Rhode Island Sea Grant
FACT SHEET

Biofilters for Recirculating Aquaculture Systems

P1463
RIU-G-97-003
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What are they?

A biofilter is a device that allows naturally occuring bacteria to remove chemical wastes from the water in closed aquaculture systems. These filters operate by utilizing bacterial microorganisms that feed on the toxic chemical components of fish waste and converting the waste to less harmful substances. The two most important genera of bacteria used in this detoxification process are *Nitrobacter* and *Nitrosomonas*.

There are several types of biofilters, which can be classified by their method of housing the microorganisms. Some of the most common types are submerged, trickling, drum, and bead filters; however, the most important components of each of these types are the microorganisms themselves.

How do they work?

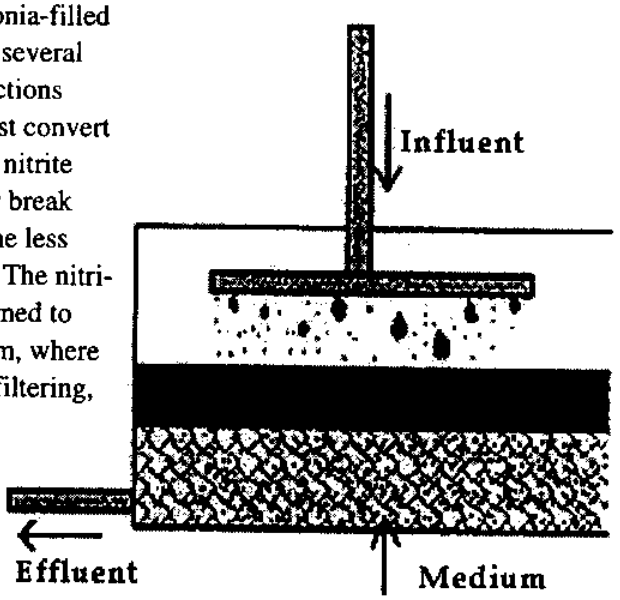
The integral job of these microorganisms is to rid the system of ammonia. Ammonia is a waste by-product of most living animals, including livestock. At high levels ammonia is toxic and jeopardizes the lives of the animals.

The ammonia-containing water is brought from the main tank to the biofilter. Inside is a medium that consists of anything from sand to plastic pieces. The main function of this material is to give the bacteria a surface upon which to grow. Once the ammonia-filled water enters the filter, several complex chemical reactions occur. The bacteria first convert the ammonia (NH_4) to nitrite (NO_2) and then further break down the nitrite into the less harmful nitrate (NO_3). The nitrified water is then returned to the recirculating system, where it is subject to further filtering, then reentry to the holding tank and reuse by the fish.

What are the comon types of biofilters?

Many different designs of biofilters are currently being used. Each has its own benefits and drawbacks, but all operate on the same principles. The four most common types are as follows:

1. Submerged- The outstanding feature of the submerged biofilter is that the medium used to feed the bacteria is heavier than the water; therefore, the filter is completely submersed in the water to be filtered. The flow enters through either a downflow (top to bottom) or an upflow (bottom to top) and



Submerged Medium Filter

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passes through the nitrifying filter. The advantage to this design is that energy use is kept to a minimum. However, there is a drawback: The water being pumped through must supply all the oxygen necessary for the microorganisms to do their job. To address this oxygenation problem, another, similar, system has been developed.

2. Trickling- This filter is almost identical to the submerged filter, except that the bacterial growth medium is not completely submerged. Instead, it is just kept wet, allowing the bacteria to use atmospheric oxygen in the filtering process. While this system eliminates the oxygenation problem, care must be taken to maintain the moisture level within the filter. If the medium becomes either too wet (creating bacterial oxygen starvation) or too dry (causing the bacteria to dry out) the microorganisms will die and the filter will no longer be effective.

3. Bead -This filter consists of polystyrene beads in a cylindrical container through which water flows. The influent usually enters from the bottom and passes through a central region containing the beads. The water is exposed to and cleaned by the nitrifying bacteria and exits through the top of the filter. The primary advantage of this system is that the medium also tends to act as a mechanical filter; that is, it filters out some of the suspended material. On the other hand, the influent water must have a high level of dissolved oxygen.

4. Biodrum- This filter consists of a cylinder filled with the bacterial medium and mounted so that it rotates around a long axis inside a tank through which the water flows. The drum is rotated at a speed fast enough to keep the medium moist but not fast enough to starve the microorganisms of oxygen. Due to its characteristic rotation, the biodrum does not require that the influent water contain a high level of dissolved oxygen.

There are a couple of drawbacks to this filtering method: The rotating parts cause a significant amount of turbulence and mixing, and biodrums require motors, which use electricity to operate, require periodic maintenance, and are subject to mechanical failure.

Limitations of biofilters

Although biofilters are an essential component of the recirculating water of a closed system, they make up only one step of the water cleaning process. Biofilters generally do not filter out solid matter, suspended or otherwise, from the water. Furthermore, biofilters are known as nitrification filters. This means that the removal of ammonia results in the generation of nitrate. Nitrate is not toxic to the fishery livestock in low concentrations, but as time progresses in a system, nitrate levels rise and can become harmful. A typical solution to this problem is periodic replacement of the system water with a fresh supply.

Choosing a biofilter

Every closed aquaculture system will need some sort of biofilter to remove harmful ammonia from the water.

When engineering a system, the designer must choose the filter that will best correspond to the system parameters. Many aquaculturists opt to develop their own designs by modifying and combining any of the above types to better fit their needs. This gives them the advantage of creating a filter that custom-fits their system. Designing a filter requires knowledge in biology and economics, as well as a basic grasp of engineering principles.

In conclusion, biofilters function to remove harmful impurities from the system by utilizing microorganisms that can be maintained using any number of the designs described above. Each one of these has its own drawbacks and advantages; therefore, careful research is important before selecting a filter for any particular system.

• Editing and layout by Rhode Island Sea Grant Information Office

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