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228. Water treatment series, part 7: chlorine dioxide can treat water. Fisher, P., Argo, B., Huang, J., and Konjoian, P. Greenhouse Management and Production 28(9):14-17. 2008.

A low concentration of chlorine dioxide can be used to maintain clean irrigation lines and to inhibit algae and diseases.

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Water treatment series: Chlorine dioxide can treat water

CHLORINE DIOXIDE (ClO_2) is an effective sanitizing agent for water treatment. In horticulture, it is used at a high concentration to remove established biofilm that lines irrigation systems, clogs emitters and can potentially harbor pathogens. For continuous application, a low concentration of chlorine dioxide can be used to maintain clean irrigation lines and to inhibit algae and diseases.

Mode of action

The chemistry of chlorine dioxide differs from gas chlorine, sodium hypochlorite (bleach) or calcium hypochlorite (tablets), which react with water to form sanitizing hypochlorous acid. Chlorine dioxide is a gas generated onsite when reagents react in a stock tank.

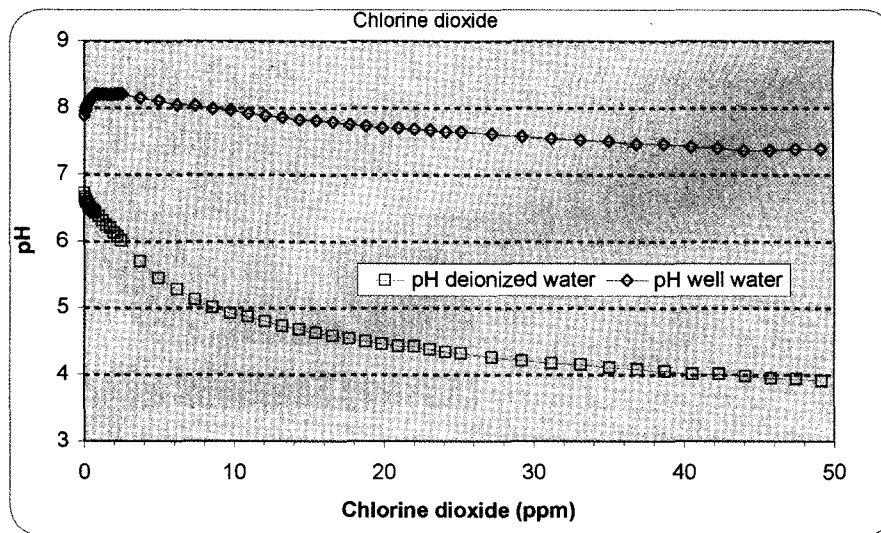


Figure 1. Chlorine dioxide, generated from Ultra-Shield, is slightly acidic. Two water sources were used: deionized water with no alkalinity and well water with 100 parts per million calcium carbonate alkalinity. Research by the University of Florida.

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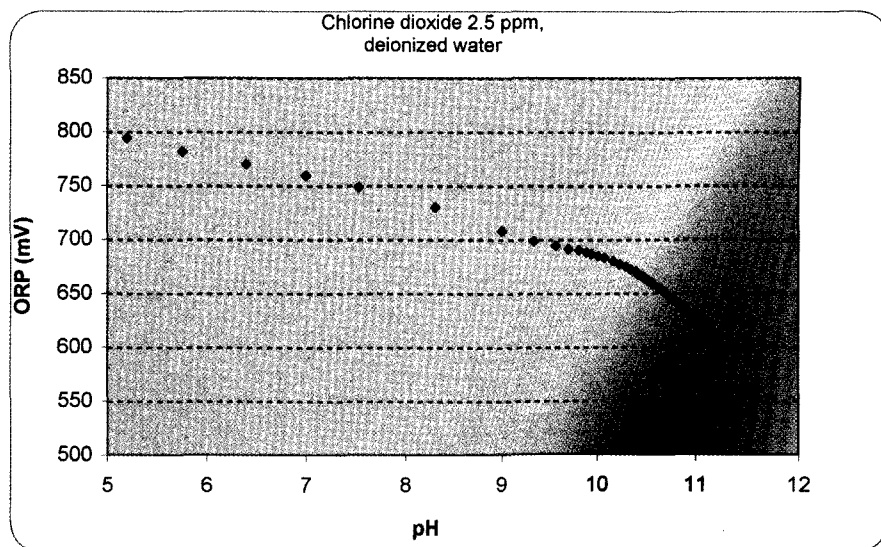


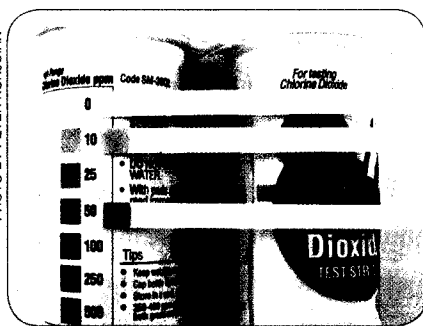
Figure 2. Chlorine dioxide, generated from Ultra-Shield at 2.5 ppm in deionized water, has high oxidizing power (as indicated by an oxidation-reduction potential above 650 milli-volts) across a wide pH range. Research by the University of Florida.

Once injected into water, chlorine dioxide remains as a highly soluble, dissolved gas. Chlorine dioxide is neutral to slightly acidic, and is effective at a wide pH range (4 to 10) for irrigation water.

The chlorine dioxide molecule is a strong oxidizer, with greater oxidizing power than other forms of chlorine at the same concentration, and is particularly effective at penetrating and removing biofilm. Chlorine dioxide is more expensive on a part per million basis for treating large volumes of water compared with other chlorine forms. Therefore, some growers use chlorine dioxide in highly disease-sensitive areas of the greenhouse such as plant propagation, rather than treat the entire irrigation system.

Shock treatment

Label rates recommend a shock treatment of 20-50 ppm chlorine dioxide (depending on the product) maintained for 12 hours. If the concentration of chlorine dioxide decreases significantly over the 12 hours, then reapplication is needed. With any shock treatment, do not



Chlorine dioxide concentration can be measured with test strips.

use the irrigation system until it has been thoroughly rinsed and flushed with clean water because of the significant risk of phytotoxicity. It is best to perform the shock treatment between cropping periods or in empty growing zones. Avoid running the shock solution through emitters that will be clogged by deposits in the line.

For continuous treatment, inject sufficient product at the water

Chlorine dioxide products

Chlorine dioxide must be generated onsite. In the past, large-scale chlorine dioxide generators used in other industries faced technical challenges when installed in greenhouse operations, including the variable water and chlorine dioxide demand over time.

In contrast, newer chlorine dioxide products that are U.S. EPA registered for greenhouse use are easy to use and highly effective. Chlorine dioxide is safe when used according to label instructions, but gas released into the air is toxic and must be ventilated properly. Ultra-Shield and Selectrocide are two chlorine dioxide products labeled for the greenhouse market. Both products cost less than 1 cent per gallon of water treated at a 0.25 parts per million residual level.

Ultra-Shield

Whitmire Micro-Gen Inc. launched Prescription Treatment Brand Ultra-Shield (Chlorine Dioxide Water Treatment) in 2008. The product generates a solution of chlorine dioxide from tablets that dissolve in water in under 20 minutes, producing a solution that is ready to inject into irrigation lines.

Ultra-Shield is labeled for shock (20 parts per million for 12 hours) or continuous treatment, in addition to disinfestation of greenhouse surfaces. Ultra-Shield can control pathogens that build up or are carried through recirculating and non-recirculating irrigation systems, hard nonporous surface areas in all production, growing and holding areas such as equipment, benches, containers, tools, irrigation lines, evaporative cool-

source to provide a residual concentration (at the furthest outlet) of 0.25 ppm chlorine dioxide measured with either test strips or a meter. Growers have found that after a shock treatment, 0.25 ppm residual chlorine dioxide is effective to maintain irrigation lines free of biofilm. The initial concentration at the water source needs to be somewhat higher than 0.25 ppm to meet the demand from organic load and other components in the water.

Exposure rates

Australian research found that exposure to 3.3 ppm of chlorine diox-

ing systems, tanks, transfer lines, equipment and containers. It can be used in ornamental greenhouses, nurseries, shade houses, garden centers, floral shops, propagation houses and related systems. The product uses common greenhouse equipment resulting in low startup cost and requires little labor to operate other than initial set-up and stock tank monitoring.

Selectrocide

Selective Micro Technologies launched the product Selectrocide in 2006. A highly pure solution of chlorine dioxide is generated by placing a dry packet in water, yielding 6 gallons of 500 ppm stock solution within 12 hours. This stock solution is generated at neutral pH, is stable for about two weeks and can be injected into irrigation lines with common injection equipment. Contaminated irrigation lines can be cleared of algae and biofilm buildup by an initial shock treatment of two consecutive overnight charges of 50 ppm.

Cost of treatment depends on the volume of the system, calculated by estimating pipe lengths of the main and secondary lines and any additional connected lines that are to be treated. A 50 ppm solution costs approximately \$65 per 100 gallons. As a reference, the volume of 100 feet of 1- and 2-inch diameter PVC pipe is 4 and 16 gallons, respectively.

Once the irrigation lines are treated, continuous injection of approximately 0.5 ppm is recommended to prevent re-establishment of biofilm in the lines, leaving a residual concentration of approximately 0.25 ppm in the water as it leaves the irrigation line.

ide for 10 minutes killed spores of *Alternaria zinniae*, *Fusarium oxysporum*, *Colletotrichum capsici*, *Phytophthora cinnamomi* and *Pythium ultimum*. Studies by University of Massachusetts researchers found that 1 ppm chlorine dioxide from Selectrocide provided control of *Pythium aphanidermatum* zoospores, whereas *Fusarium oxysporum* required treatment at 5 ppm for 20 minutes and *Erwinia chrysanthemi* bacterial cells required at least 20 ppm for control.

Plants should not be exposed to more than the 0.25 ppm rate unless specified on the product label. Product tests have found phytotoxicity

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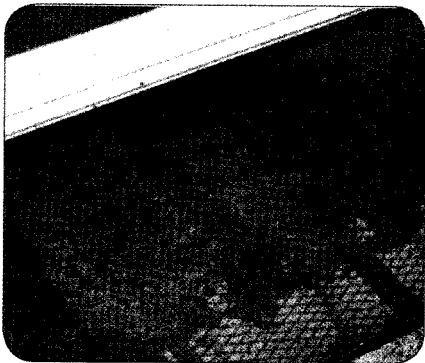
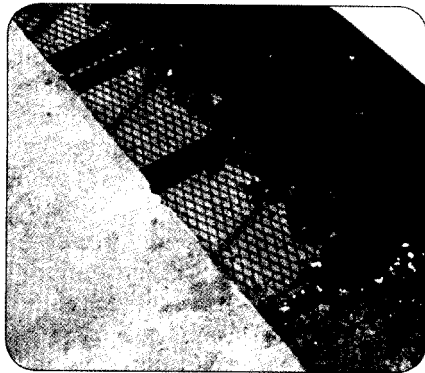
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Algae on a greenhouse floor without chlorine dioxide treatment (top) and following chlorine dioxide treatment (bottom) using Ultra-Shield at 0.25 parts per million for 14 days continuously in the irrigation water.



Plants grown without (top) or with (bottom) chlorine dioxide (Ultra-Shield at 0.25 parts per million for 14 days) applied continuously in the irrigation water. Note algae growth in top photo.

at 1-2 ppm chlorine dioxide when water was applied repeatedly to impatiens and geranium foliage in mist propagation.

Periodic applications of chlorine dioxide to roots or foliage are less sensitive than continuous mist propagation above 0.25 ppm. Phytotoxicity testing in your situation on a small group of plants, as with any agrichemical, is recommended.

Although growers have not reported plant micronutrient deficiencies when using chlorine dioxide, research has demonstrated that the presence of micronutrients in the irrigation water will increase the chlorine demand of the water. For example, researchers at USDA-Agricultural Research Service and Washington State University found that 0.6 ppm of chlorine dioxide was needed to kill 50 percent of *Fusarium oxysporum* conidia in pure water, but the lethal dose increased to 1.9 ppm after 10 minutes of mixing with 1 ppm of iron, manganese, copper and zinc fertilizers. This result emphasizes the complex reactions that occur when a sanitizing agent is mixed with irrigation water.

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Chemical names and trade names are included as a convenience. The use of brand names and any mention of commercial products or services does not imply endorsement by the University of Florida, nor discrimination against similar products or services not mentioned.

Individuals who use chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Obtain information about use and examine a current product label before applying any chemical. ❖❖



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