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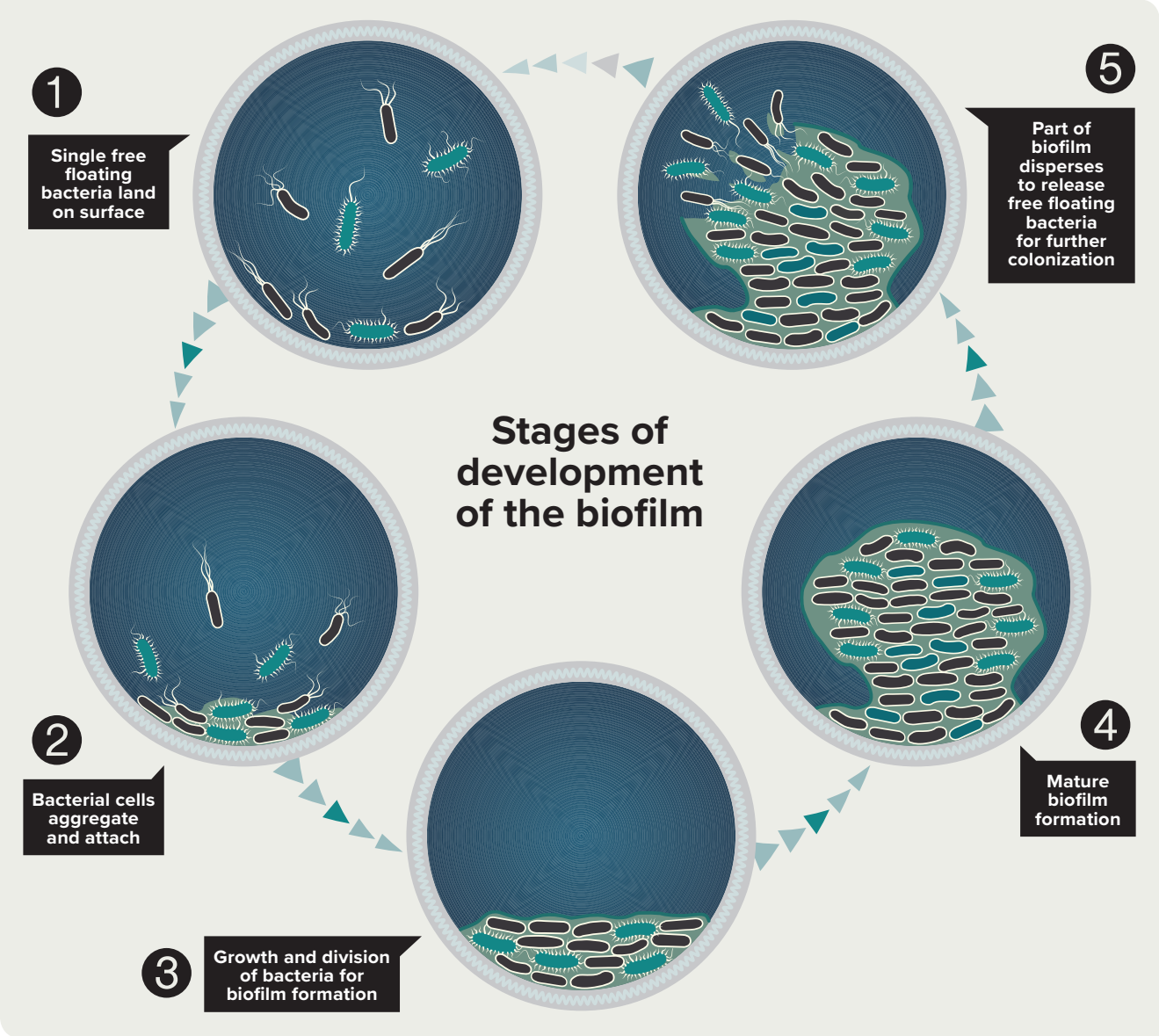
BIOFILM PREVENTION AND TREATMENT

By Shaye Donald

WHAT IS BIOFILM?

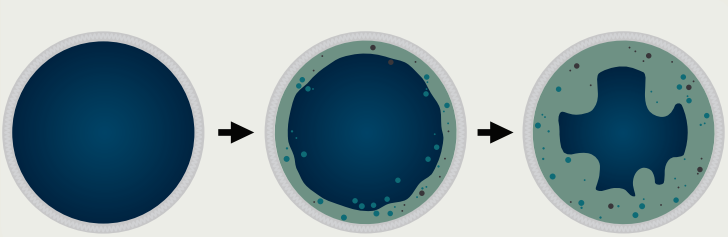
Biofilm is a broad term for a colony of microorganisms (primarily bacteria) that form on almost every surface, especially ones exposed to water and nutrients. This article focuses on the colonies that grow on the interior surfaces of irrigation equipment in a horticultural or agricultural setting.

As the name suggests, this colonization begins as a thin 'film' of slimy, glue-like substances that are secreted by bacteria/microorganisms that allow other bacteria and microorganisms to adhere to the surface of the pipe. Over time, these colonies form into larger colony structures consisting of many different species of bacteria and other microorganisms as well as extracellular secretions that form a protective 'matrix' around the colony (known as the extracellular matrix, or ECM).



WHY UNDERSTANDING BIOFILM IS IMPORTANT

Reduction in System Performance. Biofilm accumulation reduces the diameter of pipes, and eventually leads to large chunks of biomass being dislodged from the interior of the pipe, potentially clogging drip emitters and drastically reducing the efficiency of irrigation systems.



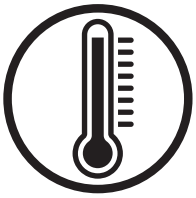
Harbor Disease Causing Organisms. Aside from drip emitters clogging, biofilm can harbor toxic substances and pathogenic organisms that increase the risk of plant or human disease. The anaerobic environment within the layers of biofilm 'matrix' is conducive to the growth of noxious organisms as well. This is another critical reason to avoid untreated accumulation of biofilm in an irrigation system.

BIOFILM ACCUMULATION HAZARDS

Biofilm can start and accumulate rapidly in modern irrigation systems. This process can be accelerated for several reasons:

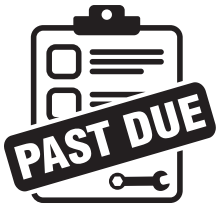
1. NUTRIENT RICH SOLUTION (FERTILIZER)

In fresh water without fertilizer there is less food for microbes compared to the nutrient rich solution growers use for crop production. The nutrients in fertilizer solutions are taken up and used by the microbes for growth and reproduction. In a nutshell, the food that is meant for the plants is effectively "stolen" by the microbes instead. This is undesirable.



2. TEMPERATURE

Irrigation events can be few and far between. In between irrigation events, the increased temperature of grow rooms, greenhouses, or sunny outdoor fields is absorbed by irrigation tubing, increasing the reproduction rate of microbes living in the tubing.



3. LACK OF MAINTENANCE

Infrequent cleaning and sanitation gives biofilm a foothold. Some growers are unaware of the issues biofilm accumulation causes, or how to prevent it. Maintenance schedules may not be adhered to, or worse, they might not exist in the first place.

4. POORLY DESIGNED IRRIGATION/FERTIGATION SYSTEMS

An irrigation system is only as good as its design. Without key pieces of equipment such as flush valves, filters, and a comprehensive maintenance plan, the system will fail eventually. HGC offers professional irrigation design recommendations and advice with maintenance.

5. FERTILIZER ADDITIVES THAT CONTAIN CARBOHYDRATES

Many fertilizer products on the market today contain carbon sources, especially sugars or organic acids or amino acids, which are often used as plant nutrients or to encourage the growth of beneficial microorganisms in the root zone. Unfortunately, microorganisms that live in water and irrigation systems will also happily consume these carbon sources.

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PREVENTION

Prevention of biofilm is critical to keeping an irrigation system performing with a high degree of effectiveness. Prevention techniques include a combination of chemical treatments, good irrigation design, proper fertilizer selection, and periodic flushing.

CHEMICAL TREATMENT

One of the most common ways to prevent excess growth of biofilm is to inject sanitizing products at a low rate continuously or at frequent predetermined intervals during crop growth. The term for this practice is chemigation, and is something that people who use municipal water are (directly or indirectly) familiar with. This is because one of the most widespread examples of chemigation is the addition of chlorine or chloramine into municipal drinking water supplies to prevent harmful organisms from growing.

The table below is a summary of commonly used sanitizing chemistries used to prevent biofilm accumulation in irrigation systems.

Chemical	Formula	Pros	Cons
Hydrogen Peroxide	H_2O_2	• Low cost • Readily available • Decomposes into water and oxygen	• Toxic at high concentrations • Potential to react with fertilizers • Concentrated solutions are dangerous to handle • Low persistence in line
Hypochlorous Acid	HOCl	• Can be injected continuously • Generated on-site or purchased as a liquid • Prevents scale accumulation as well as biofilm	• Relatively Costly • Most efficacious at a pH of 6-7.5
Ozone	O_3	• Highly effective for biofilm remediation • Decomposes into oxygen • No chemical residue • No buildup of ions • No waste from generators	• Must be generated, no liquid input • Reacts with Fe, Mn, NO_3, and bicarbonates. • Highly corrosive, system must have specialized equipment • Ozone can be harmful to humans • High capital cost and complexity
Chlorine Dioxide	ClO_2	• Effective even if biofilm has built up • Readily available • Strong oxidizer • Powdered, generated, or liquid form available. • Effective in a wide pH (4-10)	• Can be toxic to plants if not monitored closely • Hazardous to handle • Chlorine can have adverse effects on crop health • Concentrates ‘offgas’ over time, so tanks need to be replaced frequently
Peracetic acid	CH_3CO_3H	• Very effective when used in conjunction with peroxide (H_2O_2)	• Expensive in the long run • Strong oxidizer, interacts with fertilizers and pesticides.

Note: Always use appropriately registered products for cleaning and sanitizing. Always abide by the label directions for use for products to ensure proper application rates and methodologies.

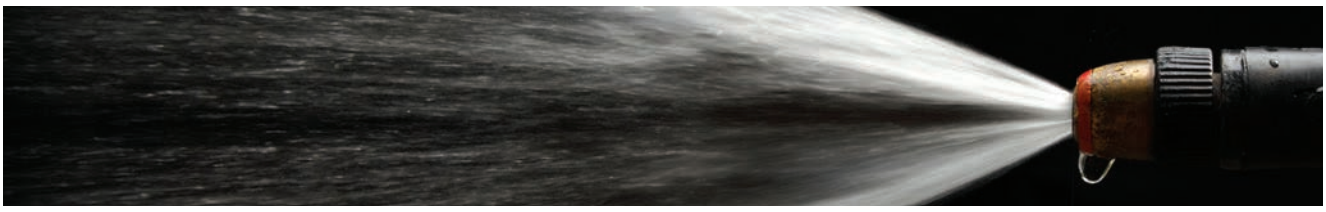
FERTILIZER PROGRAM AND IRRIGATION DESIGN

Fertilizer selection and irrigation design are both critical for the prevention of biofilm. This in conjunction with a maintenance schedule will ensure that the irrigation system stays in top working condition. Not considering fertilizer selection and irrigation design puts the operation at risk of system failure.

Considering the types of fertilizer inputs can help a grower reduce the speed of biofilm development. A grower who is only using mineral nutrients will experience less biofilm accumulation, and require less maintenance than a grower who wants to use a variety of amendments containing various carbon sources such as sugars. Hawthorne makes it a point to assure that nutrient programs are based on the needs of growers as well as the irrigation system that will be implemented.. Technologies that are not matched properly will result in problematic implementation.

PHYSICAL REMOVAL (PERIODIC FLUSHING)

Another common method to reduce biofilm accumulation is with routine flushing of the irrigation system using specifically placed valves. Strategically placed flush valves are key to using this technique. When a flush valve is opened, a much higher flow rate is allowed through the system than when an irrigation event takes place. Done occasionally, this can help dislodge biofilm and eject it through the valve rather than push it through drip emitters. Flushing works well **only when used in conjunction with other forms of treatment.**



The most effective way to utilize flushing is by first treating the water with what is commonly known as a ‘shock treatment’ for the system (below)

Note: Never allow biofilm ‘chunks’ to be pushed through drip emitters. This will quickly clog the small openings of the emitters if done improperly. Always use flush valves.

BIOFILM TREATMENT

If biofilm has been left to accumulate without any preventative action then it will likely require a shock treatment to remove large amounts of biofilm that is residing in the irrigation system. This shock treatment is a multi-step process:

SHOCK TREATMENT

Note: This is not a 'plant friendly' process. Make sure all drippers are removed from pots and the product. The best time to perform this treatment is in between crop cycles when there are no plants growing.

1. Using an acid-based detergent solution, fill all irrigation lines. Any acid such as hydrochloric, nitric, phosphoric, or sulfuric can work. Alternatively, acid-based cleaning products that contain surfactants add cleaning power. Using any acid, a pH of 3 is recommended for this process so as to solubilize lime scale and other mineral buildup. Always use properly registered products and refer to the label first for directions with any cleaning product.
2. Let this solution set in the lines for 1-2 hours.
3. Flush all lines fully with fresh water until clear water comes out of flush valves.
4. Next add BioSafe Systems' Sanidate® 12.0 (or 5.0) or another oxidizing agent. Follow label rates.

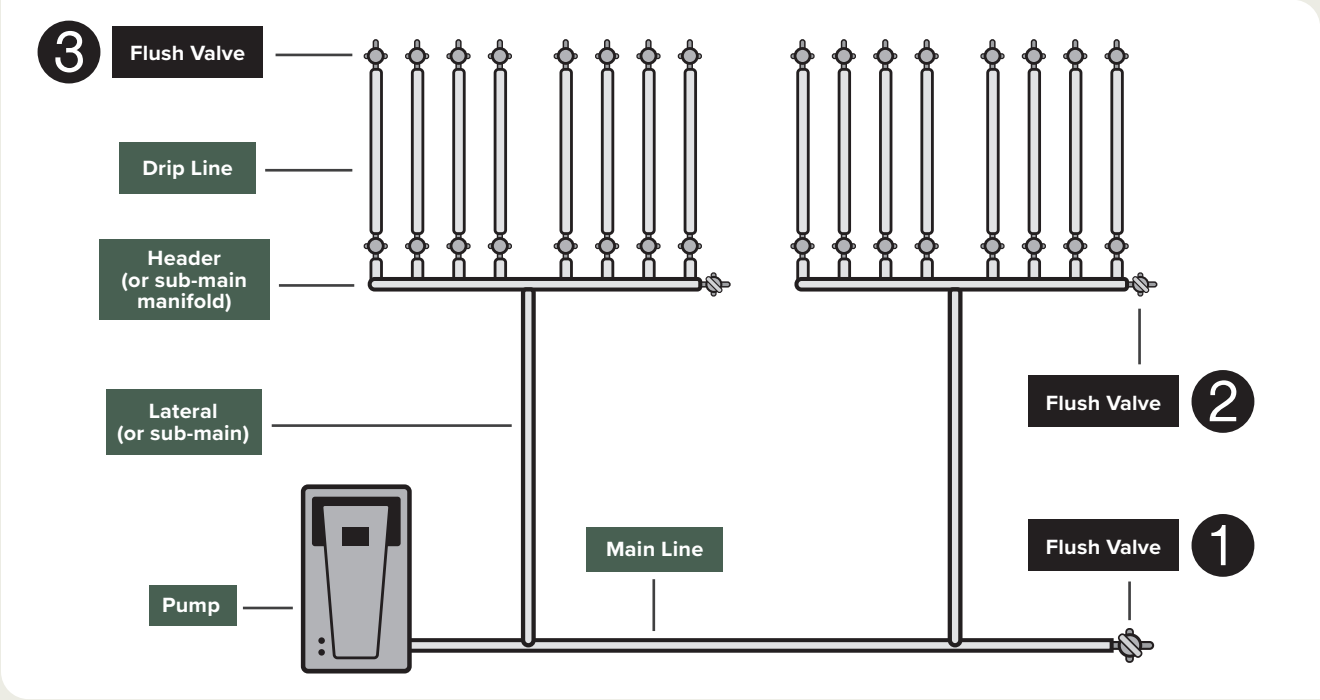
Note: Use proper personal protective equipment (PPE) when conducting any operation using these acidic or caustic materials. Always use recommended manufacturer instructions and directions. Be aware that some acids may corrode some soft metal irrigation parts.

5. Let the solution sit in lines for a minimum of 3 hours, ideally 8-10 hours or overnight.
6. Flush fresh water through until clear water comes through. Ensure that none of the biofilm is forced through emitters or filters. It is a good idea to remove filter inserts for this step, or use a bypass if there is one Reword this section properly.

Check system to assure that the shock treatment was effective. If not you may need to repeat the process.

It is recommended to run through this procedure **every time a crop production cycle is completed** (generally speaking every 6-10 weeks).

Note: When flushing lines clear of debris always open flush valves that are attached to larger pipes first. See order below:



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CONCLUSION

Biofilm is inevitable and is unavoidable in irrigation systems, especially in those where fertilizer is being applied through the system. It begins to form inside a pipe within seconds. If it goes unchecked, biofilm will result in clogged filters and emitters, costly repairs, and crop damage from pathogens or undiscovered drought stress. As the saying goes, an ounce of prevention is worth a pound of cure. This is the case for biofilm, where an untreated system can quickly lead to clogs in the system and even crop loss.

The best way to manage biofilm is by utilizing all of the tools described in this article. Starting with good irrigation design and proper fertilizer selection before the system is even set up. From there, consistent injection of appropriate sanitizing chemistries into the irrigation system as well as a defined maintenance plan is essential to any crop production facility.

THE PRODUCTS AND ADVICE TO KEEP YOU IN THE GAME

- Hawthorne Gardening Company, in partnership with the largest irrigation equipment manufacturers in the world, is here to help you maximize your crops' potential with the best irrigation management strategies and information available today.
- Our dedicated team can assist you in every step of the way to ensure that your system will work exactly how it is supposed to from day one.

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