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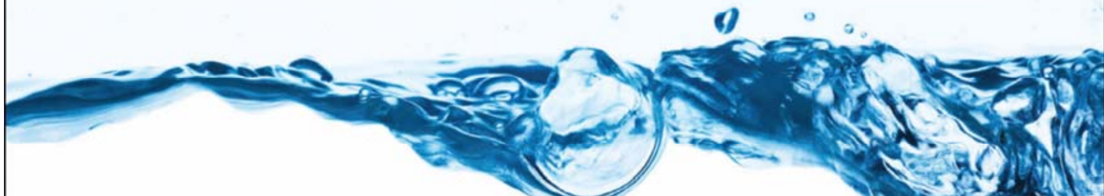

Water treatment

By Peter Konjoian

Growers can measure a product's activity based on its oxidation reduction potential

Most growers who chemically treat their water are locked into monitoring water sanitizing products by concentration, specifically in parts per million. Knowing how many ppm to inject is a logical way to start, but focusing on concentration alone becomes limiting as more information is collected on what occurs within the water in an irrigation system.

Water's three dimensions

Water management can be thought of as a three-dimensional challenge: physical, chemical and microbial. Most growers know how to manage the physical dimension related to pressure, flow and filtration, as the topic is well-researched.

Water's second dimension, its chemical properties, is also well-understood, but only in the last two decades. Initially the focus was on water pH, but then researchers and growers learned that alkalinity is more important than pH to monitor and manage. Even though the knowledge is relatively new, it nevertheless contributes to how growers manage crop nutrition and has profoundly influenced fertilization practices.

Water's third dimension, microbial, is the latest area of research. Only in the past decade has this dimension begun to be studied within horticulture. Microbial contamination of irrigation lines, drip emitters, boom and mist nozzles, holding tanks and collection ponds has become a major obstacle as the industry moves toward zero runoff and recycling of water. The biofilm microbes causing concern can be non-pathogenic, such as algae and related slime organisms or pathogenic such as Pythium, Phytophthora and other water-borne, disease-causing organisms.

Top: New length of schedule 40 PVC greenhouse irrigation pipe. Middle: Greenhouse irrigation pipe that supplies clear water with tan layer of biofilm. Bottom: Greenhouse irrigation pipe supplying constant feed showing algae-biofilm complex.

Biofilm — it's everywhere

Up until six years ago few people were familiar with what biofilm is. This living complex of organic and inorganic components colonizes and grows in every irrigation line and holding tank used to water greenhouse and nursery crops. Very few growers who have cut into an irrigation line, particularly one carrying fertilizer, have NOT encountered a biofilm lining on the inside surface of the pipe.

Since discovering the presence of biofilm in irrigation systems, water treatment technologies have emerged, and growers now have several effective water treamtent options from a microbial perspective. Most are based on injecting chemical oxidizers, which attack and destabilize microbial organisms and other organic constituents of the water stream.

Oxidation reduction potential

Oxidation reduction potential (ORP) is all about the movement of electrons. In general chemistry, when a compound is oxidized it means that elec-

Key Points

1 Microbial contamination of irrigation lines, drip emitters, boom and mist nozzles, holding tanks and collection ponds has become a major obstacle as the horticulture industry moves toward zero runoff and recycling of water.

2 Most water treatment technologies are based on injection of chemical oxidizers. These oxidizing compounds attack and destabilize microbial organisms and other organic constituents of the water stream.

3 Rather than focusing on the product rate needed (ppm), growers can better measure a product's activity based on its oxidation reduction potential.

trons are lost. When oxidation occurs, the lost electrons end up somewhere else. Reduction is the process whereby electrons are gained. There is always a balance in reactions. Oxidation is accompanied by reduction and the electrons are always accounted for. When dealing with water treatment products, they are not simply oxidizers, they are also accompanied by reduction.

Oxidation is an effective sanitizing treatment. When powerful oxidizer products are injected into the water stream, they actively search for electrons to acquire. The organic compounds in water, including living organisms, offer a plentiful source of available electrons. Bacteria and fungi need a certain electrical balance to live and function, and if that is disrupted, negative things usually occur to them. These negative things include denaturing of proteins, breaching of cell walls and membranes, and disruption of life-sustaining biochemical pathways. In short, oxidation kills these organisms.

When an oxidizing water treatment product finds and acquires electrons from living organisms in solution it eventually becomes reduced itself. Once the product's appetite for electrons is satisfied, it no longer is able to act as a sanitizer and is either lost from the solution or remains as a spent and ineffective byproduct.

Oxidizing agents

Table 1 lists common oxidizing agents along with the indicators of their oxidation activity. Oxidation strength describes the strength of a product's reactivity. A higher number means the product reacts with more things. But there are strengths and weaknesses at both ends of the list. A product like Chlorine dioxide may be lower in oxidation strength, but it is higher in oxidation capacity, which means that each molecule has the capacity to gain more electrons than the other listed products. This gives it a benefit.

ORP measurement

ORP is measured by electrical current in terms of millivolts (mV). An ORP meter shows a mV reading and continuously monitors the treated water stream. Alarm levels can be set, and the unit is capable of real-time computer communication, allowing the grower optimal control of water treatment management.

Using ORP

A basic understanding of ORP accurately defines water treatment options. Table 2 presents the amount of contact time needed between an oxidizer and *E. coli* bacterium to kill it based on ORP. Regardless of the oxidizer used, if not enough oxidizer is added to the system and the ORP remains at or below 450 mV, the kill time is infinite. This means the level of ORP is ineffective in controlling *E. coli*.

ORP levels the playing field for oxidizer products. It takes different concentrations of different products to achieve an ORP of 450. As more oxidizer product is added to water, the ORP kill times decrease. At an ORP of 600 mV, kill time is reduced to 10 seconds. Increasing the ORP to 650 mV results in instantaneous kill of *E. coli*.

For fungi, yeast, mildew and mold, an ORP of 750-800 mV is needed to provide instantaneous kill. Horticultural water treatment applications are moving toward establishing this target range as optimal. These applications include greenhouse and nursery irrigation water treatments.

An oxidation reduction potential meter measures electrical current in terms of millivolts (mV) and continuously monitors the treated water stream.

Table 1. Oxidizing agents and their reactivity.

Oxidizer	Oxidation strength	Oxidation capacity
Ozone (O_3)	2.07	2 electrons
Hydrogen peroxide (H_2O_2)	1.78	2 electrons
Hypochlorous acid (HOCl)	1.49	2 electrons
Hypobromous acid (HOBr)	1.33	2 electrons
Chlorine dioxide (ClO_2)	0.95	5 electrons

Table 2. Amount of contact time needed between an oxidizer and E. coli bacterium to kill it based on oxidation reduction potential.

Oxidation reduction potential in millivolts (mV)	Kill time
450	Infinite
500	1 hour
550	100 seconds
600	10 seconds
650	0 seconds

Comparing oxidizer products

Discussing oxidation strength of oxidizer products in terms of ORP rather than ppm allows these products to be compared based on their ORP values. Instead of comparing chlorine dioxide efficacy at 0.5 ppm to chlorine gas at 1.5 ppm to peroxide at 25 ppm, ORP allows the three treatment methods to be compared similarly. Based on comparisons, it takes more peroxide product to achieve the same ORP as chlorine dioxide or chlorine gas. Rather than focusing on the product rate needed (ppm), growers now have a much better measure of a product's activity based on its ORP. **GM**

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