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FEATURES

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Sanitation Station

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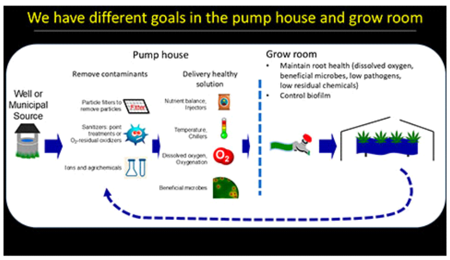

Water sanitation is a critical factor in hydroponic systems. Plant pathogens such as Pythium, Phytophthora and Fusarium can be distributed through recirculating water, increasing the risk of disease outbreaks. Effective water treatment helps control plant pathogens, human pathogens, and also algae and biofilm formation that can clog irrigation emitters and increase pests such as shoreflies.

Figure 1. Remove contaminants in the pump house and deliver a healthy solution to the grow room.

Choosing the right water treatment system

There's no one-size-fits-all solution for water treatment. The appropriate choice of method depends on installation and operating costs, production scale, space availability, compatibility with other production processes and the microbes being targeted. When designing a water treatment system for your hydroponic setup, keep the following factors in mind:

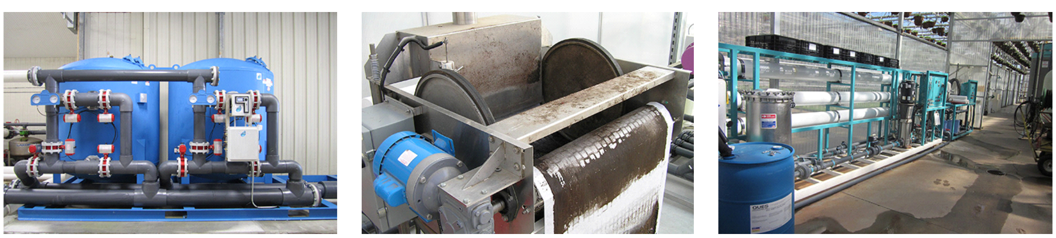

Figure 2. A sand filter (left), paper media filter (center) and reverse osmosis filter (right). Photos by Paul Fisher.

Think holistically as a coordinated system, not just one technology: In the pump house, the goal is to remove contaminants from source and recirculated water, and then rebalance nutrients, oxygenate and regulate temperature (Figure 1). The more contaminated the water, the more steps that are required in the treatment chain in the pump house. Ensure an adequate dose is applied to control the target pathogens and refer to the Waterborne Solutions tool in cleanwater3.org for dosing information.

In the grow room or greenhouse, avoid residual chemicals and create a healthy root zone environment. That may mean the need to remove chemicals such as chloramines with a granular activated carbon filter or other technology before treated water is sent to the greenhouse. Monitor the nutrient solution and ensure it consistently meets your defined quality specifications. Mitigate other potential sources of contamination such as young plants, containers, equipment, air exchange and workers.

Promote root health: Oxygenation improves plant health by raising dissolved oxygen (DO) levels and thereby avoiding root stress. Warm root zone temperatures reduce DO and encourage pathogens such as Pythium, so chillers are often essential for summer production. An otherwise sterile nutrient solution in the grow room actually makes it easier for disease to occur if pathogen spores are present. Either naturally occurring or dosing with beneficial microbes may help prevent disease.

Figure 3. Phytotoxic symptoms on Rex lettuce shoots and roots after 42 days in deep-water culture hydroponics with chlorine doses of 0, 0.5, 1, 1.5, 2 and 4 $mg{\cdot}L^{-1}$ (left to right). Photos by Kenderdine and Raudales, University of Connecticut.

Filtration is the first step to ensure the effectiveness of any disinfection method. Just like we clean then chemically sanitize growing surfaces, we first need to "clean" water by removing suspended particles such as substrate, algae and plant debris because those particles can clog emitters, reduce the effectiveness of disinfectants and consume oxidizing agents that are needed to eliminate pathogens. Clear water is also vital for UV treatment because UV light needs a high transmission rate to reach pathogens.

Filtration technology options such as those shown in Figure 2 are each suited to different particle sizes and contaminant types. The higher the total suspended solids or turbidity in water, the more filtration steps are required (from coarse to fine pore sizes) to achieve the final desired quality.

With all filters, there's an operating cost as well as a required maintenance plan, such as back flushing or media replacement. Monitoring water quality with a turbidity meter before and after filtration is a good onsite check for water clarity and filter efficiency.

Sanitation technology options

Water sanitation can be achieved with several different sanitation technologies, each with pros and cons.

Oxidizing agents: This group of technologies controls microbes by oxidizing (removing electrons) from microbial cell membranes, proteins and DNA in microbes.

Ozone: An excellent choice for many hydroponic operations because it provides a short, sharp shock with highly reactive dissolved ozone gas, leaving only dissolved oxygen as the main residual. Oxidation of micronutrients can be an issue, requiring iron chelates and manganese to be added back following treatment.

Chlorine (hypochlorous acid): Available in several forms (calcium hypochlorite, chlorine gas, electrochemically activated brine solution [ECA], purified hypochlorous acid and sodium hypochlorite). Chlorine can cause root phytotoxicity, especially when chloramines form when chlorine reacts with ammonium fertilizer (Figure 3). Use calcium nitrate sources that are ammonium-free. Repeated treatment with sodium hypochlorite can cause undesirable sodium build-up (adding to electrical conductivity [EC] and interfering with essential nutrient uptake).

Hydrogen peroxide/ peroxyacetic acid: Sometimes used at a continuous low dose or pulsed periodically with a higher dose to reduce phytotoxicity risk.

Chlorine dioxide: This dissolved gas can cause root phytotoxicity and isn't normally used in hydroponics. Mainly used for plants in container substrates.

Cold plasma: A promising new technology similar in mode of operation to ozone, currently only available for low flow rates.

Other processes

UV radiation: UV light damages the DNA of microorganisms, rendering them inactive. For UV treatment to be effective, water should be clear and free of suspended solids, which can block UV light. Iron chelates also reduce UV transmission and in turn UV causes photodegradation of chelates. UV is therefore mainly used on source water before fertilizer addition. Use a UV model with auto-cleaning of the bulb to reduce biofouling and make sure the unit is sized with adequate UV output for your flow rate and turbidity.

Copper ionization: Copper is a biocide that isn't usually used in hydroponics because copper in solution can be phytotoxic, causing reduced root growth and phytotoxicity on foliage. Mainly used in greenhouse production with container substrates.

Membrane filtration: Ultra and nano-filtration have small enough pores to exclude plant pathogens. However, low flow rate and biofouling are often an issue within recirculating systems. The main application is reverse osmosis in source water to exclude most ions such as sodium and chloride.

Heat pasteurization: Provides an effective point treatment, but isn't widely used in North America because of capital and energy cost.

Avoid dumping nutrient solution

If you design and operate an effective water sanitation system and periodically rebalance nutrients, then you can not only maintain root health, but also avoid the need to dump nutrient solution into the environment. Our goal is to approach a closed-loop system with recirculating hydroponics in order to be both profitable and sustainable.

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