THE THREE KEYS to Water Treatment Design

WHILE MARGINS CONTINUE TO SHRINK, GROWERS ARE RECOGNIZING THAT HIGH-QUALITY WATER RESULTS IN SUBSTANTIAL BENEFITS IN MANY AREAS OF PRODUCTION. ***By Al Zylstra***

We all occasionally get caught up in the search for a single game changing idea that will result in a dramatic gain that saves the day or brings us to the next level. And we've had a few of those in the industry over the years. But, as I think back on the past couple decades in this industry, the majority of improvements have been relatively small, incremental improvements that often go unnoticed until viewed in the rear view mirror of our businesses.

Many years ago while searching for a way to make a business grow to the next level, I learned that the compounding effect of small improvements in several areas was a much better way to achieve improvement than relying on achieving a major improvement in a single area. Instead of trying for one big hit with a 30 percent reduction in costs or boost in sales, for example, I learned to look for small one to ten percent improvements in many areas. A little here, a little there, and pretty soon it yields a big result. I've observed that the same is true in plant production, even more so because of the hundreds of thousands and millions of units produced in a single operation.

What would be added to your bottom line if you could make several small improvements simultaneously? For example, increase the successful germ percentage in all plug flats by 3 percent, reduce the time to finish that plant by 3 percent, reduce the number of those plants lost to disease by 3 percent while reducing your fungicide use by a few percent. While the benefit of any one of those would be nice, it probably wouldn't be enough to write home about. But the compounded result to the bottom line of all of those little improvements is impressive.

Growers are recognizing that high quality water results in substantial benefits in many, perhaps most, areas of production. Water is one of the largest inputs by volume, and is the most broadly applied input, so it makes sense that improving it will impact nearly every aspect of production. And that impact is often negative, so a lot of the focus in the industry is on fixing the water, and that is necessary. But many growers are also coming to recognize that there is much to be gained by improving the quality of their irrigation water beyond just fixing the problems. In fact, they have learned that it is the added benefits of serving their plants with the highest quality water that yield the biggest payoff.

In this article, I am specifically addressing the issue of cleaning up water and not directly addressing the more common water treatment requirements of pH adjustment and reducing excess levels of specific ions. I will leave that to another writer or issue.

In many greenhouse visits and phone calls from growers, it is unfortunately apparent that very few irrigation water treatment systems have been properly designed to be completely successful. That does not need to be.

Designing and implementing a successful water treatment system, one that will not only fix problems but also deliver additional benefits, requires attention to details in more than one area. There are many considerations in developing an effective water treatment plan and obtaining a properly designed water treatment system, far more than can be addressed in a single article. Many attempts are made to address the complex task of water treatment with a single solution, the magic bullet. It doesn't exist.

A successful and completely effective irrigation water treatment system will always consist of more than one function, and must always address at least three key areas of concern. Following is a brief overview of the three areas that must be addressed in developing an effective water treatment plan and system design.

Source Treatment

Each water source, be that a well, surface water or a municipal water supply, presents specific challenges. Many treatment methods can be used successfully to treat water directly at or from the source. The primary function here is reducing or removing excessive particulate, pathogens and pests such as algae.

The first function in dealing with the water source must always be filtration. The effectiveness of virtually every downstream system is affected by the amount of organic and inorganic particulate flowing to it or through it. Removing as much of that material as is reasonably possible before going downstream to other systems is nearly always less expensive than dealing with the additional costs or problems resulting from poorly filtered water. Those problems include disinfection systems that cannot

adequately disinfect, plugged fertilizer and acid injection ports, fouled EC and pH sensors, fouled valves and clogged emitters. Surprisingly, most disinfection systems I see or hear about in the course of travels are fed inadequately filtered water. The result is an owner that has paid good money for a disinfection system that is not adequately disinfecting. That's bad value and we can't afford that anymore.

In general terms, the finer the filtration the better. Go with the finest filtration your capital budget can afford or you can finance, surely no less than 50 microns, and get to 5 microns if you can. It will pay off in the long haul. Clearly the type and cost of filtration required will be driven by the water source, but the more there is to filter out, the more beneficial the filtration is.

Once the water is adequately filtered, only then can it be cost effectively disinfected with reasonable efficacy. Really, if the water isn't sufficiently filtered, don't bother with the disinfection; you will be spending more money than necessary and getting less results than you pay for. When it comes to disinfecting source water at this stage, there are many options available since there is generally more contact time available before the water gets to the plants and the planktonic form of the microbes at this point is easier to deal with, as will be discussed in the biofilm section to follow. So, various forms of chlorine, hydrogen peroxide, heat pasteurization, ozone, chlorine dioxide, UV light and others can all be effective at reducing pathogens at this point. And the better the pre-filtration the less the amount needed to get the job done.

The water coming out of the pipe or the well or the stream or pond has been filtered and disinfected, then you send it through your RO unit if needed, it is injected with acid to adjust the pH, and fertilizer is injected; then it's off to the piping system to be delivered to the plants. We're good, right? Not so fast, the biggest problem lies in wait just downstream.

Biofilm

Ah yes, the real boogey man is in your pipes. Let's begin with an important fact that has been established by substantial independent research, mostly only in the past decade or so. That fact is: Biofilm is a reality for every grower and it is causing problems in your greenhouse. Notice that sentence ended with a period, no qualifier is required. Biofilm is not a political or religious concept that you can choose to believe, or not; it truly is an equal opportunity problem.

Why is biofilm such a problem? The U.S. Center for Disease control recently announced a study finding that approximately 60 percent of human illness resulting from waterborne pathogens originated from the biofilm resident in water distribution pipes of municipal water systems! Municipal water, that has been filtered, chlorinated and transported in clean pipes. What do you think may be the percentage of plant infections originating from greenhouse and nursery pipes that carry fertilizers to feed the biofilm and heat and light exposure to encourage growth? In most facilities probably more than from the water source itself. If you only clean up your water at the source without dealing with the biofilm you are addressing less than 50 percent of the problem, probably a lot less — a fact borne out in many grower stories.

What is biofilm? A technical definition is: a thin and resistant layer of microorganisms adhering to the surface of a structure, which may be organic or inorganic, together with the polymers that they secrete to adhere to that surface.

You should know more, but space here does not allow, so to get more of the story I encourage you to read some of the many industry articles and presentations by me, my esteemed colleagues Charlie Hayes, Peter Konjoian, and others; as well as a plethora of references and research results available online. A white paper on biofilm is also available for download at www.dramm.com/html/main.isx?sitesec=1.0.0.60

The short story on biofilm is that within a few seconds of perfectly good water flowing from a well or even a chlorinated municipal water supply into a never-before-used (new) pipe, a biofilm begins to form. Seconds, not days or years as is often believed. An equally important fact about biofilm is that it grows nearly as quickly upstream as it does downstream. So, whatever microbes live in your greenhouse or on your plants that come in contact with a hose end, a boom nozzle, etc., will very quickly show up in the biofilm in your pipes. Within a few hours that biofilm is fully formed and begins to dispense planktonic mircoorganisms downstream to the plants being irrigated.

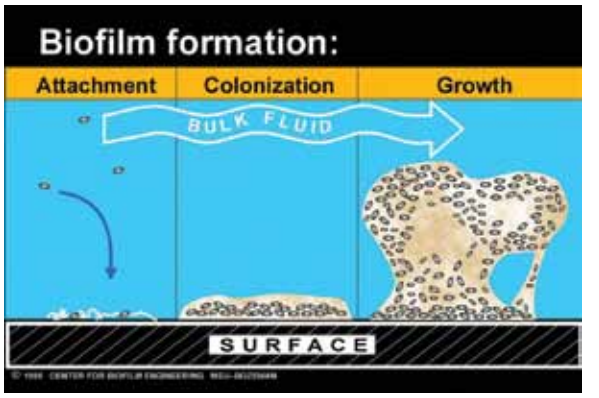
What do those microorganisms consist of? Pretty much whatever might be in your source water and whatever has lived in your greenhouse, including Pythium, Phythopthora, Rhizoctonia, Fusarium and more. Fun, huh?

A glycocalyx (gooey polymer) secreted by the biofilm cells holds them to the pipe surface, very firmly and very stubbornly, in what is often referred to as a biofilm matrix. This matrix protects the cells that secrete that polymer, and when an unsuccessful effort is made to remove them they fight back and secrete more polymer, usually making the biofilm even thicker.

Because biofilm grows upstream as well as downstream, and because it takes very little encouragement or population to begin forming, simply cleaning up the source water will not treat or eliminate the biofilm.

Eliminating biofilm requires three key characteristics:

1) The water treatment must be capable of carrying a residual effect downstream that is capable of attacking and quickly eliminating the biofilm matrix. This eliminates a number of disinfection candidates that may have been adequate for cleaning the source water, including: filtration, UV light, heat pasteurization. They are all removed from the list simply because they are not capable of carrying a residual and therefore have no effect whatsoever on a biofilm matrix.



Top: *Stages of biofilm development.*
Bottom: *Healthy poinsettia root system, the result of high dissolved oxygen.*

2) The water treatment must be capable of destroying the biofilm matrix. If the matrix isn't destroyed, a few residents of the biofilm may be eliminated but the majority are still there and will quickly rebuild, and continue to cause problems. This eliminates some additional disinfection candidates because, although they may establish a residual under the right conditions, they are ineffective at penetrating and destroying the matrix that is the biofilm. Chlorine and copper ionization are eliminated as they are both proven in research to fail before the biofilm matrix is destroyed, even at very high concentrations.

3) The water treatment must be capable of continuous injection and treatment because the biofilm matrix begins building within seconds of a pipe or other surface being completely clean and is mature within a day or two. This eliminates, or at least dramatically reduces the effectiveness of shock

treatments with acids, peroxides and flushing.

So what works? Really three treatments are capable of doing the job, when properly designed and applied. Ozone is the strongest and most capable method, chlorine dioxide is capable with some limitations, and activated peroxygen is capable with some limitations.

Plant Health

Finally we come to the real point of the entire purpose of treating water in the first place, healthy plants. Most reasons are obvious for why a healthy plant is important, but one often not given adequate importance is the plant's own ability to defend itself against attacks by pathogens and resulting attacks by some pests. A healthy plant, functioning at the top of its game, is the first and best defense against problems, whether it is from the water, the soil or the air. They are less susceptible to infection, less attractive to pests, and more robust to survive successful attacks.

If the water is cleaned at the source, and the biofilm is eradicated so it doesn't recontaminate the water, but that water stresses the plant and doesn't enhance the plants health, we have not accomplished the objective of developing a "completely effective" water treatment system. In an ideal world, we want to go beyond the axiom of "first, do no harm," we want to do something good for the plant if we can.

Several chemicals, including chlorine and chlorine dioxide are toxic to most plants at relatively low levels, levels generally quite close to the concentration required to affect disinfection and biofilm eradication. These same chemicals also begin to stress the root system of most plants at levels well shy of the concentration needed for disinfection. Other oxidizers, including ozone and peroxygen, are capable of increasing the dissolved oxygen level of the water delivered to the root system thereby enhancing plant water and nutrient uptake and aiding in the development of a healthier plant.

In conclusion, developing the proper water treatment system that will deliver the highest quality water to your plants will yield benefits across your entire operation. A better take on germination, faster rooting, more root mass, healthier plants that are more resistant to disease, less disease, less chemical use, faster finishing and longer shelf life at retail are all demonstrated results of high-quality water. Water treatment is a complex matter, and it requires more than just a passing knowledge of the science, so engage the services of a knowledgeable water treatment professional with good knowledge of the science behind the system to assist in the design of a complete and integrated system that includes the appropriate filtration levels and disinfection system appropriate for your water source and chemistry.

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