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Your Aquarium Filter - How Does It Really Work?

Aquarium filters are an important part of any aquarium system. As aquarium hobbyists, developing an understanding of how our filters work will help us to properly set up and care for our filters and maintain a healthy and happy fish population within our aquariums.

There are many different types of aquarium filters that each have various pros and cons associated with them. The basic principles of operation apply to all aquarium filters regardless of the make, model or type of filter that you may have. The intention of this article is to help you understand the principles of how an aquarium filter functions to keep our precious pets alive. This understanding will help you to better care for your aquarium and filter resulting in a healthy aquarium with healthy inhabitants. A follow-up article will be written to review the pros and cons associated with the various types of aquarium filters and help you decide which type of filter is best for you and your aquarium.

Mechanical Filtration: Mechanical filtration is perhaps the most easy to understand component of most filtration systems. Simply put, mechanical filter media remove debris that may be floating in the aquarium water. This debris could consist of uneaten food, fish waste or sometimes bits of aquarium substrate. The removal of this debris is most often accomplished through the use of sponges, ceramic rings, pads or polyester batting (most often called filter floss). As aquarium water passes through the mechanical media contained within the filter, any debris that may be floating in the water gets trapped in the media and is thus removed from the water. Mechanical filtration is usually deployed first in a filtration system as it will reduce the amount of water borne debris that can clog up the subsequent components of the filter.



Chemical Filtration: Chemical filtration is not an absolute necessity for most aquariums however, it is often deployed in aquarium filtration systems. Chemical filter media chemically reacts with the aquarium water as it passes through the filter to remove contaminants.

The most common type of chemical filter media is activated carbon. Activated carbon is extremely porous creating a very large surface area that contacts the water and removes impurities through the process of adsorption. Carbon can remove many contaminants and odours from aquarium water including old medication, chlorine, nitrate and tannins that are produced by any driftwood that may be in an aquarium. When paired with good mechanical filtration, activated carbon can leave the aquarium water crystal clear. Another popular form of chemical filter media is granular ferric oxide (GFO) that is used to remove phosphates from the water. GFO is most often deployed in saltwater aquarium systems.





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Biological Filtration: Biological filtration is essential to the well being of any aquarium. While it is possibly the most misunderstood part of any good aquarium filter it is undoubtedly the most important. Simply put, it would be very difficult or nearly impossible to keep fish in an aquarium for any length of time without it. Biological filtration functions based on the principles of the nitrogen cycle, I will do my best to explain how it all works in simple terms in the following paragraphs.

As fish live and consume food within our aquariums they also create biological waste. The biological waste produced by fish unfortunately contains ammonia, yes, the same ammonia that is contained in some household cleaning products. Fish also produce small amounts of ammonia as they breathe in an aquarium. Ammonia is very toxic to fish, so much so that the concentration of ammonia in any aquarium should be kept below the point that it is detectable. Biological filtration is used to remove ammonia from the aquarium water.

The Nitrogen Cycle

So how does biological filtration work? Biological filtration relies on beneficial bacteria which live within the aquarium filter. These bacteria, sometimes called nitrifying bacteria, naturally consume ammonia and produce a somewhat toxic substance called nitrite. Nitrite is also consumed by a different type of beneficial bacteria that live within aquarium filters. The byproduct of this process and end result of the nitrogen cycle is nitrate. Nitrate is largely non-toxic at low concentrations, however, it can be harmful at concentrations higher than 50 parts per million. Persistently high nitrate levels in aquariums can result in stunted growth or eventually sickness and death of fish. There are a few tactics that can be used to keep nitrates at an acceptable level within our aquariums. The first is to cultivate a third type of beneficial bacteria called denitrifying bacteria. These bacteria consume nitrate and produce nitrogen gas as a byproduct which is naturally released from the aquarium water into the air. Denitrifying bacteria require low oxygen levels to thrive (not very compatible with the requirements of our fish) and rarely exist in quantities that are sufficient to keep our nitrate levels in check over the long term. The most common method used to keep nitrate levels in check is to perform regular water changes with our aquariums. A 25% to 50% water change performed weekly is usually sufficient to accomplish this. Aquariums with higher bio loads (more fish) require more frequent and larger water changes.

An interesting fact about nitrate and phosphate, which is another relatively harmless byproduct created by fish waste, is that plants love it. The next time you are applying fertilizer to your lawn take a look at the ingredients, you will see that nitrate and phosphate usually rank high on the list. A sure sign that nitrate and phosphate levels are too high in an aquarium is excessive algae growth. Algae, which is a plant, will grow faster and in greater abundance when adequate light and high levels of nitrate and phosphate are present. Although algae is often considered to be unsightly by most aquarium hobbyists it can actually be used to control nitrate levels. More commonly, either aquatic or non aquatic plants such as pothos are used to consume the nitrate in aquarium water. These plants, if present in sufficient quantity, can drastically reduce or even eliminate the need for water



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changes. The water that is removed from the aquarium during water changes can be used to water the plants in your home or garden. Your plants will love the nitrate and phosphate that act as natural fertilizers within the water!

Cultivating Beneficial Bacteria

So how do we get all of this beneficial bacteria to grow within our aquarium systems. The first step is to give the bacteria a place to live. Beneficial bacteria grows on surfaces, it does not live in a free floating state in our aquarium water. The biological filtration media that most of us use within our filtration systems is usually extremely porous providing the greatest surface area possible for bacteria to grow on. In addition to growing on the biological media that is intentionally added to aquarium filters to promote bacteria growth, beneficial bacteria will also grow on the sponges and other media that provide mechanical filtration as well as within any chemical filter media that may exist in a filter. Beneficial bacteria can also grow on aquarium substrate if it is present and on other surfaces within the aquarium itself.

It takes time for beneficial bacteria to establish itself and multiply to the point where it can consume all of the ammonia that is being created within an aquarium system. This time is most often referred to as “cycling” an aquarium filter. When fish are first introduced to a brand new aquarium system they will begin producing ammonia that will accumulate in the aquarium water. The ammonia levels will continue to rise until such time that the beneficial bacteria establish themselves within the aquarium system and begin to consume the ammonia. As the bacteria multiply, the ammonia levels will begin to stabilize and eventually drop to the point that they are not detectable. The nitrite that is produced by the bacteria that are consuming the ammonia will also accumulate in the aquarium water. Nitrite levels will rise until such time that nitrite consuming bacteria establish themselves and multiply to the point that they are able to consume all of the nitrite that is being produced. Remember that ammonia and nitrite are both toxic to fish. It is not recommended to cycle an aquarium with fish that are known to be delicate. It is also important to minimize feeding and keep very few fish during the aquarium cycling process, this will minimize the amount of ammonia and nitrite that accumulate in the water and keep it at a level where it does not kill the fish. Fish can *slowly* be added to a new aquarium once it has been cycled, as the bio load increases it takes time for the bacteria to multiply to the point where it can consume the additional ammonia and nitrite that is being produced. The aquarium water will often appear cloudy during the cycling process. The aquarium cycle is complete once the water clears and the ammonia and nitrite levels reach an undetectable level. It will typically take weeks for the cycling process to complete.

“Tricks of the Trade”

There are several things that can be done to minimize the impact that cycling an aquarium will have on the aquarium inhabitants and promote a stable and healthy population of beneficial bacteria within our aquarium systems. I will review a few of them here.



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- Monitor the water parameters - The single most important thing you can do to monitor the health of your aquarium is to frequently check the water parameters.

There are various test kits available from pet supply stores that will allow you to do



this. You can monitor the water parameters during the cycling process, watch the ammonia and nitrite levels rise and eventually drop to zero when the cycling process completes. Ammonia and nitrite levels should remain undetectable once the cycling process is complete, a spike in either is usually an indicator of trouble and action should be taken to control the levels immediately. It is also recommended to check for the presence of ammonia and nitrite any time the aquarium water

becomes cloudy or the fish begin to exhibit odd behaviour. In addition to monitoring the ammonia and nitrite levels it is also important to monitor the nitrate levels to ensure that they remain at an acceptable level. A large water change will improve the situation if nitrate levels get too high and the frequency water changes should be increased going forward to keep nitrate levels within an acceptable range. PH, GH, KH and temperature can also be monitored if the species of fish you are keeping are sensitive and require these water parameters to remain within a certain range.

- Pre-seed your filter with bacteria - If you are setting up a new aquarium and are fortunate enough to have more than one aquarium or have a friend with an aquarium, you can execute the following method to speed up or eliminate the need to cycle your aquarium filter. Take some of the biological filter media from a well established aquarium and place it in your new filter. This will “seed” your new filter with live beneficial bacteria from the established filter and allow the bacteria to immediately start consuming ammonia and nitrite within your new aquarium. Provided that the bacteria survive the transfer process they should be able to handle a light biological load from the get go and quickly multiply to the point that you can start adding more fish to your aquarium. It is important to carefully monitor the ammonia levels within your aquarium for the days and weeks after it is set up to ensure that the beneficial bacteria are keeping up with the biological load of the aquarium.
- Use aquarium additives during the cycling process - If you are setting up a new aquarium and do not have access to a source of beneficial bacteria there are additives that can be used to reduce the stress on fish during the cycling process. These additives usually chemically bond to the ammonia and nitrite to make it less toxic to aquarium inhabitants. Some of these additives also claim to contain beneficial bacteria although the benefits of adding beneficial bacteria to the water column are not entirely known.
- Cycle your aquarium with household ammonia - It is possible to cycle an aquarium filtration system by adding small amounts of household ammonia to the aquarium on a daily basis. This offers the advantage of allowing beneficial bacteria to establish themselves within the filter without introducing any stress to the fish that will



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eventually inhabit the aquarium. Once the aquarium is cycled, small quantities of fish can be added and slowly increased as the beneficial bacteria multiply. Remember that larger fish produce more waste and thus more ammonia. You will know when the cycling process is complete when ammonia and nitrite levels within the aquarium water both become undetectable. Remember to continue monitoring your water parameters after fish are added to ensure that ammonia and nitrite levels remain undetectable.

- Exercise caution when cleaning your filter or replacing the filter media - Once we have taken the time and effort to establish a healthy population of beneficial bacteria within our filter, it is important to care for these bacteria when we clean our filters.



Otherwise, we risk killing all of the beneficial bacteria and causing the aquarium system to crash. Over time, detritus and other debris will build up within the aquarium filter and restrict water from freely flowing through it. When this happens the decreased flow rate is usually easily detectable by observing the filter indicating that the filter needs to be cleaned. If possible, it is best to establish a maintenance schedule that includes cleaning the filter before the water flow rate is significantly impacted. When cleaning your filter please

remember that chlorinated tap water can be toxic to beneficial bacteria. A common practice is to rinse the filter media with old aquarium water rather than chlorinated tap water. This will greatly reduce the risk of killing all of the beneficial bacteria within the filter during the cleaning process. Occasionally, the filter media will reach a point where it has to be replaced. Chemical filter media usually has to be replaced every few weeks to maintain its effectiveness. Mechanical and biological media can usually be rinsed when the filter is being cleaned and can last many months or even many years. Remember that beneficial bacteria grow on all of the media within a filter, not just the biological media and the last place we want to put all of our beneficial bacteria is the garbage! When it becomes necessary to replace some of the media within the filter it is important to not replace it all at the same time. This will allow the majority of the beneficial bacteria to remain within the filter when it resumes operation. Beneficial bacteria will quickly multiply and begin to grow on the new filter media provided that as much of the old filter media as possible is retained within the filter. Remember to monitor the aquarium water parameters after cleaning the filter or replacing some of the media to ensure that ammonia and nitrite levels remain undetectable.

Conclusion:

Aquarium filters play an important role in any aquarium system. These filters usually contain mechanical, chemical and biological media to keep our aquarium water clean and clear and our fish healthy. Understanding how our filters work and in particular how biological filtration functions helps us to better care for our aquariums, filters and fish. I hope that this article will help you to start and/or maintain a healthy and happy aquatic system.