

## Aquarium Filtration Guide

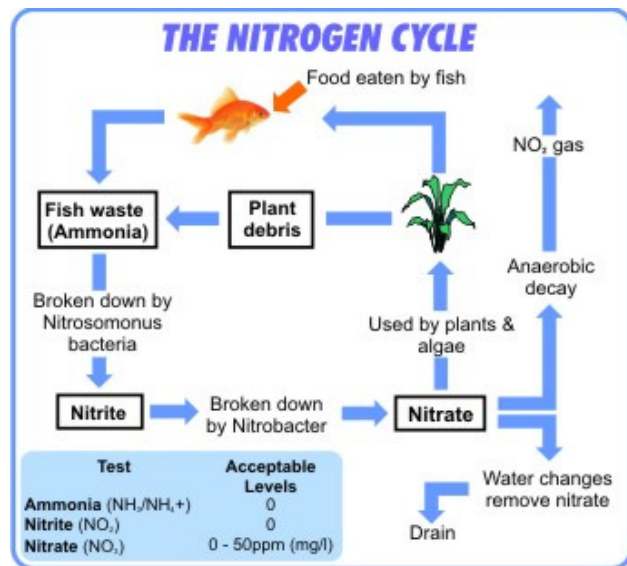
The heart of your aquarium is its filtration system. In the wild, fish waste, produced by breathing and eliminating, is diluted by vast volume of water and movement. In the aquarium, this kills your pets. Luckily there are many choices to ensure clean water and a healthy environment. Basing your decision on the size of your aquarium, as well as number of fish you hope to keep will help guide you to the best choice. To achieve the absolute best water conditions, **it's best practice to use more than one type of filter / filtration method.** Filtration is not a substitute for water changes. Think of filtration this way...even though your car has an oil filter, you still need to change the oil.

### *Filtration Methods*

There are many types of filters currently on the market that range in size, price, and their ability to perform the three essential types of filtration (mechanical, chemical, biological). A quick definition of each type is listed here:

|                      |   |
|----------------------|---|
| <b>• Biological:</b> | A culture of beneficial bacteria that consumes the solid waste and much of the ammonia; require a surface on which to colonize                                |
| <b>• Chemical:</b>   | Media used, such as bed of carbon or sand, alters the composition of water, removing toxins from the water  |
| <b>• Mechanical:</b> | Water is agitated to promote interface between the water and the air, pumping more oxygen into the water. Solids are trapped by filter until removed/cleaned. |

If filtration is the heart of an aquarium, then biological is the heart of your filtration system. Especially in a marine aquarium, you must have a biological filter **in addition to** one of the other two types. An average filter does not have enough biological support to process saltwater. The capacity of a biological filter is determined by the available surface area for bacterial growth and the oxygen content of the water passing over them. Toxic ammonia, which is produced by natural plant decay, fish waste, and uneaten food, is removed by nitrifying bacteria in the biological process. This type of bacteria consumes ammonia, processing it into nitrites, then into nitrates. (See “The Nitrogen Cycle” diagram. Credit: <http://koiorganisationinternational.org/?q=blog-entry/springtime-bioactivity.>)

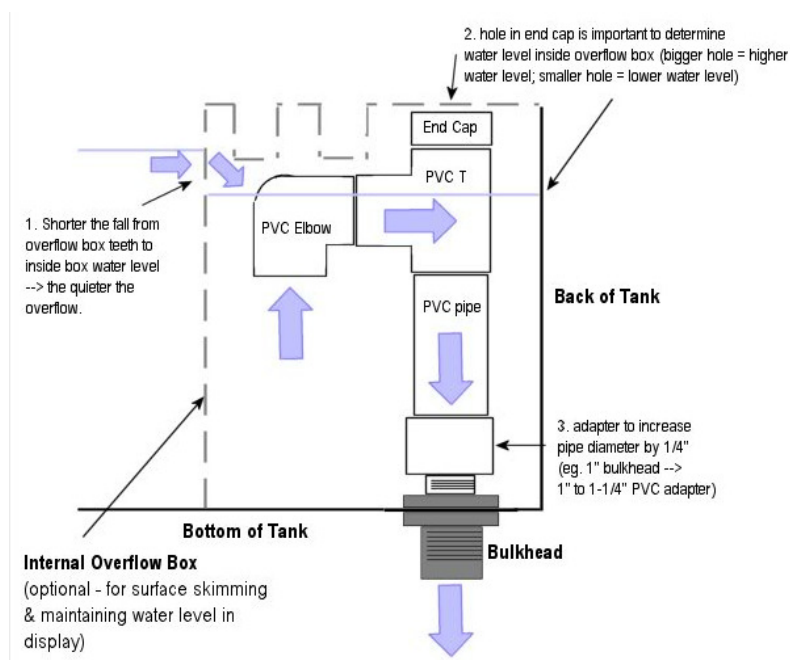


## Internal vs. External Filters

Filtration systems are primarily internal or external to the aquarium. Internal filters sit inside the tank whereas external filters sit underneath the tank in a cabinet, hang on the back of the tank, or can be built into the hood above the waterline. External filters are designed with a hermetically closed container connected to the aquarium by intake and exit pipes. They can be placed near the tank or under it, and usually are employed for bigger aquariums since they have stronger pumps.

I do not highly recommend an internal filtration system that is built into the aquarium. These are best suited for beginner hobbyists with a small aquarium (less than 50 gallons). They are difficult to clean, require supplemental filtration because they are not efficient, and does not allow for much equipment customization. Such aquarium systems sometimes use the entire back panel space. This doesn't allow much for room or water volume and the aquarium may have to be moved to correctly service it.

Alternatively, consider an aquarium with a built-in overflow. This option is available on aquariums 50 gallons in size or larger. Like other internal filtration systems, this design will use space inside the aquarium. However, the overflow box is only used to draw the water from the surface, and has the added benefit of removing the organic film on the surface of the water. In this design, two or more holes are drilled on the bottom of the aquarium inside the overflow box. Water overflows through the top of the overflow box, then drains down and through the drain pipe (usually a 1" pipe) that is sealed by the bulkhead. The bulkhead is used to seal the holes in the aquarium and helps channel the drain water through hard (PVC) or flexible vinyl hoses. Water is drained down to the filter, located below the aquarium which is concealed in the cabinet stand. In this design, there are two methods of filtration.



The drained water is then filtered by either a wet/dry filter or a sump tank with added biological support. Then, a return pump – either submersible or external – returns the filtered water back to the aquarium through a second bulkhead. This is a slightly more expensive option but one to seriously consider. If you want to graduate into a reef aquarium, this is the only option.

## *Filter Types*

### Undergravel Filters

Underground filters are the classic filters of the past. It is designed to sit in the base of the aquarium, between the glass/acrylic and substrate, such as gravel. Collecting bacteria that live on the gravel, the water is filtered as it passes over the gravel and up the lift tubes. (See pictured undergravel filter.)

If you choose this filter type, there are several considerations. First, choose the appropriate sized gravel. Too large sized gravel might not provide enough surface area for bacteria to saturate. Conversely, gravel too small may fall through the plate's open slots, causing anaerobic bacteria to develop. You will need a lot of gravel – 1 to 2 pounds per gallon of water (or 1 to 1.5 inches thickness).

Second, consider how you will move water through this filter's lift tubes. There are two methods for doing so. You can use a large air pump to drive air through the air stones and up through the lift tubes. As the bubbles raise up the lift tubes, it draws water through the plate and out the tubes. The better way to circulate water through this filter's lift tubes is to use powerheads, which are powerful water pumps that move water more efficiently. (Reverse flow is even more efficient.) The increased water flow allows more use of the gravel's surface area, while preventing anaerobic bacteria from developing. Third, avoid using heavy/excessive decorations or rocks as this will damage the undergravel plate. Live plants can also present a problem as their roots will grow into the plate, obstructing important water flow. In general, decorations and plants will cause this filter type to work harder, and thus, not as effective. It's important to maximize the surface area of the undergravel filter.

Proper maintenance on an undergravel filter is crucial to keeping your aquarium healthy. There are two keys to maintaining it successfully. First key is to also run a power or canister filter (to be discussed later) along with it. This will cover all three phases of filtration – biological, chemical, and mechanical. Secondly, many aquarists say the most effective way to clean this type of filter is to dismantle the entire aquarium, including removing the gravel to wash it. This is not only troublesome, but it may also kill beneficial bacteria that will be difficult to re-colonize. Alternatively, you can vacuum the gravel well once every three to four weeks, and perform a 30% water change. Careful not to vacuum too often, or conversely, not enough, as either might disrupt good vs. bad bacteria balance.

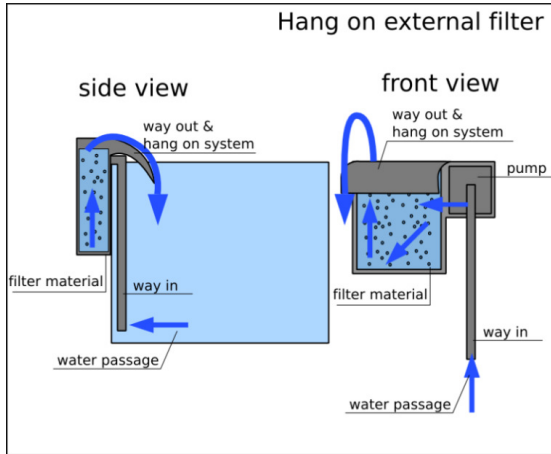
Overall, if you choose to use the undergravel filter due to its price effectiveness, you won't save much since you really need a plan B along with your plan A. Otherwise, aquariums utilizing undergravel filters tend to run higher nitrate and phosphate levels.



**UNDERGRAVEL FILTER**

This type of filter achieves both mechanical and biological (though not efficient) filtration, and some models have carbon cartridges to provide chemical filtration.

### Hang-on Power Filters



There are a few modern hang-on power filters that have enough biological support to process saltwater, along with mechanical and chemical support. This design incorporates biological wheels or grids for the added biological filtration. These units also include the pump necessary to draw the water into the filter and are completely self-contained. The aquarium water is pulled into the filter using a u-tube and flows through a cartridge or other type of filter material. Most models require filter cartridges, usually containing activated carbon, which

are designed for the specific model of filter. (See "Hang on external filter" diagram, credit: <https://en.aqua-fish.net/articles/internal-external-aquarium-filters-diagrams-forum>.)

Hang-on power filters are also an economical choice and good for the beginner aquarium hobbyist since they're easy to service. Again, choosing the appropriately sized filter for your aquarium system is important to ensure maximum water quality. Though it's not the best choice for a marine aquarium, if you choose this type filter, it's best to choose a unit that is significantly over-rated for your aquarium size. For example, a filter that is rated for 60 gallons should be used in a saltwater aquarium no larger than 30 to 45 gallons. The downside of using a power filter on a saltwater aquarium is due to the fact that these filters agitate the surface of the water, resulting in a large amount of salt creep which can damage your unit. Proper maintenance can prevent this.

Proper maintenance is also very important, because this is largely a biological filtration method. The biological wheels or grids should be rinsed in the aquarium water, **not** using freshwater in the sink. Doing so will kill your nitrifying bacteria. Designs using biological wheels are best since they provide excellent biological filtration thanks to the amount of air contact the water receives as the wheel spins. If your hang-on power filter employs a filter cartridge, keep in mind that these need to be cleaned/changed frequently as they clog quickly. You can lose important bacteria from the filter cartridge when it's changed unless you allow the new replacement to sit in the aquarium a few days before changing it out.

A final word about the power filter...it can be noisy and its motor is prone to breaking down. Make sure your water level is high enough to prevent your filter from sucking in air rather than water.

## Canister Filters

Canister filters are pressurized units that perform all three types of filtration. Available in two types – either a complete unit that includes its own pump, or in a modular form that requires an additional pump. The modular units are useful when combined with other types of filtration, such as a wet/dry filter (discussed below). The complete units use a u-tube as the water intake and typically a spray bar for the water return. The water entering the filter will first pass through a mechanical media such as floss and will then be forced through the chemical media such as carbon. After the chemical filtration is complete, the water then enters the last chamber containing the biological media where the nitrogen cycle is completed prior to the water returning to the aquarium.

Canister filters have become very popular choices for filtration. They have distinct advantages over other filter types. Point in case, they are housed underneath the aquarium in the cabinet stand, which leaves more room in the aquarium for fish and decorations. Without equipment in the aquarium, fish enjoy a more natural environment and less noise pollution in the water due to noisy hang-on filter motors. Since canister filters make little to no noise, they are a great choice for aquarium systems located in a bedroom – if you like to sleep!

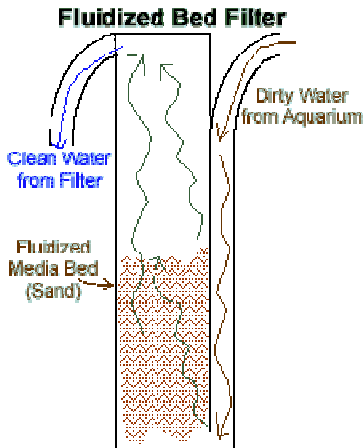


Another reason for the canister filters' popularity is they're low maintenance. On average, it needs to be serviced every six to eight weeks. Canister filters generally are larger than most comparable hang-on power filters and can hold a lot more and different types of media. If you need to convert a canister filter from freshwater to saltwater use, the process is easy – simply add as much biological media the canister can hold. Since saltwater is harder to process, canister filters are a powerful choice for marine systems.

When servicing your canister filter, remember to rinse the filter media in tank water rather than tap water so you can preserve the nitrifying bacteria. (Picture source: <https://reefbuilders.com/2013/05/24/canister-filters-cleaner-fish-tanks-2013/>)

### Fluidized Sand Filters

Looking for one of the most efficient ways to biologically process saltwater? Then, consider adding a fluidized sand filtration unit to your marine aquarium system. These systems are used commonly for commercial water filtration, and even in swimming pools and ponds. However, they are not commonly employed in aquariums, and it's a consideration the marine hobbyist should not overlook.



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(Picture credits – Diagram:

<http://www.firsttankguide.net/fluidized.php>;

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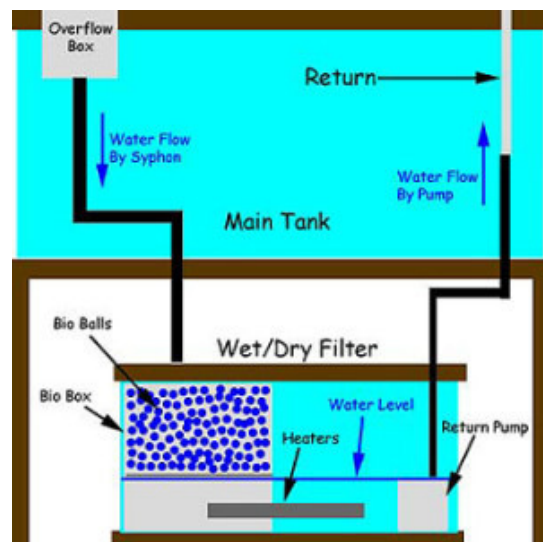
<http://www.americanaquariumproducts.com/FluidizedSandFilter.html>)

The fluidized sand filters have advantages and disadvantages. These are

relatively smaller in size and fit on the back of your aquarium. Filled with silica sand, there are numerous amounts of bacteria that live on each grain of sand. Saltwater is continuously pumped through the filter's sand, and does an efficient job. The steady flow of water keeps the sand moving, making it fluid like quick sand. Though these types of filters are relatively maintenance free, they are not trouble free. These filters can easily clog (use a pre-filter to avoid this) and back-siphon – especially during a power failure. Restarting them can be a nightmare. The greatest disadvantage to this filter type is that they consume oxygen from your aquarium. For this reason, make sure you also use a large or over-sized power filter, which will help restore the oxygen levels.

### Wet/Dry or “Trickle” Filters

The wet/dry or trickle filter primarily utilizes the biological filtration method, along with chemical and mechanical filtration. It does an outstanding job in the marine aquarium set-up, and are ideal for aquarium systems that are heavily stocked. Because this filter type is so large, it's kept underneath the aquarium, hidden away in the cabinet stand. In this location, it is easy to service. Be aware there are some trickle filters sold to hang off the back of the aquarium or built into it. These are not highly recommended because of the lack of accessibility to service the filter. Also, avoid



purchasing wet/dry filters that use a spray bar to return water to the main tank. The spray bars clog frequently.

Organic film build-up on the surface of your aquarium's water is not only unsightly; it is harmful to water quality. The wet/dry filter works to drain the surface water from the top of the aquarium surface from an overflow box. This box is either built-in (overflow aquarium) or it is usually included in the purchase of a wet-dry filter. Draining water off the top allows for only a certain amount of water to drain. This is very important since the wet/dry is an open filter and is also affected by improper water level, evaporation, and improper pump size. (See diagram at right. Credit: Randall Roberts, <http://howtocleanafishtank.net/choices-for-fish-hobby/wet-dry-aquarium-filters>)

The wet/dry filter is fairly easy to service but is priced at the top range of filtration options. Weekly rinsing of sponges and replacing the pre-filter pad on the drip tray are the bulk of maintaining this type of filtration system. Unless you are using an automatic top-off system, regular additions of fresh water need to be made to compensate for the water that has evaporated from the system. Because of the design of the overflow boxes, the water level changes in the sump, not the aquarium. It is important to monitor the water level in the sump area and not allow the pump to run dry, which may damage the pump.

As mentioned above, using an improper pump size can cause microbubbles which makes your tank foamy and cloudy, unnecessary noise, or improper flow rate which makes filtration less effective. To ensure the correct pump match-up, use the chart below as a quick reference:

| <i>Aquarium System</i>                | <i>Pump Size Needed</i> |
|---------------------------------------|-------------------------|
| 50 Gallons or less with one overflow: | 250-350 GPH Pump        |
| 50-90 Gallons with one overflow:      | 350-500 GPH Pump        |
| 100-180 Gallons with two overflows:   | 500-800 GPH Pump        |

Note that these pumps are pressurized, which means they can pump up a vertical path/flow. Do not use flow pumps, powerheads, which may flow a large volume of water but is not designed to pump vertically. Over sizing a pressure pump is acceptable, but not significantly large. Reducing pressure through a flow control valve is going to cause premature wear and excessive heat.

### Supplemental Equipment to Purify Water Health

While not mandatory, there are two devices I recommend to be used as supplemental equipment in your filtration system – a *protein skimmer* and/or an *ultraviolet (UV) sterilizer*. This is especially important in a marine aquarium to keep potentially major problems like parasitic infestations, bacteria, or algae blooms from becoming out of control.

### *Protein Skimmer*

Also called a foam fractionator, a protein skimmer removes dissolved organic compounds that if not removed can breakdown in the aquarium or filter adding to the biological load on an aquarium. Protein skimmers remove these pollutants completely from the water using air bubbles, powered by water or air pump, or both. As air and water are mixed in the skimmer chamber the bubbles rise and take with them the dissolved organics that are attracted to the bubble surface. When the bubbles with the proteins, amino acids and pollutants bubble up the tube into the collection cup they are completely removed from the aquarium. A protein skimmer typically catches harmful matter that conventional filtration cannot remove.

The first time you clean out the collection cup and see (and smell!) the waste you've prevented from entering your environment, you know you will have made the best decision to add this for your fish. Once you go to purchase a skimmer, you will have sticker shock – but you will also notice there are many types (co-current, counter current, downdraft, Venturi, needle wheel, spray induction). The differences in these types have to do with how the water/air mixture is created to form the bubbling action. Air pump-driven skimmers are usually not as efficient as water pump-driven ones. I recommend the Venturi skimmer as it is generally the most efficient because it passes more water through the unit.

There are also different configurations in skimmers – in tank, hang-on back, and sump models. Like pumps, they are rated according to the volume of water they process per hour. Also like pumps, it is better to over-size your skimmer. For example, a skimmer that is rated up to 100 gallons should not be used on any aquarium larger than 75 gallons. For reef aquariums, over-sizing should be even more dramatic. But do you really need a protein skimmer in a fish-only tank? Let me underscore the importance of filtration again. Any device, be it biological, chemical, or mechanical, that will improve your water quality should be added to your aquarium.

### *Ultraviolet (UV) Sterilizer*

The UV Sterilizer is a good “piece-of-mind” device for the serious aquarist to consider. Ultraviolet light is very intense and harmful to human eyes. However, it is a beneficial weapon in your aquarium system against algae, minor bacteria, and fungal diseases. It also destroys a good bit of parasites as water passes around the light. An important disclaimer...the UV light kills water-borne pollutants and not free-floating ones. While this device does not keep problems like these from happening, it will help reduce the intensity of the problem.

The UV sterilizer can be made more effective by ensuring you have the right amount of water flow through it. Either too heavy or not enough water flow will reduce the kill ratio with maintenance needed every 6 to 8 months. During maintenance, check all wiring, connectors, O ring seals, and replace the bulb to maximize its effectiveness.



I hope this segment has helped you make sense of such a tangled topic. There are as many opinions about filtration as there are choices. However, if you take away the important ideas behind filtration, you will be sure to set-up an environment that is hearty and healthy. The most important idea is to layer your options, using as many types of filtration (biological, mechanical, and chemical) as possible. Remember that filtration **does not** replace the need to perform water changes, but proper water flow through a filtration system will make it more effective so you can change out less water.

Author: Jim C. Chu, *Senior Aquarist* at ProAquariums (August 2016)