An Introduction to Biofilms

What are biofilms? In irrigation systems biofilms are commonly referred to as 'algae' found growing on the inside of pipes. More correctly, they are a complex collection of mainly bacteria, some fungi, and the slime that they secrete. Many bacteria, which make up the majority of organisms in biofilm, form aggregates or colonies, and in this form behave quite differently to a single bacterial cell. In any system that is exposed to water there is the potential for biofilms to develop, and these films can have beneficial as well as negative effects. Examples of biofilms are the plaque on your teeth, slime on river stones and the slime on the inside of a flower vase after flowers have been left in it for a week. Stromatolites are among the oldest forms of life, formed by biofilms cementing grains of sand together to form their unique structures. Biofilms are also used in sewage treatment to assist in removing contaminates.

Biofilms are important in plant production in a number of ways. Biofilms are the primary treatment method present in slow flow filters, and in this case the biofilm layer is sometimes referred to as schmutzdecke. While the biofilm layer is the active part of a slow flow filter, from time to time it has to be cleaned off to restore the flow rate of the filter.

Biofilms are present in every irrigation system, and their negative effects in production nurseries include clogging of filters and sprinklers, corroding of pipes and contamination of irrigation and drinking water supplies Biofilms can cause significant problems in nurseries due to blockages of irrigation equipment and creating slippery growing and working surfaces. Recent research indicates that a significant proportion of water-borne pathogens can be contributed by biofilms acting as a pathogen reservoir within the irrigation system. Biofilm also consumes oxygen in irrigation water, reducing dissolved oxygen levels being delivered to the crop.

Biofilms can be found on the surfaces of recycled pots and trays, most commonly seen as a film on the surface of the container after the larger particles have been removed. This biofilm provides protection to the underlying microorganisms from disinfectants, and the only effective way of removing it is by scrubbing the surface.

Certain bacterial diseases can also affect plants by producing biofilms in the water conducting tissue of the plant e.g. Pierce's Disease, while others form beneficial associations with plants e.g. nitrogen fixing bacteria.

Biofilm can give some physical corrosion protection to pipework, but it's generally considered that corrosion will increase on steel pipes due to the changes in oxygen concentration at the pipe surface. Anaerobic bacteria can also contribute to corrosion by generating hydrogen sulfide gas.

Nitrification of ammonia in biofilms has been found to be increased compared to the water stream. While this is unlikely to cause problems for nursery irrigation water, it may be problematic for drinking water supplies. Iron and sulfur bacteria, are common in pipe biofilm and when these detach from the biofilm layer these organisms may lead to taste, colour and odour problems.

The development of biofilm has 5 distinct stages:

1. Initial attachment: As soon as a new pipe is filled with water a biofilm begins to develop. The first step in their development is the depositing of organic material. This first layer neutralises the surface and makes it more suitable for the further attachment of bacteria, acts as a food source for the colonising bacteria, and is the foundation for successive layers of microorganisms to build on.

2. Irreversible attachment: Once the organic material layer has formed it can be colonized by bacteria passing in the water. Bacteria approach the pipe wall and are trapped in the boundary layer; an area close to the pipe wall where the velocity of water is zero. In this zone, some of the bacteria will attach to the organic layer and then, at a later time, be released – a process called reversible adsorption, while other attached bacterial cells begin to form stronger bonds with the organic layer, and eventually become irreversibly adsorbed.

3. Maturation I: In a process called glyocalyx, or slime formation, the adsorbed bacteria begin to excrete

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sticky polymers, which hold the biofilm together and cement it to the wall of the pipe. These polymers also form strands whose function it is to trap any nutrients in the water, protect the bacteria from any dangerous substances e.g. sterilants, and to trap other microbial cells which can use the wastes from the primary colonizers.

4. Maturation II: The secondary colonizers produce waste that can in turn be used as a food source for other microorganisms. As nutrients accumulate, the pioneer bacterial cells reproduce. These secondary cells produce their own glyocalyx and the biofilm begins to increase in size. In a mature biofilm 75-95% of the volume of the biofilm is made of glyocalyx and, because this contains a lot of water, a biofilm is jelly like and slippery.

The final result of all this activity is the 'algal' layer seen growing on the inside of pipes and other surfaces. Light is not necessary for this biofilm to form, as demonstrated by the formation of biofilms in pipes that are buried underground. These mature biofilms are complex and each microorganism occupies a micro-niche and is part of a cooperative community.

5. Dispersion: Once established, not only can biofilm spread by ordinary cell division, but they also release 'pioneer' cells which colonise the downstream water. As the thickness of the film grows, it extends past the boundary layer into water that has a greater velocity, and some of the cells will be broken off and taken away in the water stream. These pioneer cells will be aided in their deposition and development, because the parent film will have released organic materials that can act as the foundation layer further downstream, and as a food source.

Any microorganism that gets into any part of a water system can form a biofilm. Points of entry can be hoses with water breakers, irrigation emitters, tanks benches and growing beds. Any surface that comes into contact with a water outlet can pick up a microorganism which can then quickly turn into biofilm. This may mean in spite of treatment to remove biofilm there could pathogens still within the system that have been introduced previously.

In addition to nutrients in the water biofilm organisms depend on organic carbon for growth, as they can't 'fix' carbon from the air, Consequently, organic matter in a water supply can also contribute to the growth of biofilms.

How long does it take a biofilm to develop? In one experiment it was found that some cells were able to adhere to electropolished stainless steel within 30 seconds of exposure. The full development of a mature biofilm may take from several hours to several weeks depending on the prevailing conditions.

Biofilms can be managed in irrigation systems, but it is difficult to eradicate them. Another article titled "Managing Biofilms" discusses techniques that can be used to minimise the problems caused by biofilms.

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