Horticultural operations are facing increasing pressure to solve sanitation issues related to water treatment. Some of the pressure is external originating from government regulations and consumer preferences. Most of the pressure, however, is internal and includes better disease management, integrating capture of irrigation runoff with recycling opportunities, elimination of biofilm and algae control.

The list of available water treatment technologies is a short one. When the unusual demands of horticultural production and post-production practices are considered, the list of technologies that offers effective solutions becomes even shorter. Chlorination, ultraviolet light, chlorine dioxide, ozone, copper and peroxide comprise the list most growers are considering. This article will present a technology review of chlorine dioxide and discuss its potential to solve sanitation issues in greenhouses and nurseries.

Biofilm, Sanitation’s Epicenter

Biofilm is a living complex of organic and inorganic components that becomes established on surfaces that are in regular contact with water. Such surfaces include pressurized irrigation lines, non-pressurized recirculation system return lines, holding tanks, mixing tanks, containment vessels and so on. Largely comprised of highly adaptive bacteria, biofilm layers attach themselves to hard surfaces and then grow, becoming thicker and quite established over time.

In horticultural operations such as greenhouses and nurseries, common fertilizer injection actually serves as an accelerant to biofilm growth. Most growers are quite familiar with the presence of biofilm in their fertilizer lines. The layer of slimy growth is seen whenever a line is cut into for repair. Biofilm growth is not restricted to fertilizer lines, however, and is also common in clear water lines, although usually by a slightly less dramatic presence.

An interesting relationship exists between the bacterial complexes making up biofilm and algae. The relationship is a synergistic one; what one needs the other provides. In fact, they work so well together that biofilm is able to provide algae with sufficient energy to substitute for algae’s need for sunlight. Any grower who has scratched his or her head after cutting into an underground pipe and found it lined with green, algae-laden biofilm in the absence of sunlight has personally experienced this phenomenon. Consider this a highly evolved organic system, one that has survived the test of time.

It’s no wonder most water treatment technologies are not capable of breaking biofilm down. The photo at left shows sections of PVC pipe cut longitudinally to show the inner surface; top–new line, middle–clear water line showing tan colored biofilm contamination, bottom–fertilizer line showing algae and biofilm complex.

Chlorine Dioxide’s Potential

Chlorine dioxide is widely viewed as one of, if not the most effective, sanitizing agents created by man. A decade ago when the Hart Senate building in Washington, D.C. was infested with anthrax, it was chlorine dioxide that was used to disinfest the building. In that application, the building was gassed with chlorine dioxide. In horticulture it is injected via its liquid state into irrigation lines.

One property of chlorine dioxide that provides a large part of its potential is it is a gas that is very soluble in water. On-site generator technology allows for the production of a stock concentrate in the 2,000 to 3,000 ppm range. This stock solution is then injected into irrigation systems to a final, hose-end concentration below 1.0 ppm that results in excellent water sanitation.

Connected to this solubility characteristic is that as a gas dissolved in water, chlorine dioxide is free to diffuse or move within its solution. Due to this property, its molecules are free to move about within an irrigation line. They capitalize on this freedom of movement by penetrating biofilm layers and killing the complex right down to its attachment sites along the hard surface it has colonized. With the exception of ozone, no other sanitizing technology has the ability to diffuse this effectively.

Connecting The Dots

Once it is understood that biofilm flourishes in horticultural operations, it encourages algae and it is capable of sustaining disease organisms, including waterborne plant pathogens, we can associate value to its control. Connecting these dots along the sanitation and disease control continuum allows our industry to hone in on how to eliminate the problems and improve operational sanitation significantly. Imagine the corner of a subirrigation bench with algae and crop debris. It can be assumed that such contamination is also capable of harboring plant pathogens, particularly those that are waterborne, as well as insects such as fungus gnats and shore flies.

Greenhouse Vegetable Production

A large greenhouse tomato, pepper and cucumber operation in California (pictured at right) injects chlorine dioxide into its irrigation water and post-harvest water network to sanitize various production and post-production systems. First, constant injection to achieve a residual of 0.25 to 0.50 ppm in the irrigation water has removed pre-existing biofilm in the lines and prevents its re-establishment. A secondary benefit of this application is elimination of drip-emitter clogging resulting from organic matter deposition associated with biofilm growth and sloughing.

Algae control is another secondary benefit as the trough irrigation system is significantly cleaner with respect to algae buildup than prior to treatment. Because control is a function of continual contact between treated water and the surfaces, complete elimination of algae is dependent on the physical design of the irrigation system. Design flaws that include dead legs in irrigation runs and areas where both effective contact and regular contact time are not achieved need to be identified. These stubborn areas within an irrigation system next need to be managed with an additional effort that often involves periodic treatment with a higher dose of chemical. Such design flaws should be eliminated as irrigation systems are expanded within an operation. Once again, connecting the dots is allowing us to better understand the problems in order to solve them.

Once the tomatoes are harvested, they literally are dumped into an underground water network that floats them to the grading and packing area. Once in this area the tomatoes are transferred to a water bath containing chlorine dioxide for surface sanitation as they are cleaned, graded and packed. Tomatoes are received in a packing area via an underground water system and are raised into a chlorine dioxide solution as they float through the sanitizing and cleaning process.

Another advantage that chlorine dioxide offers with regard to vegetable and other edible crop sanitation is that because of its gaseous nature, any molecules not consumed in surface sanitation escape to the air and eliminate the need to rinse the product with water to remove any residual chemical. This avoids the issue of ensuring that rinse water, in itself, is free of microbial organisms and not re-contaminating the product. Freshly harvested produce is passed through a field-level hydro-cooler. Chilled water removes field heat, rinses soil and debris and also provides initial surface sanitizing of produce on its way to a packing shed. The water in this system is treated with chlorine dioxide.

Outdoor Nursery Production

An outdoor nursery in California recently switched to chlorine dioxide injection with a main objective of improving drip emitter performance. With year-round production and an irrigation system that captures runoff in a surface pond for reuse, clogging of drip emitters due to biofilm accumulation was a major problem. Pictured above are two drip emitters (left–new emitter; right–biofilm clogged emitter). Note the pyramidal accumulation of algae and biofilm clogging the emitter tip causing failure.

Constant inspection of drip lines and replacement of clogged emitters had grown into a full-time responsibility for one employee of this nursery. Chlorine dioxide treatment has eliminated the problem with minimal attention now being required to maintain the drip lines.

Greenhouse Ornamental Production

The ranks of greenhouse growers using, trialing and considering chlorine dioxide includes those with the following objectives:

– Elimination of biofilm from irrigation lines and holding tanks

– Elimination of drip emitter clogging

– Significant reduction of algae

– Treat irrigation water for disease control

– Treat captured runoff water for re use

Pictured above is a boom irrigation system applying chlorine dioxide treated water in a vegetative propagation greenhouse.

In the months and seasons ahead this group of growers will be the source of additional educational articles as it learns how to harness the potential of chlorine dioxide.

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