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201. Water treatment series: sodium, calcium hypochlorite can treat irrigation water. Fisher, P., Argo, B., Hong, C., and Huang, J. Greenhouse Management and Production 28(6):21-22, 24-25. 2008.

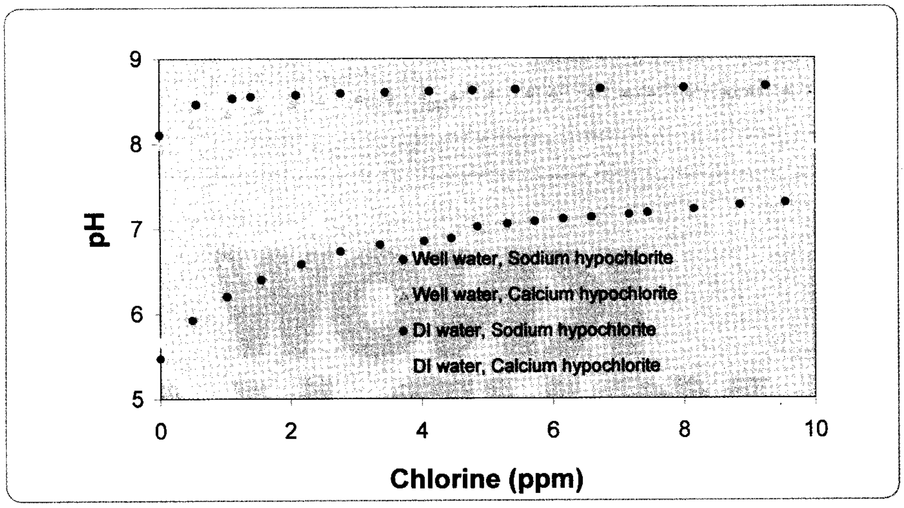
Next month: How to apply sodium and calcium hypochlorite in greenhouse and nursery irrigation systems.

Knowing how sanitizing agents react in water will ensure that these chemicals are used safely and effectively.

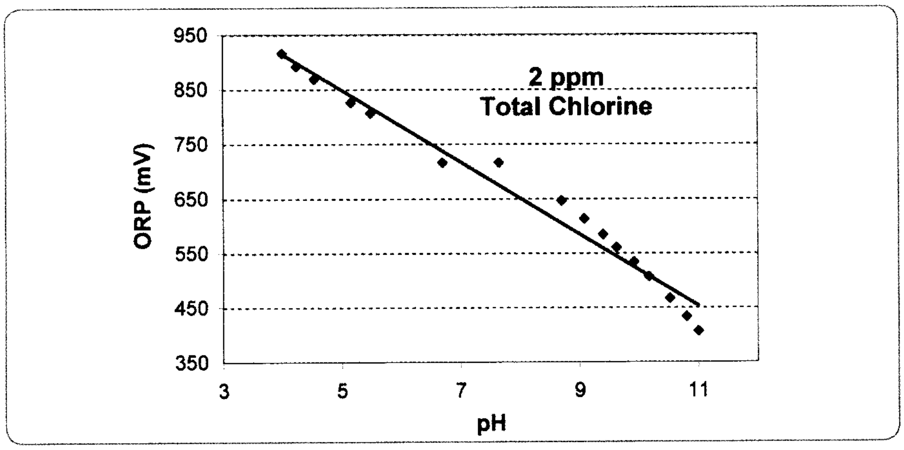
By Paul Fisher, Bill Argo, Chuanxue Hong, Jinsheng Huang, Austin Looper, Dean Wiegers, Rick Vetanovetz and Youbin Zheng

Water treatment series: Sodium, calcium hypochlorite can treat irrigation water

CALCIUM AND SODIUM hypochlorite are widely used to control waterborne pathogens and algae in irrigation water. You are probably most familiar with these materials as liquid bleach (sodium hypochlorite) and solid swimming pool "shock" (calcium hypochlorite). Understanding water chemistry is important so you use these materials safely and effectively.



Hypochlorite is a base. Increasing the concentration of sodium or calcium hypochlorite causes the water pH to increase. In this case, deionized (pure) water or well water (112 ppm alkalinity) was used with Clorox regular bleach (sodium hypochlorite) or calcium hypochlorite. The exact pH-concentration relationship varies with chemical type, chemical source and irrigation water quality. In contrast to hypochlorite, chlorine gas and chlorine dioxide sources do not raise water pH.



ORP, a measure of sanitizing power, increases as pH decreases. pH should be maintained in the range of 6.0-7.5. At a higher pH there is less sanitizing effect; at a lower pH toxic gases can be released. Research by University of Florida used deionized water and Clorox regular bleach.

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Concentration, mode of action

Chlorine oxidizes organic matter. This includes not only the sensitive membranes, enzymes and DNA of pathogen and algae spores, but also includes peat, plant material and micronutrient chelates carried in the water. Hypochlorite is used up during sanitizing because its chemical structure also changes, leaving calcium or sodium chloride. Filtration of nontarget organic matter as a water pretreatment is important to reduce the amount of chlorine required.

"Free chlorine" is the combined concentration of hypochlorous acid and hypochlorite along with dissolved chlorine gas. "Free residual" chlorine means the concentration of free chlorine remaining in the sample after the chlorine demand of the water is satisfied. Having the proper amount of free residual chlorine is important because that represents the remaining chlorine available to sanitize. Free residual

Understanding chlorine chemistry

Adding either sodium hypochlorite or calcium hypochlorite to water produces the hypochlorite ion (OCl^-) and hypochlorous acid (HOCl). The balance between these two chemicals is determined by the pH of the water. Hypochlorous acid (which predominates at a solution pH below 7.5) is 20 to 30 times as effective a sanitizer as hypochlorite (favored by a pH above 7.5).

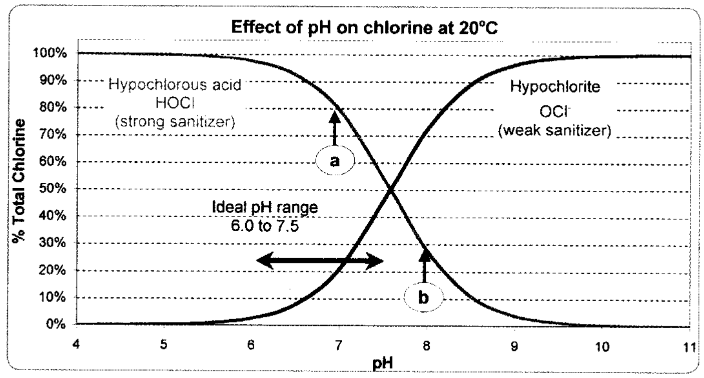
Chlorine is most effective at the optimum pH range of 6-7.5. At a higher pH, more chlorine is needed for the same result. For example, if there was 1 part per million of free chlorine (HOCl + OCl^-) at pH 7, how much free chlorine would be required to have the same effectiveness (HOCl concentration) at pH 8?

Looking at point "a" (pH 7) on the graph, about 80 percent (0.8 ppm) is hypochlorous acid (HOCl). At point "b" (pH 8), only 30 percent (0.3 ppm) would be hypochlorous acid.

So $0.8/0.3 = 2.7$ ppm free chlorine at pH 8 would be needed. Nearly three times the amount of sodium hypochlorite or calcium hypochlorite would be needed at pH 8 to have the same effectiveness as 1 ppm free chlorine at pH 7.

It is strongly recommended to have chlorine systems professionally installed. A system that constantly monitors and can correct water pH reduces the amount of chlorine applied, increases effectiveness and improves product safety. For example, toxic gases are given off if the acidification system malfunctions and the pH falls below 4.

As with all sanitizing agents, talk with experts, follow label instructions and train your staff.



Chlorine has two main forms in water. Hypochlorous acid is a strong sanitizer and is favored at a pH below 7.5. Hypochlorite predominates at high pH and has less sanitizing power.

chlorine decreases over time, as the free chlorine reacts with organic matter (bacteria, fungi, algae, etc.) or is broken down by sunlight.

For example, 2 parts per million of free chlorine may be added at the well source. As the water flows through the irrigation system, it has contact time with biofilm and other organic matter in the pipes. Contact with water contaminants and biofilm may lead to a chlorine demand of 1.75 ppm, and in this case 0.25 ppm of free residual chlorine would remain and come out of the hose.

Virginia Polytechnic Institute and State University researchers found that 2 ppm free chlorine at pH 6 provided complete control of zoospores from 15 isolates of *Pythium* and eight isolates (seven species) of *Phytophthora*. They concluded that 2 ppm free chlorine at discharge points (risers or sprinklers) effectively controls zoospores (the swimming infective stage) of *Pythium* and *Phytophthora* species in irrigation water.

Not all life stages or species of a pathogen are equally susceptible to chlorine or other sanitizers. Virginia Polytechnic researchers found that control of mycelial fragments of *Phytophthora* required 8 ppm chlorine compared with 2 ppm for zoospores. Researchers at the University of Guelph found that 0.3 to 1 ppm free chlorine killed zoospores or sporangia of two *Phytophthora* species with a three- to six-minute contact time. Two ppm free chlorine killed zoospores of *Pythium aphanidermatum* with a contact time of three minutes. However, 14 and 12 ppm free chlorine were required to control *Fusarium oxysporum* conidia and *Rhizoctonia solani* mycelia with a 10- or six-minute contact time, respectively.

University of Guelph research at a commercial nursery site using 2.4 ppm free chlorine to overhead irrigate plants daily for 11 weeks showed that only eight of 22 species suffered minor injury. The eight injured species were either herbaceous or broadleaf deciduous shrubs. No evergreen species were injured by chlorine.

A general recommendation is to

maintain chlorine levels in water at no more than 2 ppm to avoid phytotoxicity of ornamentals, but testing on your crop mix is advised. For chlorine-sensitive crops when more than 2 ppm is required for pathogen control, the free chlorine needs to be reduced before plant contact. This can be done by dilution, filtration through an activated charcoal filter or by allowing time for the residual level to decrease.

Measuring chlorine

To minimize the risk that irrigation water and plumbing systems are potential sources of *Pythium* or *Phytophthora* zoospores, 1 to 2 ppm residual free chlorine is required at the farthest emitter. This may require an initial injection of as high as 6 ppm of chlorine.

Once biofilm is removed and there is less chlorine demand from the irrigation system, then less chlorine may be required to achieve a residual concentration of 1 to 2 ppm. The chlorine injection rate may need to be adjusted. If the primary goal is algae control, some growers have found that a residual as low as 0.25 ppm is adequate to ensure irrigation nozzles remain clean.

A chlorine meter can be purchased for $150-$300, or color test kits are available. Choose a meter that measures free chlorine, rather than total chlorine.

Another way to measure the oxidizing power of a solution is with an oxidation-reduction potential (ORP) meter, which measures in units of millivolts. It costs $100-$400. The higher the millivolts of oxidation potential, the greater the sanitizing power.

***Paul Fisher**, University of Florida, Environmental Horticulture Department, (352) 392-1831, Ext. 375; pfisher@ufl.edu; **Bill Argo**, Blackmore Co., bargo@blackmoreco.com; **Chuanxue Hong**, Virginia Polytechnic Institute and State University, Department of Plant Pathology, Physiology and Weed Science, chhong2 at vt.edu; **Jinsheng Huang**, University of Florida, Environmental Horticulture Department, huangj@ufl.edu; **Austin Looper**, PPG Chemicals, alooper@ppg.com; **Dean Wiegers**, Hanna Instruments, dwiegers@hannainst.com; **Rick Vetanovetz**, SunGro Horticulture, rickv@sungro.com; **Youbin Zheng**, University of Guelph, yzheng@uoguelph.ca.*