In Case You Missed It
Water Management Series April 2016 Issue
Unclog Drip Emitters In Your Greenhouse
GreenhouseGrower.com

Figure 1. **The irrigation pond located at a growing operation in coastal Florida had a high algae load.**

Pinpoint Toxicity In Your Pond Water

This article is the second in a series of case studies designed to help growers **R**educe, **R**emediate, and **R**ecycle irrigation water as part of a multi-state research grant (**CleanWateR3.org**).

by **PAUL FISHER**

THIS month's case study highlights a coastal Florida producer who was starting to use pond water for irrigation (Figure 1). The pond water had a lower electrical conductivity (EC) than the operation's well water, and the well water supply was running low. However, the grower realized that the open pond had a high level of algae and could possibly harbor pathogens, so he installed a water-treatment system.

Water pumped from the pond passed through a sand filter, and sodium hypochlorite (liquid bleach) was injected to chlorinate the water. The water was batch-treated in a holding treatment tank before being pumped to the greenhouse, to ensure there was adequate contact time to control algae and pathogens (Figure 2).

Despite this treatment, plant health problems occurred when the pond water was applied in the greenhouse. Some plants showed pitting and bronzing symptoms on foliage, and stunted growth (Figure 3).

Water Analysis Helps Narrow Down The Problem

Given that the plant symptoms only occurred when the pond water was used, what could be the problem? A series of water tests were run on the untreated pond water (Table 1), but none of the results were far out of range:

• pH was slightly high, but plant symptoms were not consistent with iron deficiency at high pH.

• Concentration of dissolved salts (both electrical conductivity, and a detailed analysis of individual dissolved ions) was low. Applied fertilizer concentration in the greenhouse was also low, and pesticides were applied at normal label rates. Therefore, residue on foliage or high salts in the root substrate were not damaging plant health.

Table 1. Features Of Pond Water Before Treatment
(Tested At The University Of Florida)

	pH	Electrical Conductivity (mS/cm)	Total Suspended Solids (mg/L)	Aerobic Bacteria Counts (colony-forming units/mL)
Measurements:	7.7	0.31	9.4	15,400
Target ranges:	5 to 7	<1.0	<5	<5,000

Table 2. Chlorine Terms

Term	Definition
Chlorine	A common term for the sanitizing ingredient hypochlorous acid (HOCl), which is mainly provided from liquid sodium hypochlorite (bleach), solid calcium hypochlorite (tablets or granules), or chlorine gas.
Free chlorine	The concentration of the strong sanitizer hypochlorous acid (HOCl) that dominates below pH 7.5, plus the weak sanitizer called hypochlorite (OCl^-) that dominates at higher pH.
Residual chlorine	The chlorine left over after the "chlorine demand" from contaminants in the water has been oxidized. Plant pathologists generally recommend 2 ppm of residual chlorine as HOCl to control zoospores of Pythium and Phytophthora.
Combined chlorine	A group of compounds that form when HOCl reacts with organic and nitrogen-containing molecules.
Chloramines	A class of combined chlorine molecules that are weak sanitizers. Chloramines form when free chlorine reacts with ammonium, such as is found in water-soluble fertilizer.
Total chlorine	The concentration of both free and combined chlorine forms.
Chlorine dioxide	A dissolved gas (ClO_2), which is a stronger oxidizer than HOCl and has a different chemistry. For example, ClO_2 is not as sensitive to pH or ammonium as HOCl.

• Total suspended solids and bacteria counts were higher than desired, which is typical in pond water because of algae and mi-

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Take-Home Lessons

Most growers are not trained as water-treatment engineers, but many are familiar with technology not working. Like any piece of equipment, no water treatment system is maintenance-free. If you add a water treatment system to minimize risk from issues such as plant pathogens, realize that you are also adding risk (phytotoxicity or worker safety) from equipment malfunctioning.

- Avoid complicated equipment you do not understand and ensure that the supplier provides good service.
- Put a maintenance and monitoring standard operating procedure (SOP) into place. There is always drift away from the SOP, so regular checking by a supervisor is needed.
- Growers need to be involved in testing and interpreting the water treatment equipment. It is your crop in harm's way, so do not just leave it to the physical plant staff.
- Do not rely just on the measured dose from a cheap testing kit. Check how much sanitizing agent is being used per unit volume of irrigation water. Put in an inline ORP (oxidation-reduction potential) sensor, which should read around 700 mV with 2 ppm free chlorine and pH 6.
- Never apply more than 5 ppm total chlorine, and never have more than 1 to 2 ppm of residual total chlorine. If the water demand is extremely high, then add filtration and sometimes flocculation upstream to reduce the demand, before chemical is added. Acidify the water to pH 6 so less chlorine is needed for the same sanitizing power.

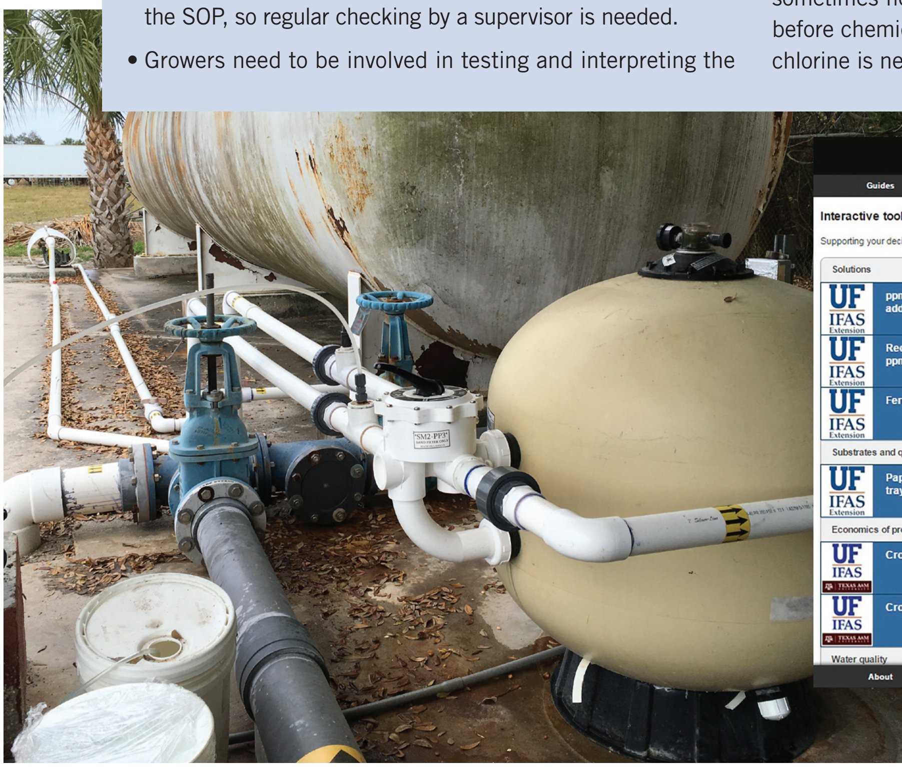

Figure 2. **Pond water was passed through a sand filter (bottom right), dosed with liquid bleach (bottom left), and held into a tank (background).**

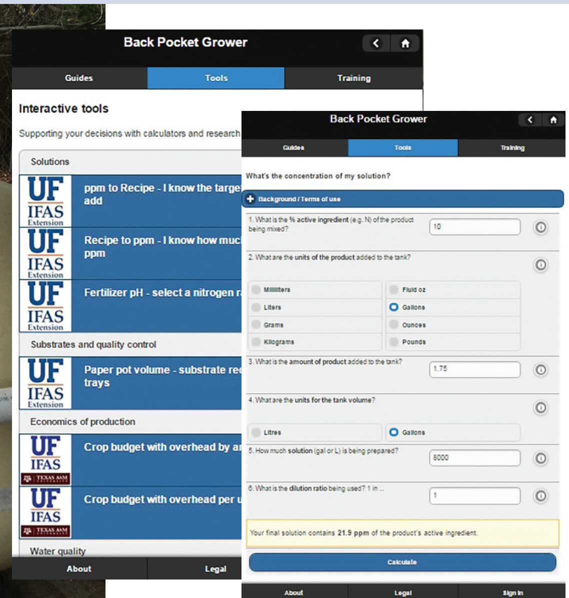

Figure 4. **BackPocketGrower.org can be used to calculate parts per million from agrichemicals, such as the sodium hypochlorite used in this case study.**

Figure 3. **Phytotoxicity symptoms found on begonia (top right) and basil (bottom right). Unaffected leaves are shown at the left in each photo.** Photos courtesy of Victor Zayas and Meehan Donovan, University of Florida.

crobial growth. However, the grower did not complain of clogged irrigation emitters after chlorination and filtration.

- No oomycetes (*Pythium* or *Phytophthora*) were found in the water sample, and plant symptoms were not consistent with root or crown rot.

That led us to focus on the chlorination treatment. The grower was applying 1.75 gallons of 10% chlorine in the 8,000-gallon tank. The test kit for free chlorine showed a reading of up to 3.5 ppm for the "residual" level coming out of the batch tank (see Table 2 for chlorine terms).

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8 Causes Of Over- And Under-Dosing Of Chlorine And Other Sanitizers In Greenhouses And Nurseries

1. Unreliable injectors that sometimes send out a pulse of high concentration — one shock can sometimes be enough to damage crops.
2. Sensors and injectors are not calibrated or maintained.
3. Relying on an injector, which indicates a "theoretical" dosage based on flow rate, but which is not actually measuring active ingredient level.
4. The wrong test kit is used, or numbers are ignored or misinterpreted. For example, free chlorine level might only represent 5% to 10% of total chlorine when chlorine is injected with water-soluble fertilizer.
5. Chlorine demand varies during the year from the pond water, but the grower does not adjust the applied dose. There is typically more algae in the summer time (high demand, low residual chlorine), and less demand and higher residual chlorine in the winter. Therefore, reduce chlorine dose in the winter.
6. Many test kits are not very accurate (e.g., $10 pool test strips are used to check water treatment on crops worth millions of dollars).
7. Some kits max out at a low level, for example 4 ppm of chlorine. The kit is therefore not able to tell if 4 or 400 ppm is being applied.
8. The people with responsibility for checking the equipment log the data without anyone taking the time to interpret the values until a problem occurs.

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The Culprit: Overdosing Chlorine

Because the nutrients in the pond combined with the active ingredient of chlorine (hypochlorous acid), the total applied chlorine was much higher than the 3.5 ppm of free chlorine being read on the meter.

We calculated almost 22 ppm was being applied. This is much higher than the safe zone of 2 to 5 ppm of applied total chlorine, and 1 to 2 ppm of residual chlorine. To calculate the dose based on the gallons of bleach and tank size, go to our website **BackPocketGrower.org**, and under "Tools" use the "Recipe to ppm" tool (Figure 4).

We have run experiments in our greenhouse to test chlorine phytotoxicity. We have not seen damage when hypochlorous acid was applied overhead at 2 ppm with each irrigation to bedding plants. However, we have heard reports from commercial greenhouses where phytotoxicity occurs with low doses (2 ppm, especially in propagation). Chloramines, then hypochlorous acid, and then chlorine dioxide, in that order, have increasing reactivity and likelihood of phytotoxicity. We have also observed phytotoxicity from other sanitizing agents applied at high rates, including hydrogen dioxide-based products and copper ionization. Simply switching away from chlorine is therefore not always the answer.

Solution: Reduce Chlorine Dosage

The grower reduced the applied dose to no more than 3 ppm of total chlorine, and 1 to 2 ppm of residual chlorine. For safety, this was based on two ways to check dosage (a) measurements of total and free chlorine, and (b) calculated amount of chemical added per volume of irrigation water. **GG**

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