Avoid irrigation system design flaws

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The challenges of cleaning a contaminated irrigation system have more to do with plumbing and design than with algae and microbial growth.

By Landon Merrill and Peter Konjoian

Visit 10 different greenhouses and chances are you'll see 10 different irrigation systems. One reason for the different systems is the ease of using PVC pipe. It has made irrigation system construction practically effortless. In part because PVC is so easy to work with, the plumbing of these irrigation systems consists of a variety of mains, submains, branches and dead legs.

Many irrigation systems mirror the expansion patterns of the greenhouse ranges in which they're installed. As many ranges increased in size, it was easier to expand the irrigation system to fit the range rather than the other way around. When many of these production facilities were expanding, water was considered an inexpensive and abundant resource. Many of the designs appear to lack any type of planning.

In our studies of sanitizing greenhouse irrigation systems, we found the challenges of trying to clean a contaminated system had more to do with plumbing and system design than with algae and microbial growth. We found several design flaws that cause numerous problems for growers in the engineering behind irrigation systems.

Water is multidimensional

Our irrigation research project has caused us to think of water as a three-dimensional resource. Different management strategies are required at each level.

Physical. Decades ago there was only one concern growers had with their water: quantity. Growers focused on pipe diameter, pump capacity and adequate pressure to operate nozzle heads and hoses.

Chemical. Growers are aware that pH and alkalinity are important water characteristics. Many have learned the importance of monitoring and adjusting pH and alkalinity to be able to irrigate with the water that has the best chemical characteristics for their crops.

Growers have also begun to use water more efficiently, delivering it through drip emitters and mist nozzles. In some cases, improved filtration has been required to remove debris that can clog low-volume delivery devices. Recirculation systems have been engineered to further improve water-use efficiency and reduce runoff.

Microbial. This is the one we are currently working to understand. Algae, bacteria, fungi and viruses are commonly found in even the most highly treated municipal water supplies. While zero tolerance to these microbial organisms is neither realistic nor required in drinking water, we have recently learned that algae and plant pathogens are present in grower irrigation systems and are causing problems. In greenhouse production, we believe that a

In some instances, trying to keep an irrigation hose off the ground is ineffective if it's placed where there could be algae and microbial pathogens, such as in this gutter.

strategy much closer to zero tolerance must be adopted regarding organisms such as algae and pythium.

Microbial contamination

Microbial contamination of irrigation water causes production problems and plant health concerns. In the photo on Page 66, an irrigation hose is placed in a recirculating system's return gutter to keep it off the ground. Algae contamination in the gutter is most likely accompanied by other microbial organisms, some of which could be plant pathogens. It's possible that, in this instance, placing the hose end on the ground would pose less risk to plants than placing it in the gutter.

We have documented the presence of algae in every greenhouse water source we've collected from across the country. Additionally, waterborne plant pathogens have been documented by many pathologists as being quite prevalent in recirculation systems. Growers who use these systems should monitor the presence of these disease organisms.

Most of the water filtration in greenhouses is inadequate. Filtration, particularly that found in recirculating systems, must be improved to remove more visible crop debris.

A common site in greenhouses is a ladder inside holding tanks. Growers routinely drain holding tanks several times a year and remove debris that collects at the bottom.

There are three design flaws that we believe are responsible for compounding some common greenhouse production problems.

FLAW #1: INADEQUATE FILTRATION

Most of the water filtration that we've seen in greenhouses is woefully inadequate. The filtration, particularly that found in recirculating systems, must be improved to remove more of the visible crop debris that settles to the bottom of water-holding tanks.

The first stage of filtering removes large, visible debris as water drains from ebb-and-flood benches and returns to holding tanks. If the debris is allowed to remain, this first line of defense can quickly backfire and end up supporting even more algae and potentially pathogenic microbial growth.

Seeing ladders inside greenhouse holding tanks is not uncommon. Growers routinely drain the holding tanks several times a year and remove debris that collects at the bottom. What is discarded is usually a layer of sedimented crop debris and organic matter including peat moss and bark, along with other common media components such as perlite and vermiculite. This rich organic environment can support significant contaminating microbial growth.

Inadequate filtration is not limited to recirculating irrigation systems. Traditional, one-directional irrigation filtration also is inadequate in many instances. Some frustrated growers have gone so far as to remove filter cartridges from in-line filters because they often become clogged.

Growers looking to filter water often have to compromise on the degree of filtration. Increased filtration is usually accompanied by a larger reduction in water pressure and decreased water flow. It usually takes more time to improve the rate of filtration. Unfortunately, few irrigation system designs have been engineered to account for this additional time.

Too many growers still make their filtration decisions based on being able to provide an adequate amount of water. They choose to limit the amount of filtration to ensure they have adequate flow and pressure. Growers need to recognize that, in most cases, too much organic material is making its way through the filters, resulting in problems beyond the point of filtration.

Microbe, soil interaction

In microbial ecology, 1 gram of topsoil contains about 10 million to 1 billion heterotrophic bacteria. This doesn't account for fungi, algae and viruses that are present, too. There are about 100,000 to 10 million fungi per gram of soil. Municipalities are required to treat water so that it has less than 500 bacteria per milliliter (the liquid equivalent of 1 gram).

The non-organic portion of soil consists of a mixture of sand, silt, clay, water and air. In terms of size, sand particles are the largest, measuring 0.5-2 millimeters in diameter. Clay particles are the smallest at less than 0.002 millimeters (2 microns) in diameter. The non-living organic portion (dead plant material), referred to as detritus, is another part of soil.

These components mix to form various sizes of particles and aggregates that can range from a few centimeters to the size of a bacterium.

Considering that most antimicrobial products can't distinguish between dead plant material and live microbes, combined with the large number of microbes present in growing media, it's clear why growers can't afford to allow greenhouse debris and microbes from entering into their irrigation systems. Since the microbes are closely associated with the soil aggregates, most of the

If concrete is not sealed, it can absorb water and serve as a habitat for algae, bacteria and fungi, which survive inside pores and resist conventional sanitizing treatments.

microbes can be eliminated simply by growers filtering out the aggregates.

Water municipalities have developed high- and low-tech ways to efficiently filter water. This has helped reduce the level of treatment necessary to provide clean, safe water.

One of the biggest grower misconceptions about filtration is that it is a one-step process. A 50-micron filter will remove a 2-inch piece of algae, but it will also clog the filter. Proper filtration requires several filters that graduate to smaller mesh sizes. Sometimes it involves incorporating multiple methods of filtration. A

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grower who wants to filter pond water to 50 microns can't just install a 50-micron filter in the water line.

Proper filtration

A filtration system is similar to a coin sorter. There are particles of various sizes, from very small to very large. If only one sorter is used to capture all of the coins, chances are you will have to unjam the sorter more frequently than if a separate sorter was used for each size coin. Similarly for water filtration, a filter will need to be cleaned much less frequently if there are several filters capturing different size particles. More importantly, the amount of water that can be filtered without affecting water pressure will increase dramatically.

Here are some general rules for using and maintaining a step-down multiple-filter system.

A reduction in pressure greater than 2 pounds per square inch from a clean filter is too much for one step.

If a filter is not cleaned until it clogs or there is a pressure drop greater than 2 pounds per square inch, the filter is not being cleaned frequently enough and it may be damaged. Filter cleaning should be a regularly scheduled practice.

The overall filtration rating of a system should be at least loth the diameter of the smallest emitter opening. Flow rates through screen filters should never exceed 200 gallons per minute per square foot of effective filter area (the total area of openings in the filter).

A 50-micron filtration, or better, for any water coming into the greenhouse should be the goal. An appropriate step-down system will make this achievable without significant loss in pressure or increase in labor. Proper filtration will not only reduce clogged emitters, associated labor and use of antimicrobials, it will also be the first step to providing clean, safe water for plant production.

FLAW #2: CONCRETE SURFACES

Most people consider concrete to be a rocklike, solid surface. The next time you look at a concrete surface, try looking at it in a different way. Concrete is actually quite porous and capable of absorbing water.

The pores in concrete not only absorb water but serve as habitats for microbial organisms. Algae, bacteria and fungi easily penetrate concrete

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and survive deep enough inside to resist conventional sanitizing treatments. Add a little fertilizer to the water and not only are the microbes living, they are probably flourishing.

Concrete water-holding tanks can be chemically sealed with epoxy to prevent microbial organisms from taking up residence in the concrete's pores.

Liners can be installed in metal or concrete holding tanks. In metal tanks, the liner prevents the metal from interacting with water.

Growers need to think of concrete holding tanks and greenhouse floors and walkways as microbial reservoirs. Once microbes move in, it's very difficult to evict them.

Inside the concrete there are little to no nutrients, a high pH and a high alkalinity. Depending on where the concrete is located, it may be continually wet, as in a holding tank; regularly wet, as in the floor of a production house; or rarely wet, as in a greenhouse walkway. While all organisms need water to grow, many can survive without water for a long period of time. Once water is present, they start to grow.

Even though some concrete pores are so small that water can't flow through them, microbes can still enter them. This makes it very difficult for typical commercial disinfectants that are dissolved in water to eradicate these organisms.

Gaseous disinfectants are thought to have a significant advantage here since the gas should be able to penetrate these pores. However, adequate research has not been conducted to confirm their effectiveness. This creates a unique situation in a greenhouse where organisms can enter the concrete, be protected and re-emerge as water and nutrients are supplied.

Correcting the concrete flaw

To correct this porosity flaw in concrete, there are several relatively simple options. Two of the easiest options are to chemically seal the concrete with epoxy, for example, or to physically isolate a concrete holding tank with a liner.

Liners are commonly installed inside metal tanks to prevent the metal from interacting with the water. This concept can be applied to concrete. In most cases, the size of the tank being constructed will determine whether to apply a chemical or physical seal.

In the case of constructing new holding tanks, concrete with the lowest porosity should be used. The fewer pores, the less organisms that can enter the concrete.

The problem of concrete harboring algae, bacteria and fungi is not isolated to recirculating irrigation systems. Traditionally irrigated production areas with concrete floors, walkways and sidewalls also serve as microbial reservoirs, which makes algae and disease pathogen control more difficult. This is not to suggest that concrete should not be used around a greenhouse. It is much better than sand, soil or gravel in the overall function of the operation. Just be aware that concrete surfaces should not be considered clean surfaces when it comes to microbial contaminants.

More water restrictions are likely

Until recently, **management of water and irrigation systems focused** on physical **dimensions only Growers must also understand water's chemical and microbial dimensions.**

Some municipalities have already implemented zero-ninofFi policies, and more are expected to enact regulations. This means redrculating irrigation systems will continue to play a major role in greenhouse production.

It is imperative that we learn how to better design and manage these irrigation systems, inducing idittilifying arid- correding- design and management flaws.

Researchers working in the area of greenhouse irrigation: agree that, as an industry, we need to develop a comprehensive approach for managing all of water's crimensions. Continuing to treat each dimension independently will be extern* inefficient and costly.

FLAW #3: IRRIGATION LINE DEAD LEGS

A third design flaw, although more commonly found with recirculating irrigation systems, can also be found in traditional, one-directional systems.

Supply and return lines should not contain dead legs. Dead legs are portions of irrigation line runs that dead end with a capped "tee" and not an "elbow." Dead legs accumulate organic matter and act as microbial reservoirs that continually contaminate water flowing past them. The alternating ebb and flow of recirculating supply and return lines, similar to an ocean's tides, allows dead leg sections of pipe to fill and empty as pressure is applied and relieved.

This flaw is particularly difficult to correct in a flood floor system where pipes are buried beneath concrete. Once dead legs are present, they are virtually impossible to disinfect without digging them up. If dead legs cannot be avoided, they should at least have blowouts plumbed in. Some type of access to the ends of the legs from above the concrete allows for treatment and effective flushing.

The easiest way to eliminate dead legs is to design each irrigation zone as a closed loop. Plumb supply and return lines within a zone so that individual irrigation units, whether they are benches or floor pads, are connected in a loop design rather than with individual runs of pipe that contain dead legs.

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