From Forest Nursery Notes, Summer 2009

201. Combat pathogens, algae with ozone treatment. Hayes, C., Evans, L., Fisher, P., Frances, A., Vetanovetz, R., and Zheng, Y. Greenhouse Management and Production 29(1):16-18, 20. 2009.

Combat pathogens, algae with ozone treatment

The success of ozone in treating irrigation water depends on the proper application, effective filtration and a cohesive system design.

By Charlie Hayes, Les Evans, Paul Fisher, Anne Frances, Rick Vetanovetz, and Youbin Zheng

Ozone is a strong sanitizing agent for treating pathogens and algae in irrigation water. In an ozone water treatment system, oxygen from the air is converted into ozone gas, which is then dissolved into water to form aqueous ozone. Although ozone is not widely used in U.S. greenhouses and nurseries, it is an established technology in Europe and in other U.S. sectors including fruit packing, municipal potable water treatment and waste water treatment in animal agriculture.

Ozone controls algae and pathogens in irrigation water by oxidizing constituents of cell walls before it penetrates inside the cell wall and oxidizes enzymes, proteins, DNA, RNA and cell membranes. Ozone is a strong enough oxidizer to remove biofilm from piping, but has a short residual time in irrigation water. Biofilm is a thin, resistant layer of microorganisms that forms on and coats various surfaces.

Mode of application

To produce ozone, oxygen from the air is converted into ozone using a corona ozone generator, which uses electrical energy to cause some of the oxygen (O_2) to break apart and reform as ozone (O_3). The ozone is then dissolved in water.

The most efficient method to dissolve ozone in water is with a venturi injector in a pressurized system.

The method of dissolving ozone in water is dependent upon the contaminant level as well as the water pressure, temperature and depth. An ultraviolet light-ozone generator typically used with swimming pools that bubbles ozone directly into an irrigation tank is ineffective because insufficient ozone is generated, and some of the gas is released into the air rather than dissolving in water.

Using ozone in a greenhouse application

Design of a commercial ozone system can be illustrated by a Midwest greenhouse operation that is currently installing a water treatment system. An ozone system will treat recycled water in irrigation tanks. The treated water will subirrigate plants on concrete flood floors. When the treated water is pumped onto the flood floor, the goal is to ensure that the recycled water has been cleaned of pathogens and algae rather than to provide residual control of pathogens.

This series is part of the Water Education Alliance for Horticulture initiative (www.watereducationalliance.org) supported by AquaHort by LHT, AquaPulse Systems, BioSafe Systems, Chem Fresh Inc., Ellegaard, Fafard, Fischer Ecoworks, Greencare Fertilizers, Griffin Greenhouse and Nursery Supplies, Hanna Instruments, Konjoian's Floriculture Education Services, National Foliage Foundation, Pindstrup, PPG Industries, Premier Horticulture, Pulse Instruments, Quality Analytical Laboratories, Regal Chlorinators, Sun Gro Horticulture, TrueLeaf/Aerotech, University of Florida, Whitmire Micro-Gen and the Young Plant Research Center partners (http://hort.ifas.ufl.edu/yprc). We thank the National Foliage Foundation and Florida Nursery, Growers & Landscape Association for supporting water research at the University of Florida.

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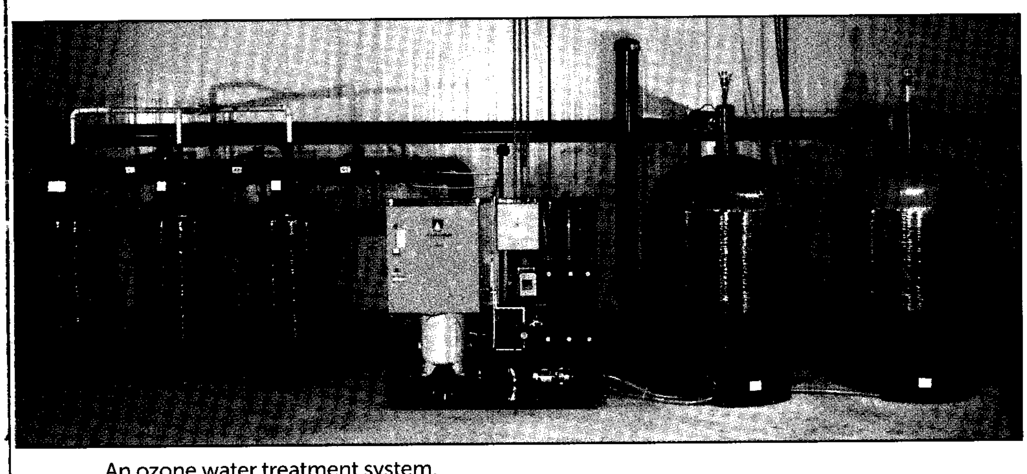
Water in each irrigation tank is circulated through an ozone system several times each day. Once the water has been ozonated, it is returned to the tank. The flow of ozonated water is directed to ensure mixing of the ozone with non-treated water in a return tank.

Required dose for greenhouse use

System design and the required ozone dose depend upon the intended application of ozone. For overall sanitation and washing down greenhouse surfaces, a high dose of ozone should be used with spray equipment that minimizes the release of ozone into the air ("off-gassing").

For water purification and pathogen control, a higher ozone dose is required to build up residual activity. This type of application requires water filtration before and/or after ozonation.



An ozone water treatment system.

29(1): 16-18, 20.

Another ozone application is for biofilm destruction, where ozonated water is placed in a pressurized piping system for at least 30 minutes.

Although research data are not yet available for nursery and greenhouse applications (research is underway at the University of Guelph), industry recommendations for ozone concentration and contact time are:

- Dissolved ozone residual levels of 0.2 parts per million for as little as 30 minutes can destroy established biofilms.
- Dissolved ozone residual levels as low as 0.01-0.05 ppm can control algae.
- Residual level of aqueous ozone (in the water) should be below 1 ppm to avoid phytotoxicity to crops. However, long term exposure to gaseous ozone (in the air), even as low as 75 parts per billion (0.075 ppm), can reduce the growth of most plant species.

Ozone damage can manifest itself in various forms, ranging from acute symptoms (visible injury to foliage including stippling, chlorosis mottle, necrotic lesions and localized waterlogging) to chronic symptoms, including subtle changes in color, reduced growth and accelerated leaf senescence.

The need for filtration

The amount of organic material in a water source is a major factor affecting the efficacy of ozone. Mechanically removing as much of the organic load as possible before ozonation occurs reduces the size of the ozone-generating equipment needed, thereby lowering sanitation costs.

Like many sanitizing agents, ozone is often combined with other technologies to increase its efficacy. Pre-filtration allows ozone to work efficiently against pathogens and algae by removing organic particles and debris like peat moss and plant roots. The more filtration that occurs, the less the organic load that has to be treated by the ozone system, and the more likely that ozone molecules will kill the remaining algae and pathogen spores. In the case of the Midwest greenhouse operation, water will pass through a media filter (a rotating drum of paper) to remove particles larger than 10 microns before ozone treatment.

Residual effects and persistence in greenhouse water

Because ozone is rapidly consumed by organic matter, its residual activity is short-lived in irrigation water. As ozone breaks down, residual compounds are produced, including hydroxyl (OH) radicals. OH radicals are effective, but short-lived, oxidizers.

The persistence of ozone in irrigation water also depends on the water temperature and pH. As water temperature increases, the half-life of ozone decreases. But the ozone dose required for bacterial destruction also decreases with warmer water.

While ozone efficacy is not pH-dependent, ozone's half-life decreases as the pH increases, especially above a pH of 7.

When ozone is added to fertigation solutions, there is the potential for the precipitation of micronutrients. Researchers at University of Florida plan to investigate this issue from a production perspective.

Monitoring ozone concentration

The most accurate way to monitor dissolved ozone is inline, or within the irrigation line itself. Dissolved ozone measurements are quite sensitive to changes in water pressure. A drop in water pressure will give a lower-than-actual reading.

Dissolved ozone can be measured with test kits using reagents or with commercial monitors. Since ozone is an oxidizer, its activity can also be monitored using either an inline or hand-held oxidation-reduction potential meter. These meters are the least expensive while ozone monitors and controllers are the most costly. In a greenhouse setting, the monitoring and control system can measure oxidation-reduction potential constantly to sense whether the ozone demand of contaminants in the water has been met and residual ozone is present.

Environmental, worker safety

To ensure environmental and worker safety, it is necessary to implement measures to minimize the release of ozone into the air. Ambient ozone gas monitors should be installed in pressurized systems that automatically shut down the generator if a leak occurs. If ozone is used indoors, safety criteria set by the Occupational Safety and Health Administration must be met.

Once ozone breaks down in water, there are no environmentally harmful residual products.

Ozone systems should always be sold as a complete system, since all materials contacting higher residuals of ozone should be made of ozone-resistant materials. Ozone injectors are typically made of Kynar, but Teflon, stainless steel and other oxidation-resistant materials can be used.

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Next month: Treating water with ultraviolet light.