

## CLASSROOM ACTIVITY

### The Nitrogen Cycle in Action: Biofiltration in Aquaculture Systems

by Bill Andrade Swampscott Middle School

Organisms kept in aquaria are living in a closed environment and are in effect living in their wastes, namely carbon dioxide, the by-product of respiration and ammonia ( $\text{NH}_3$ ) from the breakdown of nitrogen, containing organic molecules such as proteins.

Ammonia is excreted from animals as they deal with metabolic and digestive wastes and is also released from the decay of uneaten food or any death in the aquarium. Ammonia is fatal for most aquarium animals (especially fish) in concentrations of only 1-2 ppm, so if these wastes are not dealt with they can lead to death in a short period of time.... more ammonia. One solution is to change the water everyday, but this isn't realistic. The solution is biological filtration (filtration by living things).

#### Biofiltration in the aquarium

Biological filtration takes advantage of nature's way of dealing with these wastes through the Nitrogen Cycle. In this process certain forms of beneficial *Nitrosomonas* bacteria feed on ammonia and convert it into a less toxic compound of nitrite. The nitrite is then consumed by *Nitrobacter* bacteria and converted to non-toxic nitrate compounds. See the diagram below.

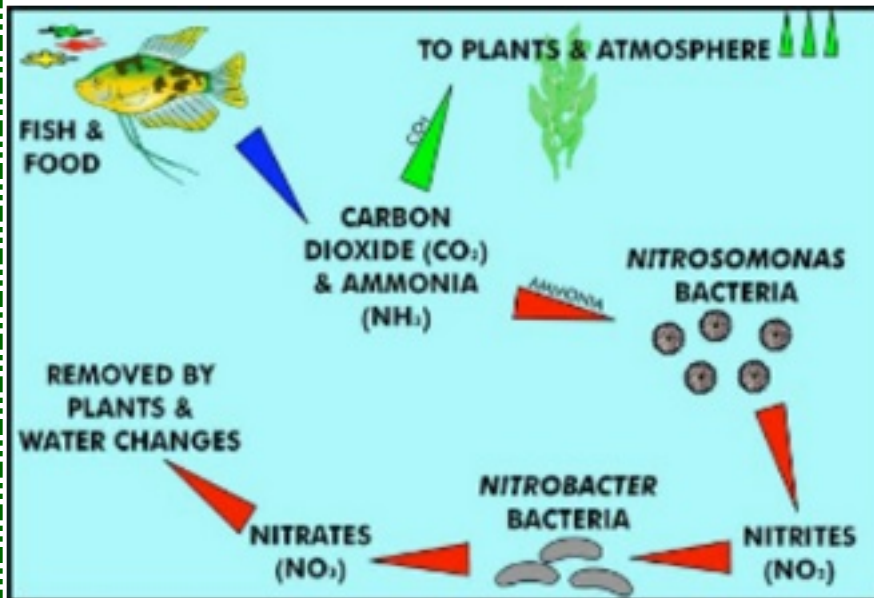


Diagram by Les Pearce from  
*Filtration and the Nitrogen Cycle.*  
[aquarticles.com](http://aquarticles.com)

Nitrate compounds are safe in high concentrations for most aquarium animals. However, high concentrations of any material dissolved in water means less space between the water molecules for oxygen. Additionally, nitrates serve as fertilizer for algae, which can become a nuisance. Therefore, partial water changes are recommended to keep the nitrate levels down.

#### Setting up a biofilter in aquaria

A good aquaculture system is set up to take advantage of the nitrogen cycle by maximizing the growth of the beneficial bacteria which convert ammonia to safer nitrogen compounds. These bacteria are everywhere and will readily multiply in the presence of ammonia and a surface for them to grow upon.

The bacteria grow on every surface in an aquarium from the tank surface to rocks, pipes, and tubes. However, this is not enough surface area to get the population density of bacteria needed to effectively neutralize ammonia. The best way to maximize the growth of these bacteria is to come up with a way to have a lot ... that's A LOT OF SURFACE AREA FOR BACTERIA TO GROW ... and that's what biofilters are set up to do.

There are many filters on the market which foster biological filtration all with advantages and disadvantages. All biofilters have water passing through beds of gravel, sponges, or thousands of plastic pellets called "Biomedias". All of these materials provide a lot of surface area in a small space for bacteria to grow.

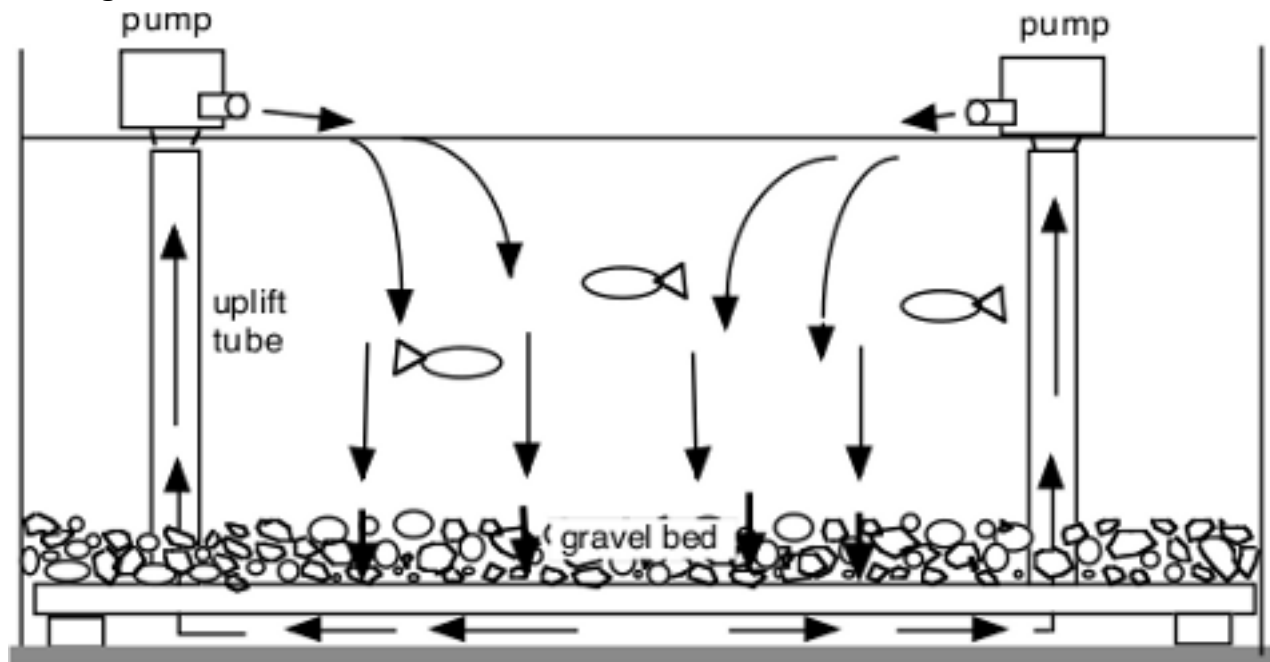
(Biofiltration Act - cont on page 26)

*Bed Filter Media from  
Water Management  
Technologies Inc.*



Look at all of the surfaces for bacteria to grow on just one pellet!

### The Undergravel Filter



The gravel bed is the “biofilter” for this system. It rests on a raised porous plastic platform. As water falls through the gravel bed bacteria change ammonia to nitrites, and nitrates and particles that make the water cloudy are also filtered. Cleaned water now lies under the gravel bed. Powerhead pumps pull filtered water up from below the gravel through the uplift tubes and into the aquarium’s living space.

Some designs use air stones connected to an air pump to bubble up water through uplift tubes. This design may be less expensive at first, air stones wear out and clog up quickly and need frequent replacement . In addition, they don’t supply the lift needed to draw water through a substantial layer of gravel effectively. I recommend using powerhead pumps on these filters. They are a little more money at first but they last a long time.

The advantage to this set-up is that everything is in the tank with two pumps. With power filters, which are also very good filters, a canister or tank sits outside of the aquarium. Water must be drawn from the tank and pass through the filter and return to the system. If there are any air locks in the system, pump failure, or pipe leaks, you can have a real mess.

The disadvantage to the undergravel system is that it does require vacuuming from time to time to keep the gravel from getting too clogged. This is a lot more maintenance than is required for most power filters.

### Getting the Nitrogen Cycle established... "Cycling"

First of all you need a good aquarium water test kit to measure ammonia, nitrite, nitrate levels and pH.

Once the tank and filter have been set up you need a source of ammonia and the *Nitrosomonas* bacteria will show up to the feast. Not right away, but in a week or two or three... be patient. I have gotten things started by adding a few drops of clear household ammonia to a tank every few days or so. You can also jump start the system by taking materials, ie. gravel or pieces of sponges from established biofilters and inoculating your new filter with bacteria.

Test the water every couple of days and it will happen; you will notice that the ammonia levels in the water have dropped to near 0 ppm and at the same time nitrite levels are climbing. This tells you that the *Nitrosomonas* bacteria are thriving but no *Nitrobacter* bacteria yet.

Keep the ammonia going as you have to keep feeding the *Nitrosomonas* bacteria. In a couple of weeks the nitrite levels will begin to drop and nitrate levels will rise indicating that *Nitrobacter* bacteria have multiplied in the system. At this point the biofilter is established and it is safe to begin to gradually add animals to the aquarium. Keep testing the water to make sure that the ammonia and nitrite levels stay at 0 ppm.

Aquarium cycling may take 6 to 8 weeks. If you can't wait that long, then be prepared to conduct frequent water changes.



An excellent class activity is to graph the progress of the Nitrogen Cycle in a new aquarium. Also, keep in mind that if you remove the aquarium animals from the tank for any length of time, you need to add a drop or two of ammonia to the water every couple of days to maintain healthy populations of bacteria in the biofilter.

Biofiltration is without question the single most important concept that one needs to understand and maintain to have a successful aquaculture system.