Managing Biofilms

Biofilms can create many problems in production nurseries including, reducing flow in irrigation pipes, blocking emitters, harbouring plant diseases and producing slimy surfaces. While attempts can be made to eradicate biofilm by the treatment of pipes and surfaces, there are a number of features of biofilms that make it difficult to entirely remove these organisms from a system. It's important to remember that biofilm control must be done continuously, not intermittently, and that plants mustn't be damaged or killed in the process.

Biofilms have a number of features that make them challenging to manage in irrigation systems:

Biofilms attach to the edge of the pipe where the force of water flowing past isn't sufficient to dislodge them.

Biofilms can attach to most surfaces, even very smooth stainless steel.

Biofilms have the ability to shield themselves with slime, which reduces the effectiveness of disinfectants.

After treatment, biofilms can reinitiate the secretions that hold them to the surface making them stronger over time i.e. the problem may get worse after treatment.

Biofilms concentrate nutrients. There are sufficient levels of nutrients in water for biofilm growth, even in water containing nutrients below measurable levels. In nurseries, particularly where water is being recycled, there may be significant amounts of nutrient in the water, generally causing significant problems with biofilms. Even potable water that has been disinfested and has low nutrient levels can still support the growth of biofilms.

The density of a biofilm is a result of the bacterial level of the water entering the system, temperature, how long the water remains in the pipe, presence of disinfectants in the system, pipe materials, surface-to-volume ratio, flow rates, availability of nutrients for growth, chlorine: ammonia ratio and the activity of nitrifying bacteria.

Steps in managing biofilm

1. **Monitoring** system blockages, odour, high residual demand of disinfectants and even microbiological testing.
2. **Review water quality** and distribution system characteristics—pipe materials, system hydraulics, pH, temperature, nutrient, disinfectants used.
3. **Develop a strategy** to mitigate biofilm effects.

Biofilms are not uniform, both in distribution and makeup of the biological organisms in them, making it difficult to make one size fits all recommendations. Physical removal such as flushing, swabbing, or ice 'pigging' (using blocks of ice flowing through the pipe) or using chemical treatments may work to varying degrees, with a combination of these methods being the most effective.

Flushing is a popular method, but may not always be successful, depending on the flow rates available and the type of biofilm present e.g. manganese or corrosion scale. When using disinfectants to remove existing biofilm there is a high probability the free floating particles of the removed film will cause blockages in the system.

In practice, implementing the following strategies in a regular programme will minimise the effects of biofilm.

Reduce nutrients. The first step in managing biofilm is to reduce the amount of nutrients in the water. Water can be purified to remove nutrients, but biofilms will concentrate the small amount of nutrients remaining. Bacteria may also be able to utilise the pipe glue and plasticizers from PVC pipes, the cellulose membranes in RO filters and trace elements from metal pipes as sources of nutrients. In nurseries, keeping the levels of nutrients in irrigation water as low as possible will reduce the growth of biofilms, but will never eliminate them. Practices such as using reed beds to reduce nutrient loads may help in reducing nutrient levels.

Flush pipes*.* Flushing pipes will help to reduce the thickness of the biofilm. However, biofilms develop at the edge of pipes where the velocity of the water is zero, so a great deal of flow and turbulence is required for effective flushing and, at best, this will only remove the outer parts of the accumulated biofilm. While high water velocity doesn't prevent biofilms establishing, it will reduce the thickness and volume of biofilms, and this needs to be considered when designing pipe sizes in irrigation systems. Swabbing or pigging can improve the effectiveness of flushing, as will the removal of pipework dead ends and dead legs.

Smooth surfaces*.* The type of material the surface is made of has little or no affect on biofilm development, with stainless steel just as susceptible as plastic pipe. Rough surfaces have more surface area, and while smoother surfaces delay the initial build-up of attached bacteria, smoothness does not appear to prevent the development of biofilms. Smooth pipe should support less biofilm because it has less total surface area than rough pipe, and rough surfaces provide more protection from the flow of water that would remove biofilm. Smooth surfaces should also have less bio-corrosion due to the decrease in currents that flow between the peaks and valleys of a rough surface.

Sanitise surfaces. Sanitisation will reduce the amount of biofilm that develops. The effectiveness of oxidizing biocides decreases in the following order - ozone>chlorine dioxide>chlorine>hydrogen peroxide. Typical chlorine levels in town water are between 0.5 -2.0 ppm. This amount of chlorine has been shown to kill free-floating bacteria, but may not be enough to kill biofilm bacteria, due to the protection afforded by the slime on the biofilm. Therefore, high doses over a short periods are more effective at diffusing into the slime than low doses over a long period. If high doses are combined with flushing there will be a higher uptake of chlorine and a greater flushing effect. Decreasing pH will also enhance the effectiveness of chlorine treatment, due to the production of more effective forms of chlorine. Some forms of chlorine such as chlorine dioxide may be able to maintain biofilm at low levels if constantly injected into the system at low dose rates. Quaternary Ammonium compounds (QATs) are a non-oxidizing biocide option that may have some effects in specific situations e.g. preventing biofilms on nursery surfaces. Anionic and non-ionic surfactants can also be used, but their effect is limited. In some situations heat could also be considered if surfaces or pipework can be heated sufficiently e.g. pipework in bottom heat systems or steam cleaning surfaces.

Biofilm can also develop on the surfaces of growing containers and trays. As the biofilm can protect itself from disinfectants, the biofilm needs to be first removed from the surfaces by physically scrubbing before the disinfectant is applied.

Incomplete removal of biofilms means a rapid reintroduction will occur, so any treatment applied needs to be done thoroughly. Under perfect growing conditions, a bacterial cell divides into two daughter cells once every 20 minutes. This potentially means that, in 8 hours, 2 million cells could be produced from 1 parent cell. Fortunately, these rates are never realised because the bacteria are limited by space and available nutrients.

Effective management of biofilms requires a multipronged and consistent approach and the application of the above methods helps in achieving this.

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