental impacts.
- Use an accepted testing method.
  - o FDA BAM (Bacteriological Analytical Manual) method.
  - o U.S. EPA approved or AOAC accredited method for quantitative monitoring of water for generic *E. coli.*
  - o Presence/absence testing. Must have a similar limit of detection as quantitative monitoring.
- Document all test results and remedial actions. These must be available for verification and kept for a two-year period.

Certain agricultural water must either be required to meet the proposed FDA FSMA or LGMA metrics for Maximum Contaminant Level (MCL) Goal for *E. coli*, set by the EPA, OR it must contain approved disinfectant at sufficient concentrations to prevent contamination (CALGMA, 2018).

This fact sheet is part of the 'Minimizing Risks: Use of Surface Water in Pre-Harvest Agricultural Irrigation series. Additional information detailing specific treatment methods for agricultural irrigation waters is available as part of this series.

Additional information

1. The link for Arizona Department of Health certified labs: https://app.azdhs.gov/bfs/labs/elbis/drinkingwatertestinglabs/drinkingwatersearchc ontentpage.aspx
2. For the list of approved irrigation water testing methods, as determined by the FDA: https://www.fda.gov/Food/FoodScienceResearch/LaboratoryMethods/ucm575251. htm

3. General resources including an excel spreadsheet for EPA approved sanitizers for produce can be found on the Produce Safety Alliance website at: https://producesafetyalliance.cornell.edu/resources/general-resource-listing/

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COLLEGE OF AGRICULTURE AND LIFE SCIENCES
TUCSON, ARIZONA 85721

JESSICA L. DERY
Assistant in Extension, Water Quality and Food Safety, Maricopa Agricultural Center

NATALIE BRASSILL, MS
Assistant in Extension Water Quality, Maricopa Agriculture Center

CHANNAH ROCK, PHD
Water Quality Specialist & Professor, Department of Soil, Water, & Environmental Science

CONTACT:
CHANNAH ROCK
channah@cals.arizona.edu

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