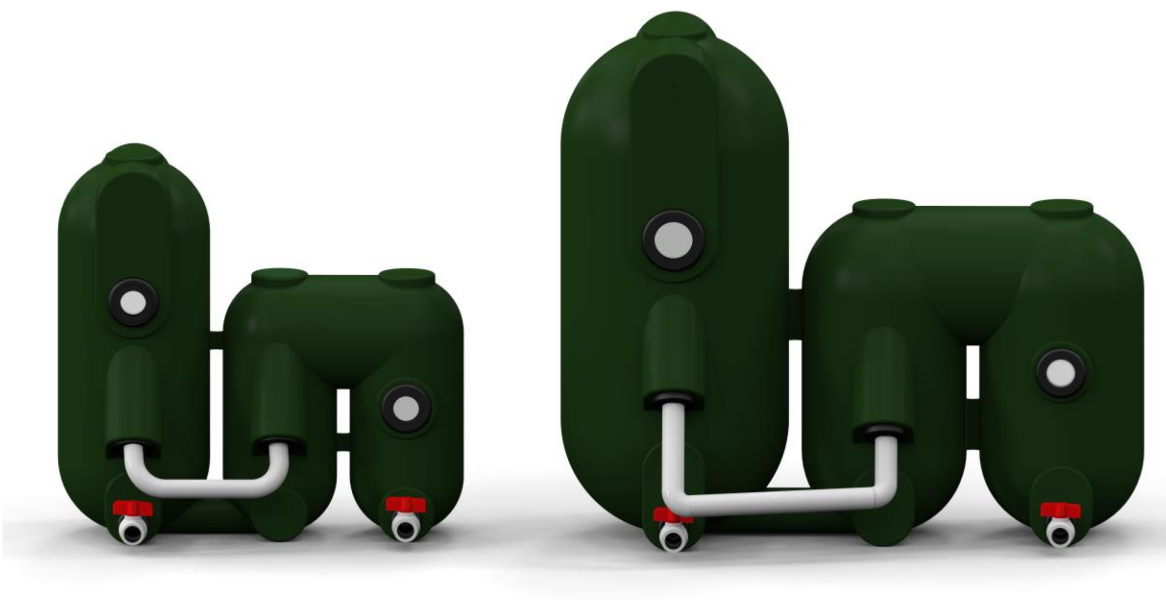
ENDURANCE SERIES



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Updated 3/29/2016 V4-AST

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Introduction to the AST Endurance

The AST ENDURANCE™ Bead Filter is the new addition to Aquaculture Systems Technologies' line of bead filters. This technology is a radical improvement on the Polygeyser® line and has been designed for long lasting, hands off operation. The auto-pneumatic backwash paired with auto sludge removal enables this filter to operate for extended periods of time without intervention.

Patented: US Patent 9,227,863 —— Patent Pending —— Canadian Patent CA 2287191 European Patent EPO European Patent EPO 977713

Like our Polygeyser® filters, these units are "bioclarifiers" capable of performing both biological and mechanical filtration. AST ENDURANCE™ Bead Filters are capable of handling biological loads 50% to 100% higher than our Bubble-Washed or Propeller-Washed Bead Filters equipped with standard bead media. Additionally, the AST ENDURANCE™ Bead Filters offer a very high degree of reliability and are virtually immune to clogging and caking, since they backwash automatically without moving parts or electronics.

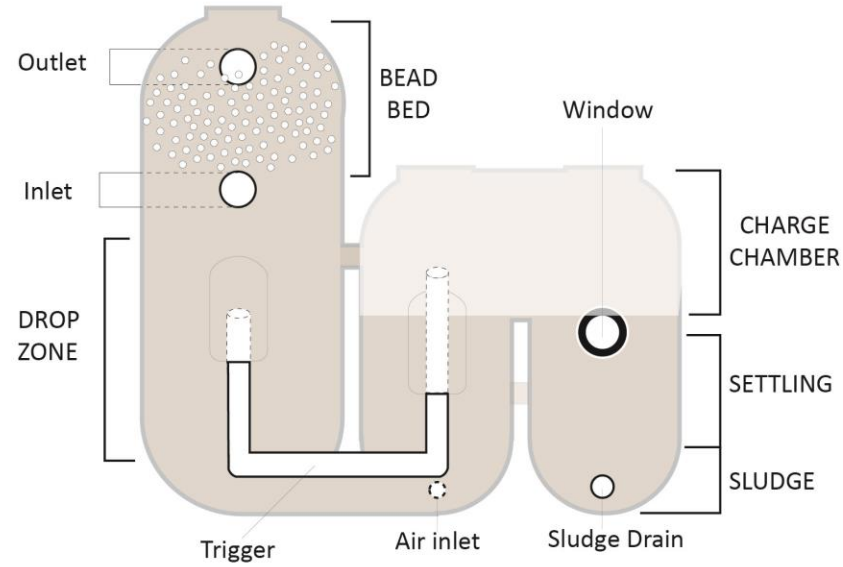
The elimination of water loss associated with backwashing is a key element in this new technology. In most applications, dozens of backwash sequences can be automatically executed before sludge removal is required. There is no water loss associated with the backwash process and the water loss associated with sludge drainage is negligible. This strategy is particularly advantageous for marine systems, where the loss of saltwater is minimized. This reduces or eliminates the need for large backwash water treatment units to reclaim saltwater since the water recycling happens within the filter.

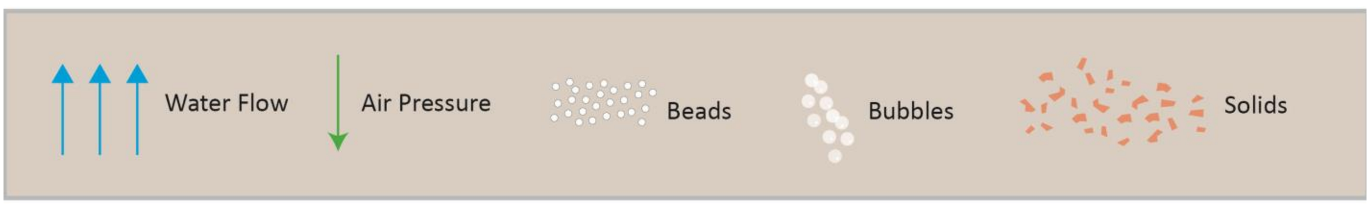
The pneumatic strategy breaks the linkage between backwash frequency and water loss and allows the nitrification capacity of the unit to be fully utilized. Frequent backwash sequences have proven advantageous for optimizing the nitrification capacity. Numerous gentle scrubbing cycles promote high rates of nitrification by maintaining a healthy thin biofilm on the bead surfaces. Typical backwash cycles occur once every three to six hours. In recirculating bioclarifier applications, where the AST ENDURANCE™ Filter operates concurrently as a clarifier and biofilter, total ammonia nitrogen (TAN) levels below 0.3, 0.5 and 1.0 mg-N/l can be expected at feed loading rates of 0.5, 1.0 and 1.5 pounds feed per cubic foot of EN bead media (8, 16 and 24 kg-feed m^{-3} day^{-1}), respectively.

Endurance Backwash Operation: Standard Configuration

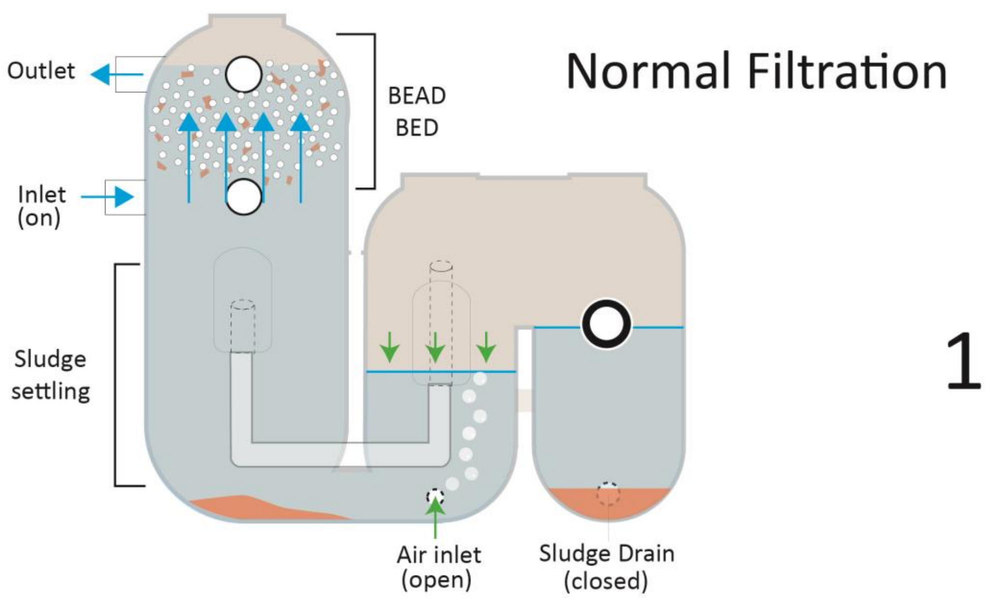
These exceptional filters backwash automatically, several times a day. The user does not need to turn off the pump or close any valves during the backwash sequence and no electric timer is required .The backwash cycle is regulated by the air that is injected into the charge chamber. The AST ENDURANCE™ cleans and recycles the dirty water produced in backwashing every two to three hours. Sludge is only removed once or twice a week. Consult this manual to take advantage of the fully automated options your new, advanced Polygeyser® Endurance Filter can provide.

Endurance Series



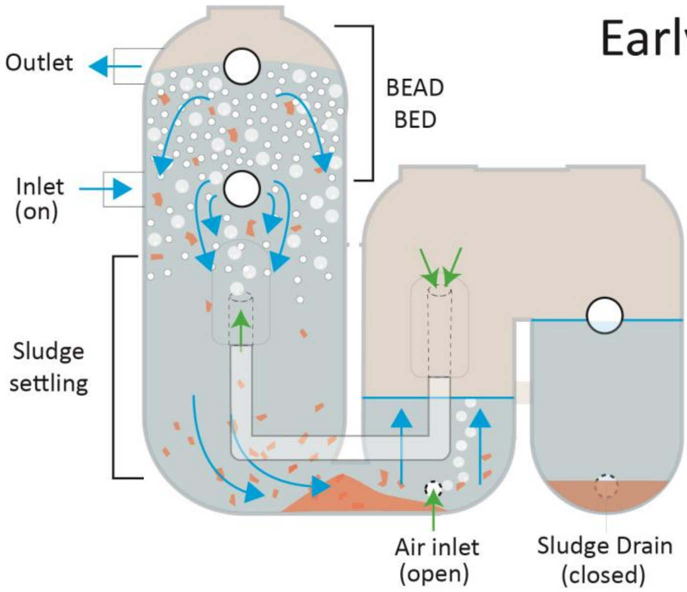


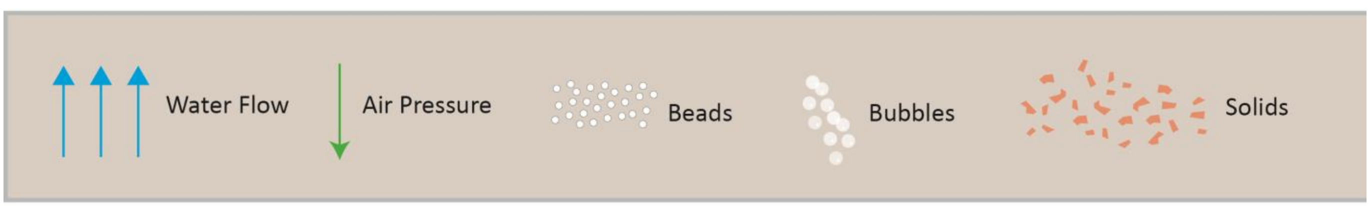
Normal Filtration



Early Backwash

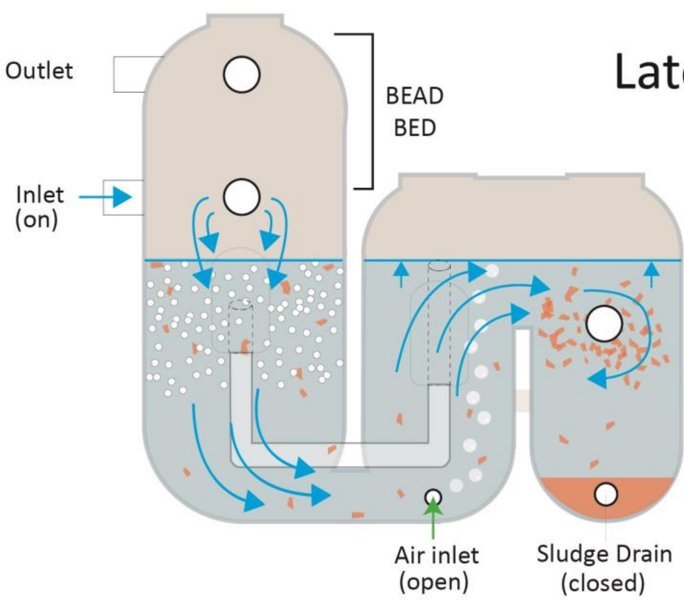
2





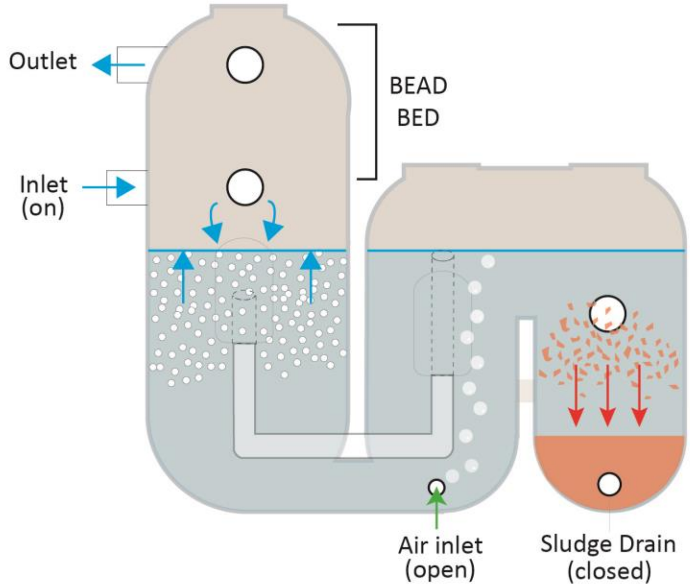
Late Backwash

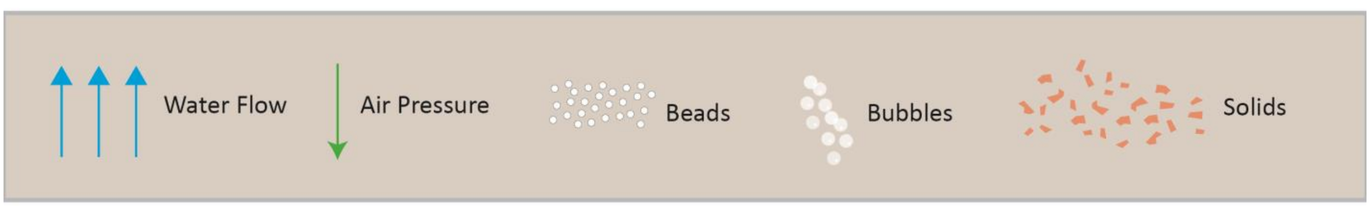
3



End Backwash

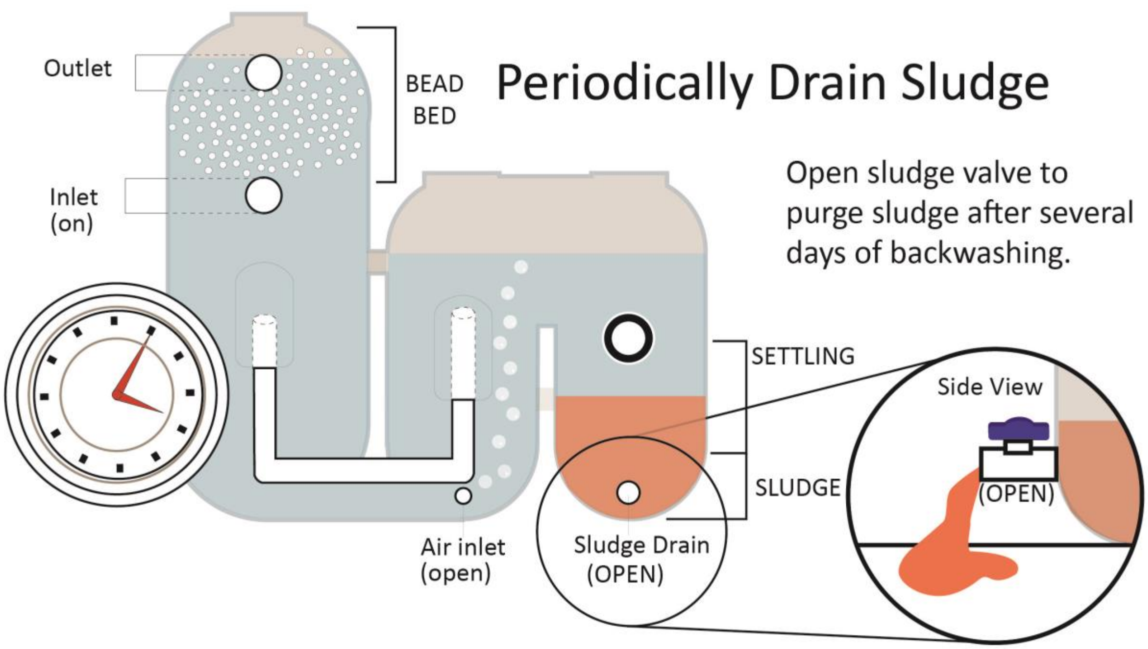
4





Periodically Drain Sludge

Open sludge valve to purge sludge after several days of backwashing.



Normal Filtration

The water moves from the inlet up through the bead bed. The bead bed provides surface area for the water purifying bacteria and captures solids within the aquatic system. Air is slowly injected into the charge chamber, gathering in the top of the filter. As more air enters, this places downward pressure on the water level. The water level drops trapping water in the settling zone, and solids from the last backwash settle into the sludge basin. The rate of air injection controls the length of time between backwashing events.

Early Backwash

Air has made its way through the trigger into the bead bed. The bubbles agitate the beads; knocking solids and biofilm off the beads. As the air pressure in the charge chamber drops, the dirty water from beneath the bead bed sweeps through the chute carrying the solids into the adjacent compartment. No water flows out of the filter during the short 3-5 second backwash event; instead the dirty backwash water is captured in the charge chamber and the sludge basin. The beads float in the drop zone where they continue to be scrubbed by the escaping bubbles.

Late Backwash

The water flows downward through the mixing bead bed and more solids are washed from the beds to settle towards the bottom. The downward flowing water sweeps into the middle compartment, flushing the solids that have accumulated on the bottom of filter and depositing them into the sludge basin. The water level rises in the shorter chambers.

End Backwash

Eventually the water rising in the sludge chamber floods the trigger, bringing water movement in the charge chamber and sludge basin to an end. Trapped solids begin to settle as the filtration chamber is refilled with the water from the inlet. The beads float back in place to reform the bead bed. As soon as the water rises to the outlet, filtration resumes. At the end of the backwash, the beads rise back to the top of the filter. Most settled solids have been swept to the sludge chamber.

Periodically Drain Sludge

The filter will continue to filter and backwash itself several times a day. After the sludge has built up, the user can open the sludge valve to drain the concentrated sludge from the filter. The filter backwashing frequency is usually set for a few hours, so the filters will backwash several times a day. Sludge accumulates in the sludge basin. Every few days, perhaps once a week, the sludge drain must be opened to let the sludge out. A natural fertilizer, the sludge can be poured out on the lawn or nearby plant where it will naturally degrade.

Limit the sludge volume to one gallon to prevent bead loss.

Plumbing Configurations

The AST Endurance™ can operate using a water pump for circulation and an air pump for backwash, or with just air pumps in an airlifted configuration. To run off of an airlift, your tank water level has to be at least six inches above the top of the filter. If this is not possible, use a water pumped configuration.

Standard Pond Configuration with UV sterilizer: Water Pumped

Water is circulated through the filter using a water pump (not pictured). Water goes through the filter and out the top. This cleaned water can be directed through a UV for clearer water, or can go directly back to the tank or pond. Installation of a valve between the pump and the filter is recommended to allow for flow control.

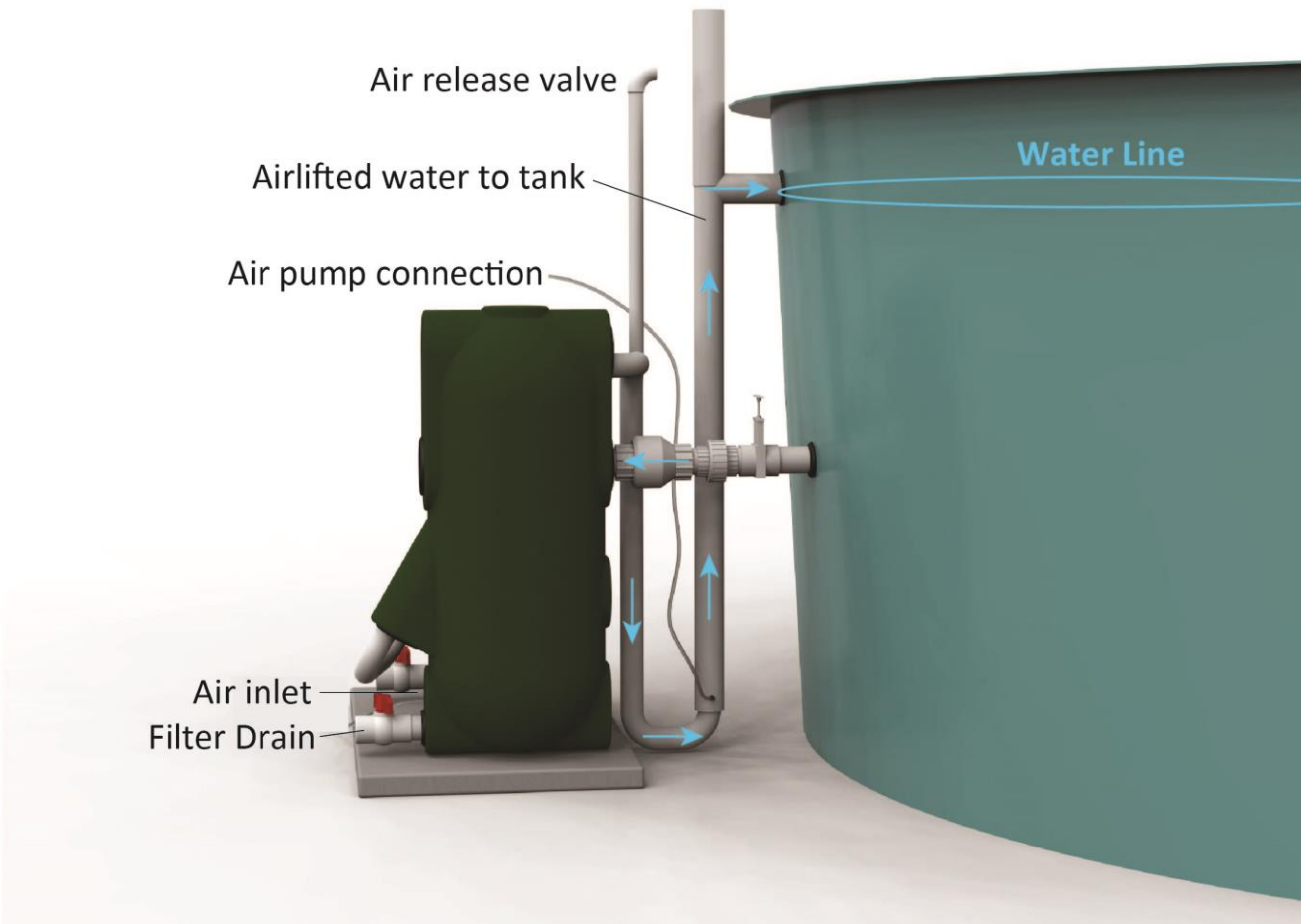
Exceeding the recommend flow rate can result in fluidization of the bead media. If this occurs, simply throttle back the flow until the beads are no longer fluidized. If the beads are fluidized, they will not capture solids or backwash properly, resulting in reduced water quality.

The elbowed long pipes at the top are air releases to keep air pockets from forming. The clear tube shown in the diagram runs to a water pump (not pictured). The water pump moves water into the inlet, the lower opening on the large filtration chamber. A check valve should be installed (brass check valve pictured in the above illustration to relieve backpressure on the system. Failure to install air release valves could result in over pressurization of the Endurance filter. **Over pressurization caused by improper installation or operation will void the warranty.**

The AST Endurance ™ is designed as a low-head filter. Operating pressure should therefore not exceed 5 PSI. Installation of devices causing excess backpressure on the discharge side of the filter should also be avoided. See *Water Pumped Units: Recommended Air and Water Pump Pairings* for suggested equipment.

Airlift Configuration

For tanks whose water level is, at minimum, six inches above the top of the filter. Air is injected into the bottom of the U pipe coming out of the filter. The bubbles lift the water back into the tank without the use of a water pump.



Installation

The AST Endurance™ is designed to accommodate two different operational configurations, i.e. **Air Lift** and **Pump** flows.

1. Prepare your filter's location. The AST ENDURANCE™ should be installed on a level surface. The top of the filter should be at least 6 inches below the water level if using an airlifted return.

2. Connect a return pipe, not provided, to the union at the top of the Endurance filter to run the clean filtered water back into the tank. See *Configurations* to set up an airlifted or water pumped system.

3. Attach air supply line to the ¼" barb connector. Install the air pump above the water level to prevent flooding in case of power shortage. We also recommend the installation of a check valve in this line to prevent back flow of water into the air pump, which can present an electrical hazard.

4. If you do not want to drain your filter directly onto the ground, you can place a bucket under the drain valve, or run a PVC line to wherever you want the sludge to drain. The sludge can be used as fertilizer for plants. See *sludge removal options* for more details.

5. Fill the tank or pond, set the air on high for the first 24 hours, and let the system circulate. Check all your connections and fix any leaks in your plumbing.

6. Adjust your air flow down, so that the filter only backwashes 4-6 times a day. You may require more frequent backwashes for high loading, or reduce it for a very lightly loaded system. More air means more frequent backwashes.

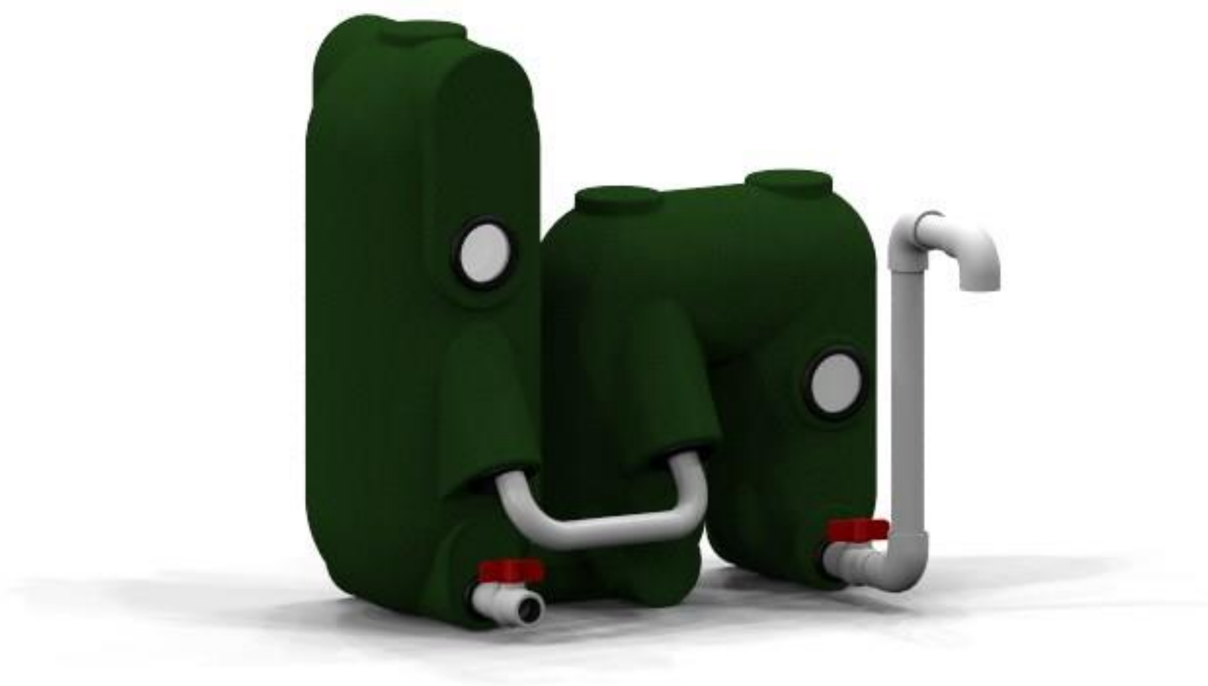
7. The provided valve on the inlet of the filter should be closed when the system is off, or when the tank is being drained. Beads can be forced out by the backwash or siphoned out when the tank or pond is drained too low.

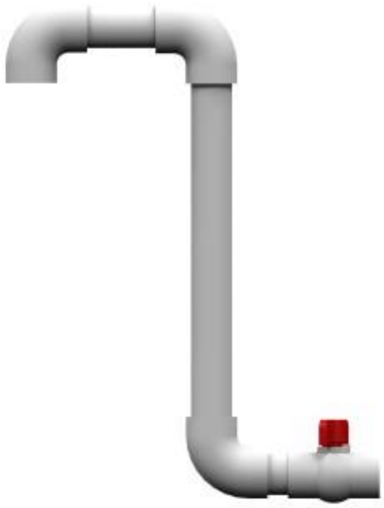
Sludge Removal Options

Raised Bucket Drain: Manual Operation

To drain sludge unto a standard 5 gallon bucket, a few lengths of pipe and three 90° degree elbows can be used to increase the drain height to so that the sludge can easily be drained into a bucket placed on the ground. You can now transport the sludge to plants requiring fertilization, or dilute it to make 'compost tea' to water your plants. This pipe should stand as tall as the shorter chambers on the filter.

Limit the sludge volume to one gallon to prevent bead loss.





Parts:

QTY 3 - 90 degree ball valves. Slip by slip

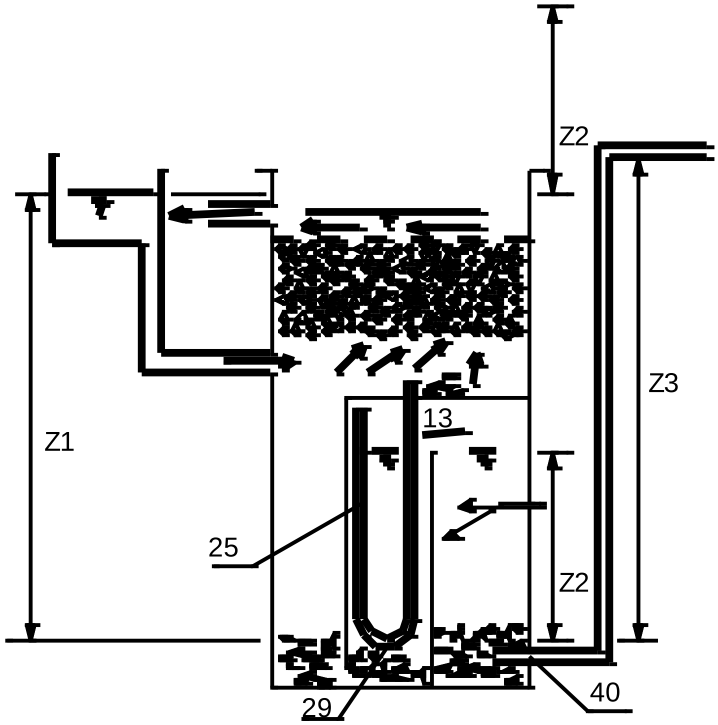
Length of PVC tubing

Ball valve included with filter

Pneumatic Sludge Discharge

A pneumatic sludge discharge dispenses sludge out of the system when the filter completes its backwash cycle. The height of the pipe above the filter determines how much sludge will be removed. Any system allowing for adjustable height will let you regulate the amount of volume purged during each backwash. The sludge can be collected into a bucket, sent to a garden, or down the drain.

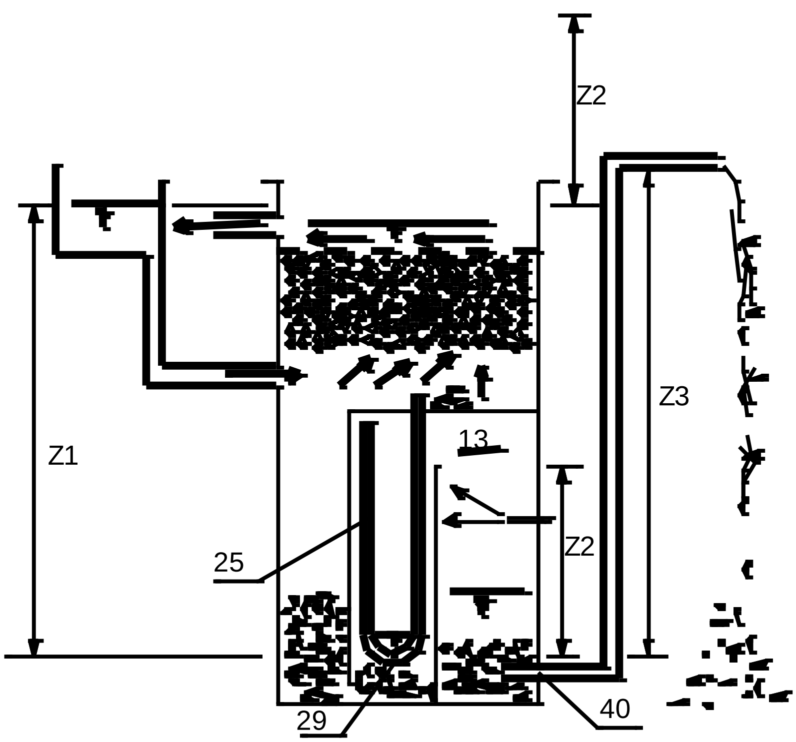
This is similar the bucket drain option, only with a higher pipe (taller than the highest filter chamber) and adjustable height options. The simplest height adjustment is to be able to pivot the assembly- making the height higher or lower, diagonally. This can be achieved with a few threaded pieces.

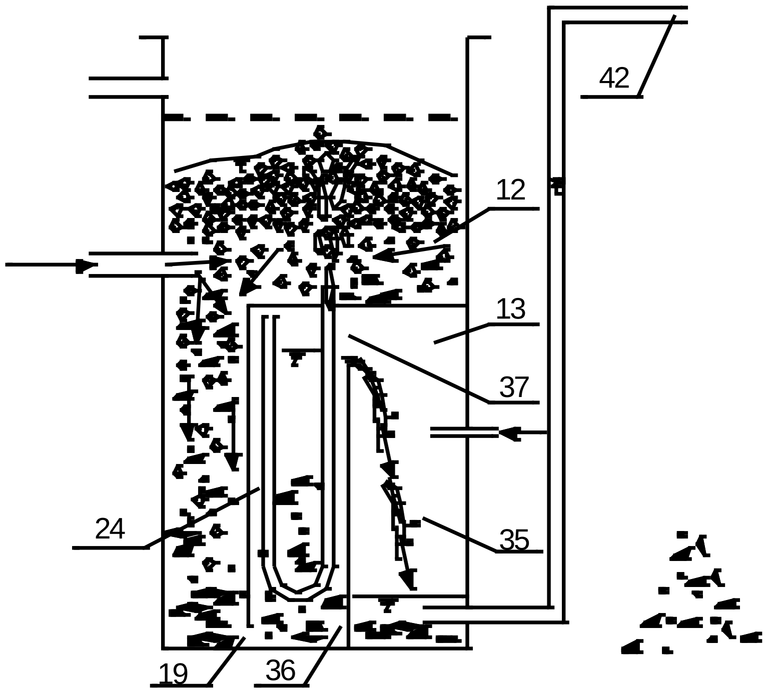


$$P_{13} = Z_1$$

$$P_{40} = P_{13} + Z_2 = Z_1 + Z_2$$

If $Z_1 + Z_2 > Z_3$ *then Sludge will spill as* P_{13} *increases*

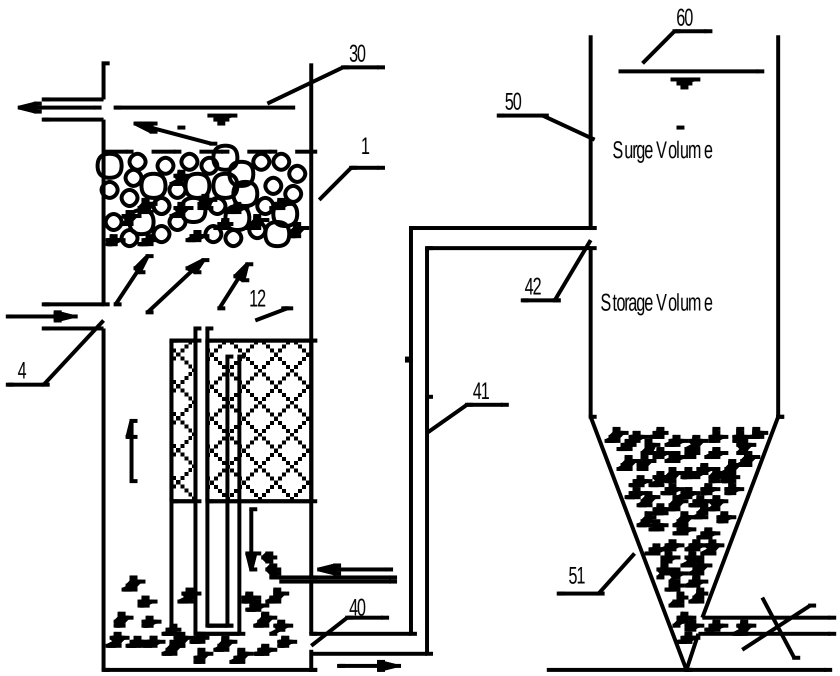




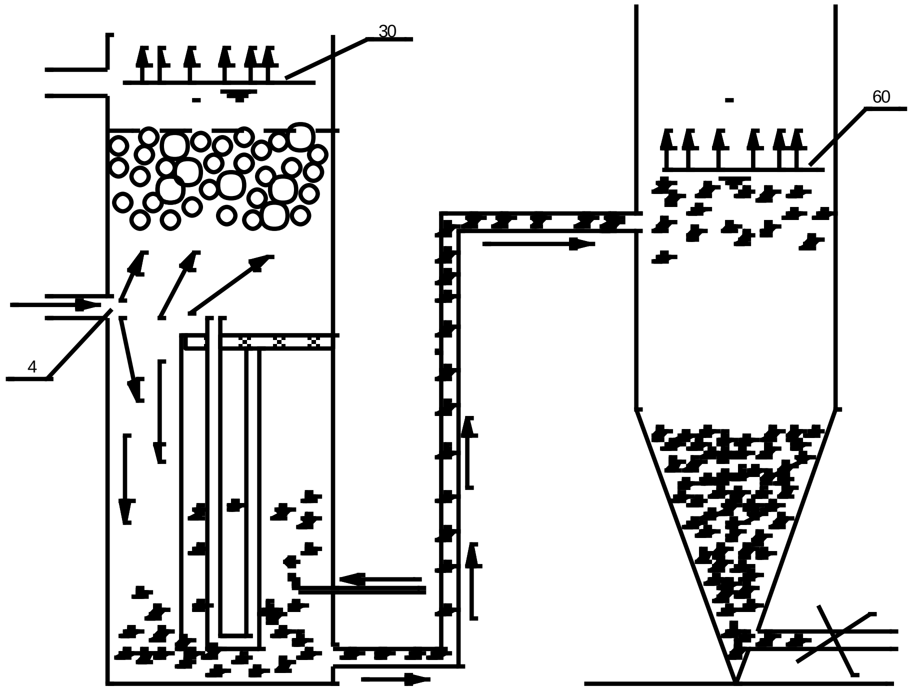
Pneumatic Sludge Discharge for Water Pumped Systems

These would be installed in the same manner as the regular pneumatic sludge discharge with the addition of an air release to regulate pressure. Failure to install these correctly can result in over pressurization of your filter, voiding the warranty and possibly breaking the unit. The installation of a bypass to control air pressure is simple and protects your filter and equipment. A pipe that stands six inches above the filter, or an air release valve can be used. This is installed on outlet pipe that runs back to the tank. See *standard pond configuration with UV* for plumbing details.

Pneumatic Sludge Exchange



The Polygeyser® filter (shown on the left in the diagram) is connected to an external reservoir such as a tank or sump. When the trigger fires, clarified water on the top of the external reservoir is drawn back into the system. At the end pf the backwash, the sludge from the filter is forced through the connecting pipe into the external reservoir. There, the sludge settles to the bottom and clarified water inhabits the upper level of the reservoir. This clarified water is the exchange water that is pulled into the filter during the exchange sequence.



It is important to drain the external reservoir periodically as a buildup of nitrites and nitrates will occur as the wastes breakdown. The advantage of this system is that it maintains a consistent water level in the culture system even as solids are being purged from the system.

Water Pumped Units: Recommended Air and Water Pump Pairings

In selecting an appropriate air pump for the system, the air flow capacity (scfh or lpm) required to effect backwashes at the desired intervals as well as the air delivery pressure must be taken into consideration. When the filter is operated with a water circulation pump, the air delivery pressure must exceed that of the water pump to prevent accidental flooding of the air pump, which may present an electrical hazard. For this reason, the selection of air pump is ultimately dependent on the selection of water pump in water pumped systems. A check valve should be installed in the air line to prevent flooding of the air pump in the event of a power outage and to protect the air pump in case of excessive pressure development in the filter.

Install the air check valve on the air line before the air pump. Air can exit through the check valve. In the case of failure, the check valve will close so that water cannot flood the pump.

We recommend using an air pump capable of producing the most frequent backwash intervals that may be required. The flow rate can then be regulated by installing an air flow meter, with a built-in regulating valve. AST offers an air flow meter kit known as a SUFLOWKIT which includes an acrylic 1- scfh flow meter, aluminum mounting bracket and two ¼” barb fittings. If using a LUFT Air pump, you can adjust the air flow using dial directly on the pump, and the use of a SUFLOWKIT can be avoided.

Because of the danger of improperly selected water and air pumps, we have recommended pumps that work well with one another for Endurance applications. Please consult the tables below. **Failure to use appropriately sized air and water pumps can result in damaged air pumps and hazardous electrical situations. AST is not liable for any harm or damage caused by improper installation or sizing.** Incorrectly sized and/or installed units void the warranty.

Endurance 2000

Air Pump	Air Flow	Water Pump	Water Flow
LUFT Air Pump TL5	.05cfm@3 PSI	**Performance Pro: C1/8-22**	**15 GPM @14'**
		MDM: 3600SEQ12	**15 GPM@ 10’**

Endurance 4000

Air Pump	Air Flow	Water Pump	Water Flow
LUFT Air Pump TL5	.05cfm@3 PSI	**Performance Pro: C1/8-36**	**35 GPM @ 10’**
		MDM: 3300SEQ21	**35 GPM @14’**

Airlifted Units: Recommended Air Pumps

The Polygeyser® units have a charge chamber that must fill completely with air to trigger the backwash event. An underpowered air pump will not backwash the unit frequently enough to sustain ideal water quality. These air pump recommendations are not for systems using a water pump for circulation within the system. See Water *Pumped Units: Recommended Air and water pump pairings* for water pumped configurations.

We recommend using an air pump capable of producing the most frequent backwash intervals that may be required. The flow rate can then be regulated by installing an air flow meter, with a built-in regulating valve. AST offers an air flow meter kit known as a SUFLOWKIT which includes an acrylic flow meter, aluminum mounting bracket and two ¼” barb fittings.

Airlifted systems operate at a very low head. Several commercially available air pumps are capable of delivering the required volume and meeting the pressure demands for a single unit. Some recommended air pumps include:

MODEL	Air Pump	Air Flow
Endurance 2000	**ALITA AL-80**	**3 cfm@ 2.13**
Endurance 4000	**ALITA AL-200**	**MDM: 3300SEQ21**

Listed air pumps are for minimum required airflow to airlift at designed flow rates. If you have a larger system or specialty application, please consult with AST sales or technical staff for assistance.

Another option is to use small oil-less air compressor with a storage tank and built in pressure regulator. The storage tank will provide improved overall stability and means the air compressor does not run continuously. Additionally, the pressure regulator allows you to set the air output pressure so that it will be greater than the pump output pressure at all times. We also recommend this set up for operating multiple units. Sears, Home Depot and Lowe's all sell these types of portable air compressors. A possible disadvantage of using an air compressor is the sound produced when the compressor turns on to re-fill the storage tank.

The size of the compressor depends on the number of units you wish to backwash. A portable air compressor, which stores air in a tank at 90-100 psi, holds approximately 1.1 ft^3 (8.2 gal or 31 L) of air per gallon (3.8 L) of tank storage space. We recommend you choose a compressor with a tank volume of at least 8 gallons (30 L) per filter. The estimated time between successive compressor operations using a 8 gallon storage tank is approximately 30 minutes and the relationship seems to be linear so that an 16 gallon tanks runs only once per hour. Note the time between compressor operations is approximate and may vary depending on a number of conditions including compressor manufacturer, temperature, and elevation above sea level. Note: a larger tank storage volume is always better and simply means your air compressor will run less often to keep the tank full

Replacement Parts

Description	Part No.
Endurance 2000 Air Trigger Assembly	
Endurance 4000 Air Trigger Assembly	
1" Uni-Seals	
1 1/2" Uni-Seals	10106
2" Uni-Seals	

3” Uni-Seals	
1” Ball Valve	
1 ½” Ball Valve - Endurance 2000 Intake	
2” Ball Valve	
¼” npt x ¼” barb air inlet fitting (polyethylene)	TE2044P
3” to 2” Reducer bushing for Endurance 4000 Inlet	
1” union – Endurance 2000	
2” union – Endurance 4000	
Enhanced Nitrification (EN) Bead Media	BEAD-ENMEDIA2
External Plumbing Kit - Airlift	
External Plumbing Kit - Pumped	
Endurance 2000 Suflow Kit	EN2K-SUFLOWKIT
Endurance 4000 Suflow Kit	EN4K-SUFLOWKIT

Troubleshooting

Elevated Nitrite (NO_2) Levels

- Elevated levels of Nitrite may occur if the dissolved oxygen concentration in the effluent leaving the filter drops below 2 mg/l. Low DO concentrations leaving the filter can often be solved by increasing the dissolved oxygen levels in the tank/pond or through increased aeration or by increasing the flow rate through the filter.

- Elevated Nitrite levels may also occur if your total alkalinity (as $CaCO_3$) drops below 80mg/l. We recommended you maintain your alkalinity at 100-200 mg/l as $CaCO_3$ at all times. If you experience low alkalinity, simply add baking soda to the filtration system periodically to maintain proper levels. Sodium bicarbonate is not suitable for aquaponics applications because sodium can harm plant development and growth. Applications of different liming agents, such as potassium hydroxide (KOH) and Ca(OH)2 are recommended for balanced plant growth.

- Elevated Nitrite levels can also occur from over washing the bead bed. If the flow rate, effluent oxygen and alkalinity are satisfactory, the backwash frequency can simply be reduced. This situation typically occurs when you go from periods of high loading and frequent backwashing to periods of reduced loading but still maintain frequent backwashing.

- Although generally the nitrification can be achieved across a wide ban of backwash intervals, backwashing for cold water systems must me more carefully managed. Generally, backwashing should be limited to a low frequency (<1 day) for cold water applications. The reduced frequency allows more time for the slow growing NOBs to recover from backwashing biofilm damage.

Low Effluent Dissolved Oxygen

- Low Effluent Dissolved Oxygen concentrations are usually the result of too low a flow rate. Effluent D.O. concentrations should be maintained above 2 mg/l at all times. If you are not flowing water through the filter at the filters maximum flow rate, simply increase the flow through the filter.

- Or you can increase the amount of aeration in the tank or pond to increase influent D.O. concentrations which will usually result in increased effluent D.O. concentrations.

- Low DO concentrations may also occur if the backwash frequency is set too low. If the bead bed is allowed to clog, reduced flow and effluent oxygen concentrations will occur, which will affect the nitrification performance. Please refer to “Backwash Frequency” section for recommended backwash frequencies at various feeding rates.

- Low D.O. concentrations can also result if you do not remove sludge and waste from the filter often enough. The sludge should be drained every week minimum, to prevent excessive oxygen consumption by the activity of heterotrophic bacteria.

- Low dissolved oxygen levels in the filter effluent can also be caused by low dissolved oxygen in the influent (or fish tank). Filter sizing is generally based on the assumption that the influent dissolved oxygen concentration is between 5-6 mg/l. Increase the aeration in the tank or consider operation the filter in a recirculating format with a well aerated sump.

- In the some application the organic content (BOD) of the influent water is so high that the heterotrophs consume all the oxygen. In this case, the backwash frequency can be raised to increase the flowrate through the filter as the biofilm is more quickly removed. This procedure reduces the filter's organic loading because the bacterial biofilm is removed before it can fully respire. Filter oxygenation is improved by the higher flowrate.

Pressure Loss/Reduced Flowrate

- The most common cause of a drop in flowrate though an Endurance model is clogging of the bead bed because the backwash frequency is too low. Clogging can occur because of an accumulation of suspended particles or from excessive biofilm growth. To overcome this problem, simply increase the air flow to the charge chamber to trigger a more frequent backwash cycle.

Acclimating your Filter

Development of a biofilm layer on the media is required for biofiltration. The bacterial culture, which grows attached to the beads, performs the biochemical transformations that are so critical in the purification of recycled waters. Initially the biofilter has no bacteria and the culture must be started. The process of growing the initial bacterial culture in the biofilter or adjusting an established culture to a change in loading is called acclimation. Fortunately, the process of biofilter acclimation is easy. It just takes a little time and food for the bacteria.

The best way to acclimate a recirculating system with a biofilter is to just add a few hardy fish, turtles, or mollusks to the system and start to feed them. The total suspended solids in the system will pose no problem because bead filters capture solids primarily by physical processes that are not dependent on the development of a biofilm. The heterotrophic bacteria will grow rapidly and quickly attach themselves to the beads, so BOD accumulation should pose no problem. The nitrifying bacteria, however, are very slow reproducers and may require almost thirty days under warm water conditions (2 - 3 weeks is more typical) to establish themselves.

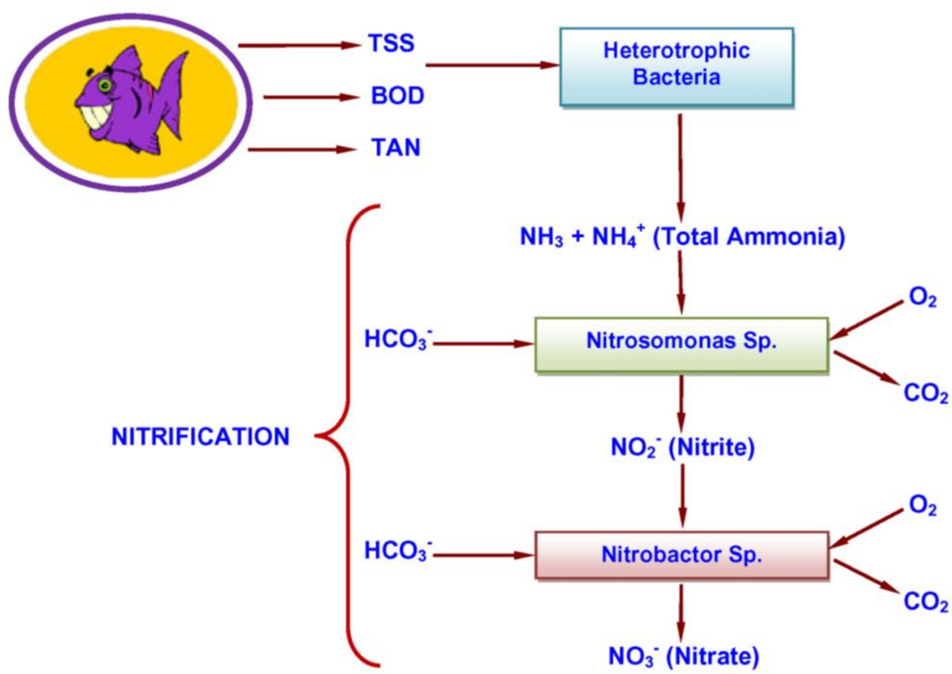


Figure 3 Two specialized types of nitrifying bacteria convert toxic Ammonia and Nitrite to the relatively safe Nitrate. Bicarbonate ions and oxygen are required in large amounts.

During acclimation, the backwash frequency of your *PolyGeyser* filter should be 1-2 backwashes per day. This will keep the bead mixed and promote homogenous growth of nitrifying bacteria throughout the bead bed.

Figure 4 illustrates the classical pattern of TAN (total ammonia nitrogen) and nitrite concentrations observed during filter acclimation with animals. The process starts with an increase in TAN concentrations. This indicate that the first group of nitrifiers responsible for ammonia conversion to nitrite are present in large numbers when the ammonia excreted by the fish stops accumulating and suddenly (within 36 hours) drops to near zero levels. At the same time there will be a sudden rise in nitrite levels, followed by a gradual increase which will continue until suddenly the second group of bacteria, Nitrobacter, catch up with their new food supply and the nitrite concentrations plummet. The filter is now considered acclimated to a light loading. This initial stage of acclimation is critical because during this period populations of bacteria which can effectively attack the specific waste produced by the animals become established and these bacterial populations adjust to operate under the water quality conditions and temperature regime found in your system. This unique culture of bacteria will remain in the biofilter for years if it is just treated with a little common sense.

Table 3 summarizes things you can do to accelerate the initial acclimation of the bead filter. These procedures can reduce acclimation time to as little as two weeks in a warm freshwater system. One of the principal limitations of acclimating a filter with animals is that little or no nitrite is available for the growth of Nitrobacter until the Nitrosomonas population has become established. This means that the very slow growing Nitrobacter cannot even get started for over a week. Therefore, you can simply reduce the acclimation time by adding nitrite at the start. The acclimation process becomes moot if you have an acclimated bead filter on your premises. Just exchange a few cubic feet of acclimated beads from the old filter with new beads and both filters will adjust rapidly. Lacking the beads, have a friend provide you with backwash water from an established filter. Just dump the sludge into the system. The bead filter will pick it up and leave the solids in intimate contact with the beads where the transfer of desirable bacteria will rapidly take place.

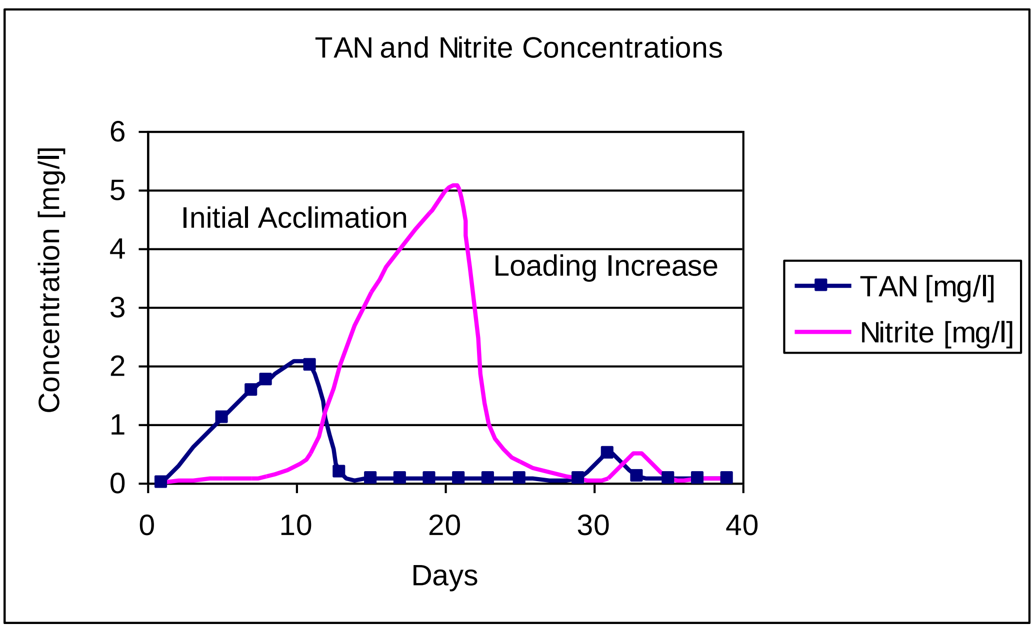


Figure 4. Tan and nitrite concentration build-ups are normally observed during the initial acclimation of a biofilter.

Table 3. Things You can do to Accelerate the Initial Acclimation of a Bead Filter

	Procedure	**How does it help?**
1	Add sodium nitrite at a concentration of 1 mg-N/l on the first day.	Allows growth of <u>Nitrobacter</u> to start immediately.
2	Add backwash waters or beads from an established biofilter. *	Introduces species/strains of bacteria that are well suited for the bead filter's ecosystem.
3	Reduce Filter Backwash Frequency	Minimizes the loss of biofloc.
4	Raise the temperature of the system to 30° C.	Accelerates bacterial growth rates by increasing metabolic rates.
5	Adjust the pH to 8.0.	Accelerates bacterial growth rates by increasing ammonia (NH_3) concentrations.
6	Add sodium bicarbonate to raise the alkalinity to 150 mg-$CaCO_3$/l	Accelerates bacterial growth rates by increasing bicarbonate availability.
* Disease may be spread with the biofilm, so make sure the source is healthy.		

You should be careful not to kill the animals, which are used to acclimated filter. The animals you select to use do not need to be the same as the ones you will be culturing. The best choice for freshwater systems is turtles. The ammonia and nitrite concentrations that will be reached will not affect these animals. Therefore, you do not have to worry. In-expensive domestic Koi or goldfish are good choices if fish are used. However, it is important that the fish or animals used during acclimation are disease free so as not to infect your high quality fish later. These animals can tolerate **<u>short-term</u>** exposure to TAN and nitrite levels of about 5 mg-N/l without harm if you keep the pH between 7.5 and 8.0 and add some sodium chloride (rock salt) or calcium chloride. Chlorides help prevent nitrite toxicity by blocking nitrite transfer in the gills. The pH range keeps the TAN in the less toxic NH_4^+ form. It is usually the nitrite peak, which is twice to three times as high as the TAN peak, which damages the fish. If the fish show signs of stress (inactivity, lack of hunger, or gaping near the surface), remove them; you will have plenty of food for the bacteria in the water column already. The fish should be reintroduced into the system once both the TAN and nitrite levels fall below 1 mg-N/l.

The initial acclimation assures that the biofilter contains the right type of bacteria. However, you then must adjust the amount of bacteria to assure there are enough of them to process the ammonia produced by the animals in the system. Therefore, the next step in the acclimation process is to increase the density of animals in moderate steps allowing some time for the bacterial population to grow to meet the increased demand. This process of acclimation to increased loading is normally undertaken with the animals of choice, since the TAN and nitrite peaks are small and quickly disappear. As a general statement, an acclimated filter will completely adjust to a sudden increase in fish density (or feed level) within 72 hours. If the step increase is moderate (< 33 percent of current load), the acclimation will probably occur without noticeable peaks. The heights of the acclimation peaks are actually controlled by the density of fish in the system, not by the size of the biofilter. That is, the nitrite peak in a system with a fish density of 0.25 pounds/gallon will display a peak concentration one-half as high as a system with a density of 0.5 pounds/gallon. Table 4 summarizes additional methods that can be used to decrease transitional peaks. The process of acclimation to increased loading occurs naturally if the bacteria and animals are allowed to grow together. The bacteria always grow faster, maintaining the proper balance between the biofilm and the animal density. For example, within a Koi pond, once the filter is acclimated to the fingerling density, the biofilter's ecosystem will take over and maintain the proper balance. Your management responsibility occurs when the natural growth processes are disrupted by sudden (unnatural) changes in the system.

Table 4. Things that Can be Done to Decrease Transitional Peaks of TAN and Nitrite When the Animal Density or Feed Rates are Increased

	Procedure	**How does it help?**
1	Increase your water loss from the system until the biofilters adjusts.	TAN and nitrite will be flushed with the water.
2	Discontinue or reduce feed rate during the transition.	TAN excretion rates from most animals increases with feeding.
3	Make loading increases in small increments (< 33 percent of current load) and separate steps by about 3 days.	Existing bacteria will absorb most of the increased load and reproduce rapidly.
4	Extend backwashing interval.	Decreases biofloc loss during the critical transition.
5	Adjust pH and alkalinity to optimum range.	Accelerates reproduction of nitrifying bacteria.
6	Artificially increase the TAN loading prior to the increase by dosing of ammonia chloride (NH_4Cl) and sodium nitrite ($NaNO_2$) to a level of 1 mg-N/l.	Promotes growth of the critical nitrifying bacteria, enriching their density in the biofilm.

Appendix A: The Science behind Bioclarification

The term “Bioclarification” was coined some years ago by Dr. Ronald F. Malone, the inventor and patent holder of Bead Filter Technologies, to describe the ability of bead filters to perform both mechanical and biological filtration in the same unit. The ability of bead filters to perform these tasks is described in detail below.

Bioclarifier = Solids Capture + Biofiltration

Clarification

Bead filters perform well in the control of suspended solids across a broad spectrum of conditions. Bead filters capture solids through four identifiable mechanisms (Table 1). With the exception of adsorption, the solids capture mechanisms are physical in nature and are common to all types of granular media filters. As a general observation, the filters seem to control fine colloidal particles best with some biofilm development. This suggests that the biofilm absorption process is an important mechanism in the control of fine suspended solids and thus water clarity. Studies have shown that bead filters capture 100% of particles > 50 microns and 48% or particles in the 5-10 micron range per pass (Figure 1).

Table 1. Mechanisms Contributing to the Capture of Solids in a Bead Filter

Mechanisms	**Comment**
Straining	Direct capture of larger particles as they pass into small openings between the beads.
Settling	Sinking of suspended solids onto the surface of the beads.
Interception	Impact of particles directly onto the surface of a bed.
Adsorption	Small particles are captured and absorbed into the sticky biofilm.

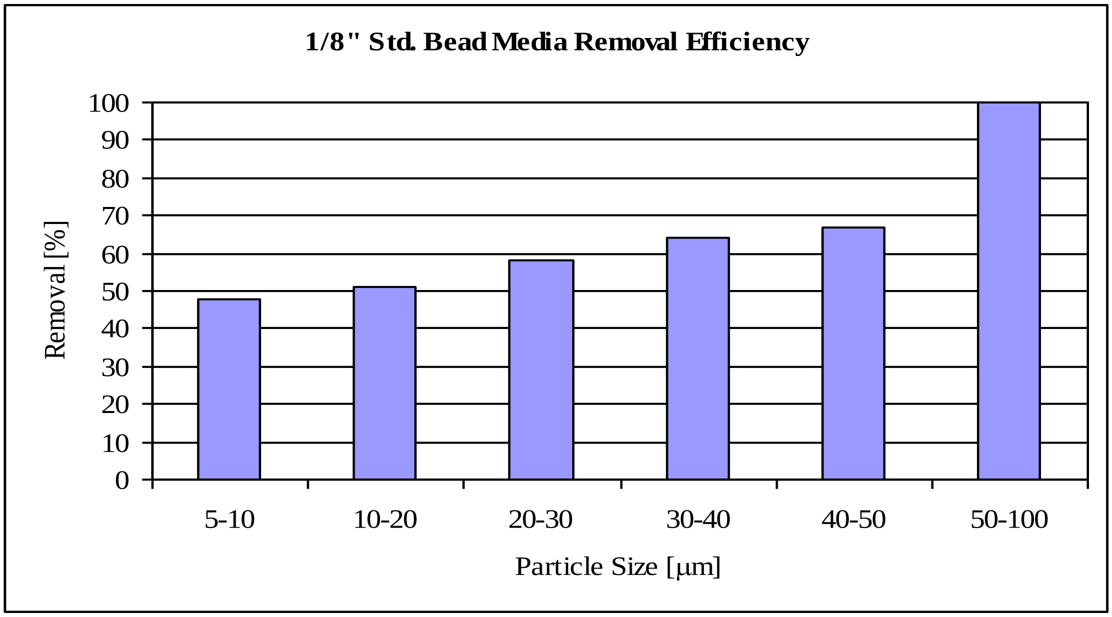


Figure 1. All particles above 50 microns are removed in the first pass through the filter and the remainders are removed with multiple passes.

The flowrate delivered to a bead filter is the principle management factor influencing suspended solids removal. The efficiency (single pass percent reduction in TSS) of a bead filter generally increases as the flowrate to the filter decreases; however, the capture rate (mass of TSS captured) tends to increase with flowrate. This apparent contradiction occurs because per pass efficiency is relatively insensitive to changes in flowrate, and so, minor drops in efficiency that occur with flow increases are more than compensated for by enhanced solids transport to the filter. Generally, recirculating rates used with closed or partially recycled systems should be maximized to obtain the lowest possible TSS level in the holding tanks.

Separation of captured solids from the bead bed is accomplished by sedimentation of released sludge after the bed is backwashed. Materials such as fats or wood chips merely float upward with the beads and are not removed. In sufficient quantity, these materials will eventually foul the bed requiring media replacement. Bead filters are also not well suited for the clarification of waters suffering from mineral turbidity problems caused by fine clays or other colloidal particles. Lacking good biofilm development, the mechanisms for the capture efficiencies are unacceptably low. Finally, the bead filters will impact but cannot control planktonic algal blooms. Although some capture occurs as a general rule, the algae can grow faster than they can be caught and thus little progress towards clarification is made. Application of the bead filter technology to the problem of colloidal mineral turbidity or algal blooms requires the use of supplemental treatments (chemical flocculation or U.V. disinfection, respectively) or the filter will be ineffective.

Biofiltration

In the biofiltration mode, bead filters are classified as fixed film reactors. Each bead (Figure 2) becomes coated with a thin film of bacteria that extracts nourishment from the wastewater as it passes through the bed. There are two general classifications of bacteria, heterotrophic and nitrifying, that are of particular interest (Table 2). The two bacteria co-exist in the filter, and understanding their impact on each other as well as on the filter is critical.

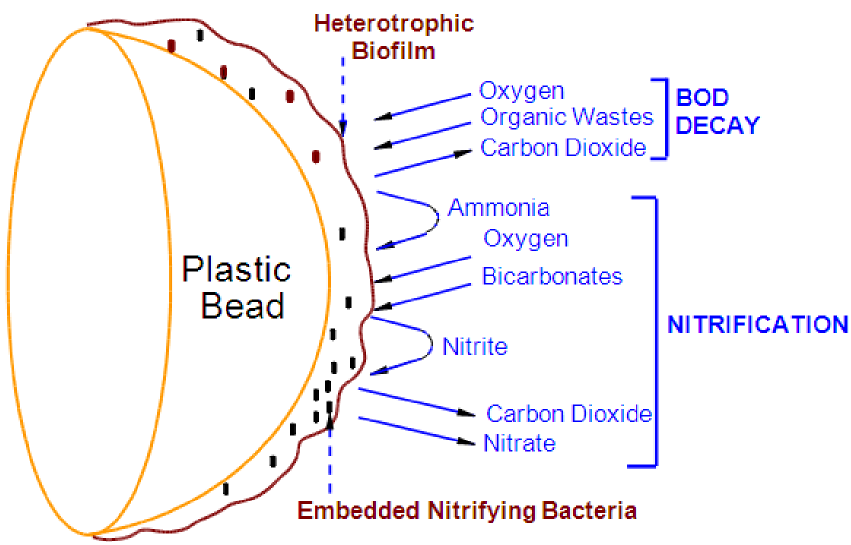


Figure 2. The bacterial film that coats each bead contains the nitrifying bacterial population. Heterotrophic bacteria also form a thin biofilm layer on each bead. The nitrifying bacteria compete with the heterotrophic bacteria for space.

Table 2. In the Biofiltration Mode, Bead Filters Cultivate Two Types of Bacteria which Perform the Critical Biofiltration Function.

	Heterotrophic Bacteria	**Nitrifying**
Function	Remove dissolved organics (BOD) from the water column; breakdown and decay organic sludges.	Convert toxic ammonia and nitrite to nitrate.
Reproduction Rate	Very fast (10 – 15 minutes)	Slow (12 – 36 hours)
Yield (mg bacteria/mg waste consumed)	0.6 – 0.8	0.05 – 0.10
Bead adhesion	Poor	Good

The classification of heterotrophic bacteria encompasses a great number of genera/species that share the common characteristics of extracting their nourishment from the breakdown (decay) of organic matter. Biochemical oxygen demand (BOD) is largely an indirect measure of the biodegradable organic material in water. Heterotrophic bacteria reduce BOD levels, consuming oxygen in the process. About 60 percent of the organic matter consumed is converted to bacterial biomass; whereas, the balance (40 percent) is converted to carbon dioxide, water, or ammonia. Heterotrophic bacteria grow very fast, capable of doubling their population every ten to fifteen minutes. If the BOD in the water being treated is very high (> 20 mg -O_2/l), the heterotrophs will quickly dominate the bead bed, overgrowing the slower growing nitrifying bacteria and consuming tremendous amounts of oxygen.

The second, yet more important, classification of bacteria is the nitrifying bacteria. These bacteria are specialists, extracting energy for growth from the chemical conversion of ammonia to nitrite and from nitrite to nitrate (Figure 3). Nitrate is a stable end product which, although a valuable nutrient for plants, displays little of the toxic impacts of ammonia and nitrite. Composed principally of two genera (Nitrosomonas and Nitrobacter), nitrifying bacteria are very slow growing and sensitive to a wide variety of water quality factors. It is not surprising that most bead filters used for biofiltration are managed to optimize conditions for nitrification.

LIMITED WARRANTY

Aquaculture Systems Technologies, LLC, (AST) warrants the material and workmanship to be free of defects under designated use and normal service on its **Endurance™ Filters** for a period of one (1) year from the date of shipment. All warranty claims must be presented in writing to AST. Normal use and service requires the following:

1. The filter must be installed and operated according to the installation and operational instruction supplied by the manufacturer.
2. Excessive weight due to heavy pipes, valves, etc. must not be carried by the inlets or outlets.
3. The filter hull pressure must never exceed the maximum pressure rating as specified by the manufacturer.

This warranty applies only to the original purchase price, and is good only when the total payment for the equipment has been received. The limited warranty (expressed or implied) during the warranty period shall consist of the repair or replacement of the items of manufacture, at the discretion of **AST**, and said warranty applies only to the original purchaser. This warranty is void if the items are damaged by negligence or accident after purchase; used for other than the intended purpose; or used with other items that affect the integrity, performance, or safety of these items. Liability does not cover indirect or consequential cost, including materials lost, labor or installation/reinstallation cost, injury, property damage, or damages caused by mishandling.

Returns for repairs must be pre-approved and the return authorization number prominently displayed on the outside of the shipping container. Returns will not be accepted without a "return authorization number". Returns for repair should be sent to the following address "FREIGHT PREPAID":

Aquaculture Systems Technologies, LLC

108 Industrial Ave.

New Orleans, LA 70121

Manufacturer's liability for incidental or consequential damages is specifically excluded to the full extent permitted by the applicable law. This warranty gives you specific legal rights, and you may also have other rights, which may vary from state to state.

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