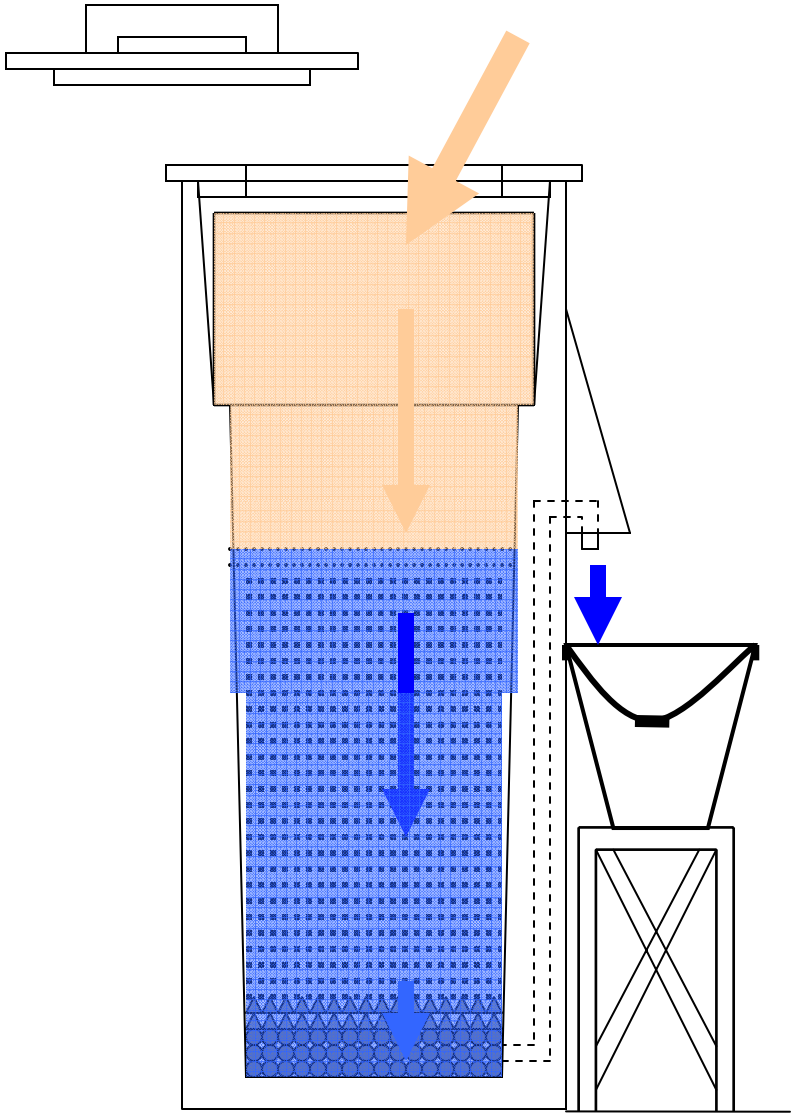


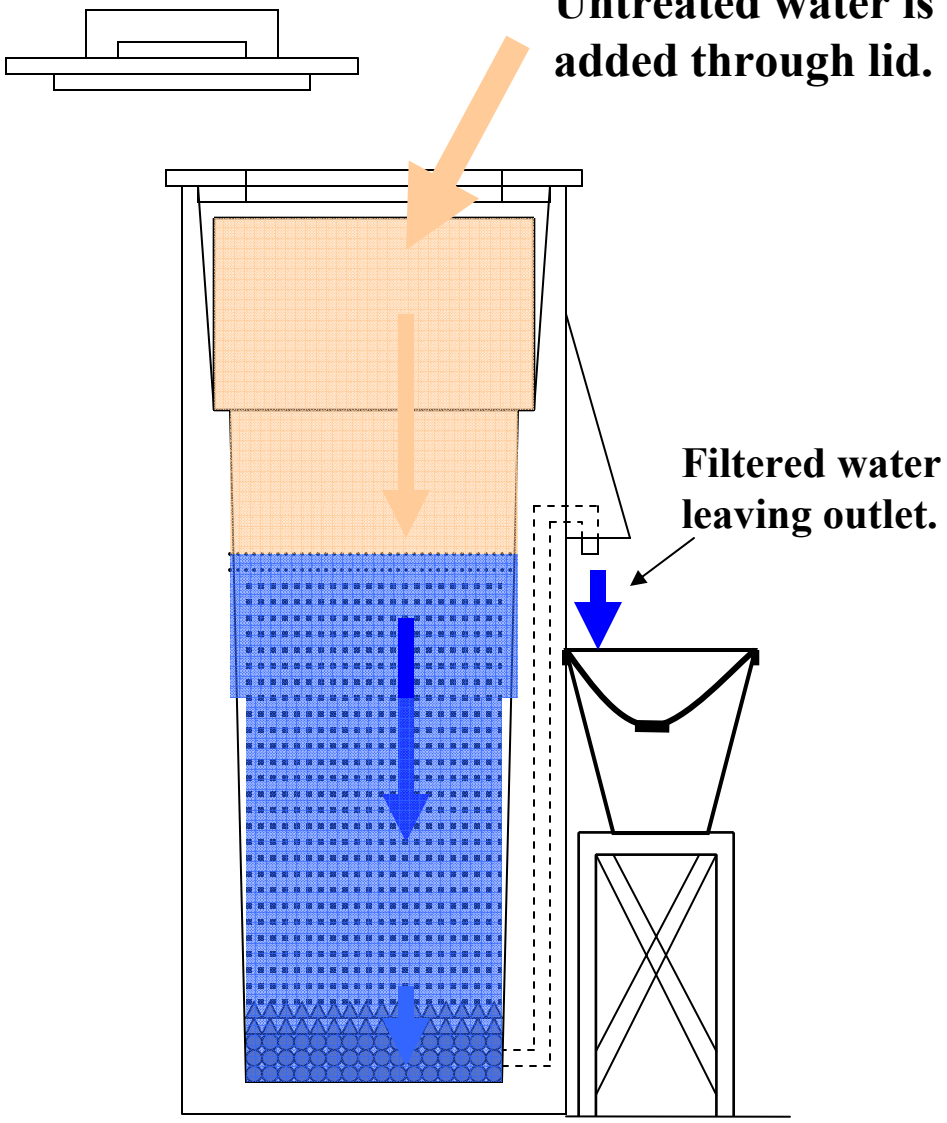
BSF Guidance Manual #3

Basic Operation of the

Concrete BioSand Water Filter

January 2009

Dr. David H. Manz, P. Eng., P. Ag.



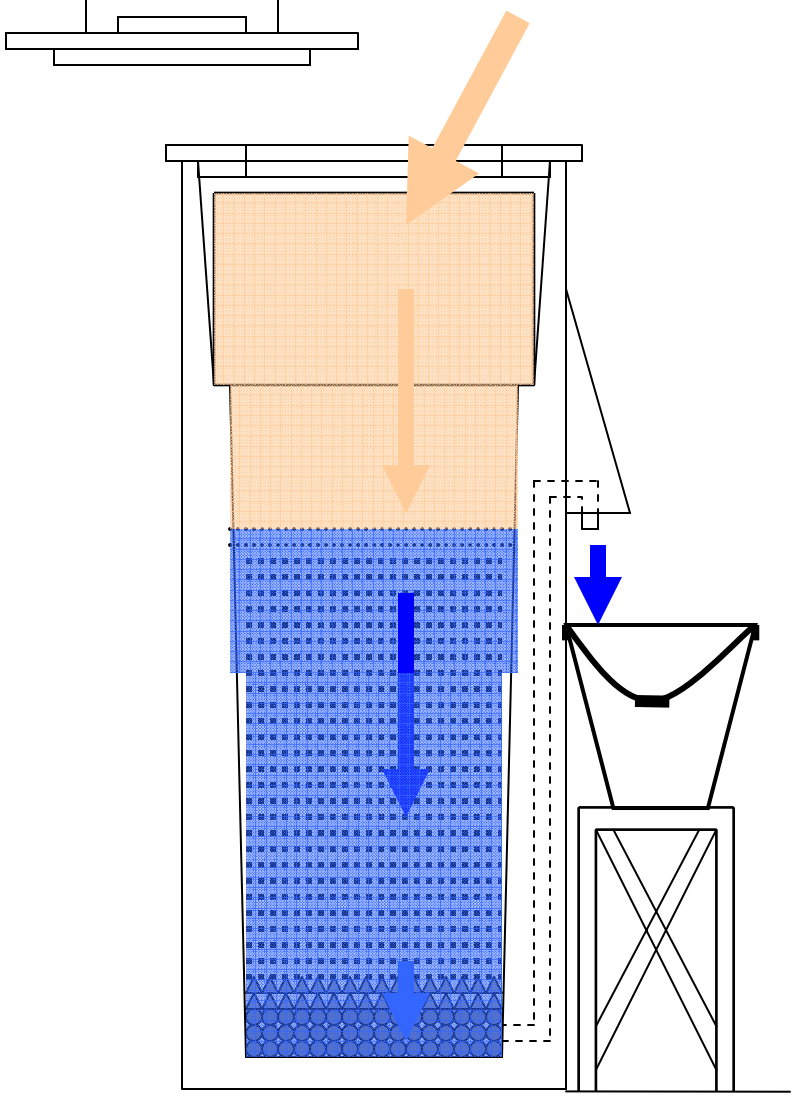
Basic Operation of the BSF

With use a biolayer will form on and near the surface of the filter media. The biolayer is responsible for most of the removal of bacteria and viruses.

Parasites and larger organisms do not require formation of a biolayer to be removed 100%.

The biolayer is approximately 1 cm deep or less because the filter is used intermittently; that is, used as required. The biolayer requires oxygen to survive and very little oxygen can penetrate into the surface of the filter media when the flow is stopped.

The depth and nature of the biolayer will vary depending on the how the filter is operated. The best filter performance can be expected when the filter is used as consistently as possible without large or frequent variation in operation and untreated water supply.



Performance

When water is first added to a filter virtually all parasites will be removed and there will be a significant reduction in turbidity (provided most of the turbidity is caused by non-colloidal particulate material). Up to 60% removal of bacteria and viruses can be expected. Residual turbidities caused by colloidal particles or dissolved substances do not impact on the ability of the filter to remove pathogenic organisms.

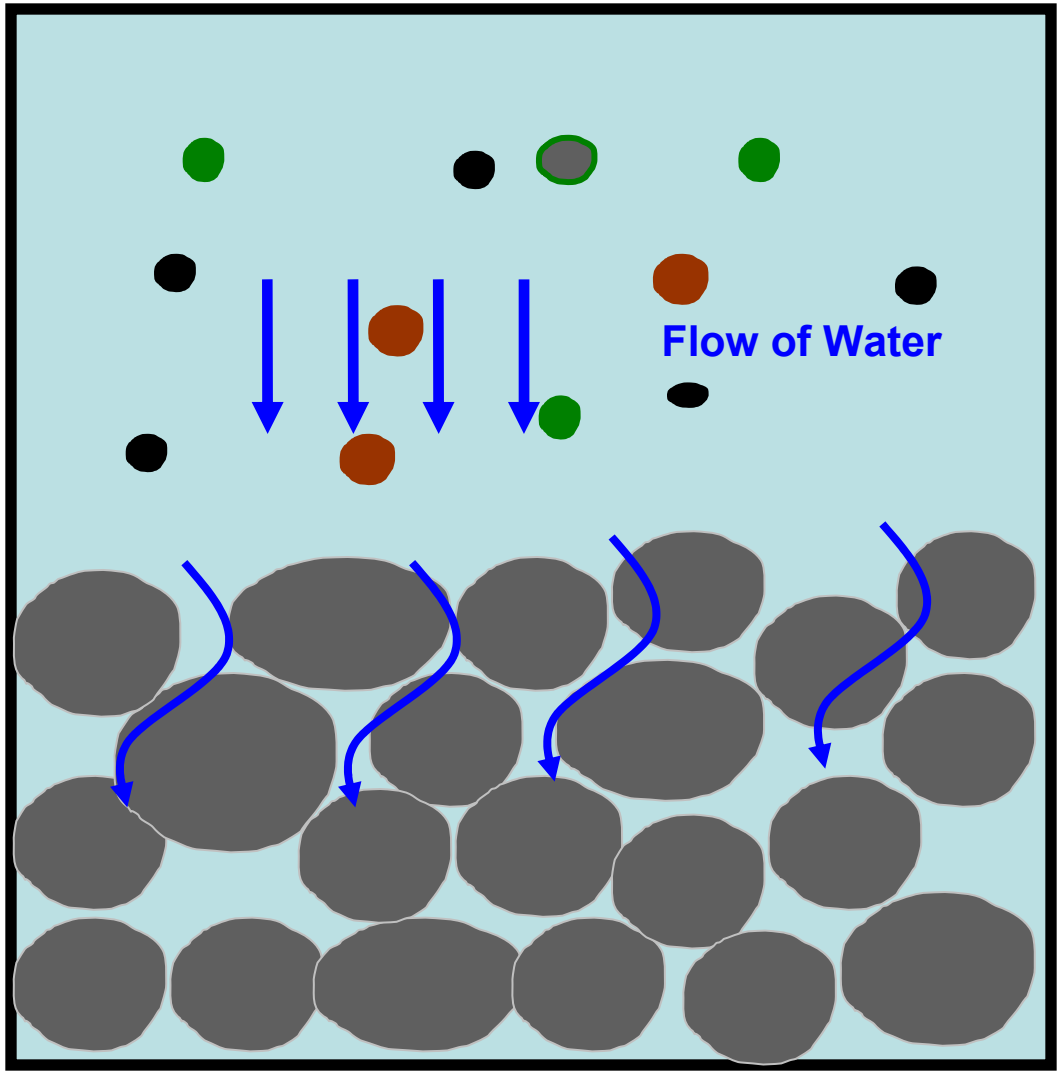
With regular use turbidity removal can be expected to improve and bacteria and virus removal rate will gradually increase to greater than 95% (See next slide.).

If !00% bacteria and virus kill or deactivation is required the filtered water must be disinfected using, for example, a dilute solution of sodium hypochlorite.

Disinfection of filtered water is recommended since it insures that all pathogenic organisms have been removed, killed or deactivated and risk of recontamination is minimized.

Operation of BSF.

Beginning of operation of the BSF – no biofilm around particles and no biolayer.



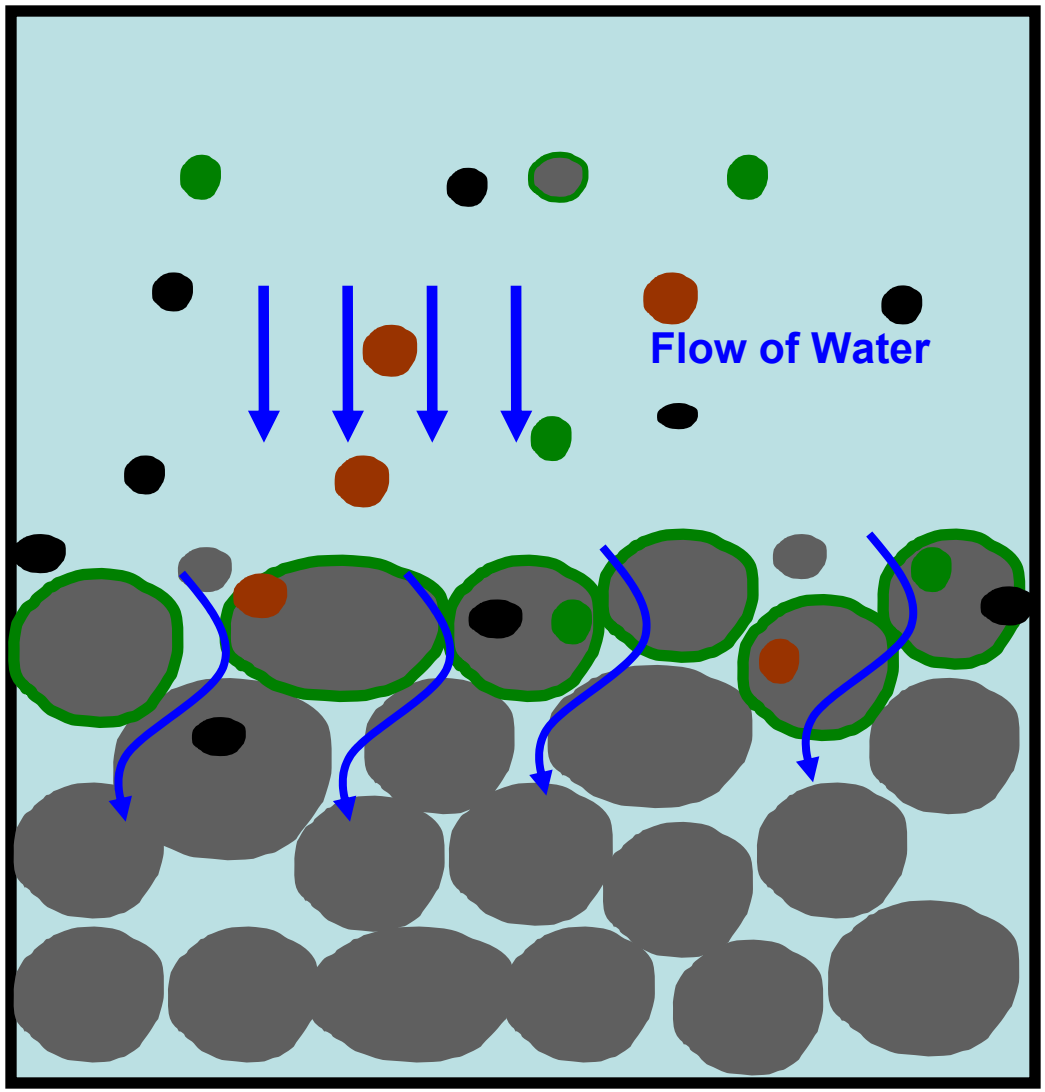
Media particle without surface biofilm.

Other mineral and organic particles or flocs of particles.

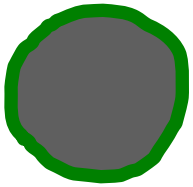
Also includes large living organisms such as algae, helminthes and the cysts of parasites.

Operation of BSF.

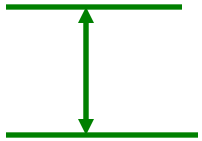
Beginning of operation of the BSF



No biolayer is necessary for removal of parasites and larger organic material and mineral particles including oxidized iron and manganese.



Media particle covered with a surface biofilm including bacteria and organic matter.

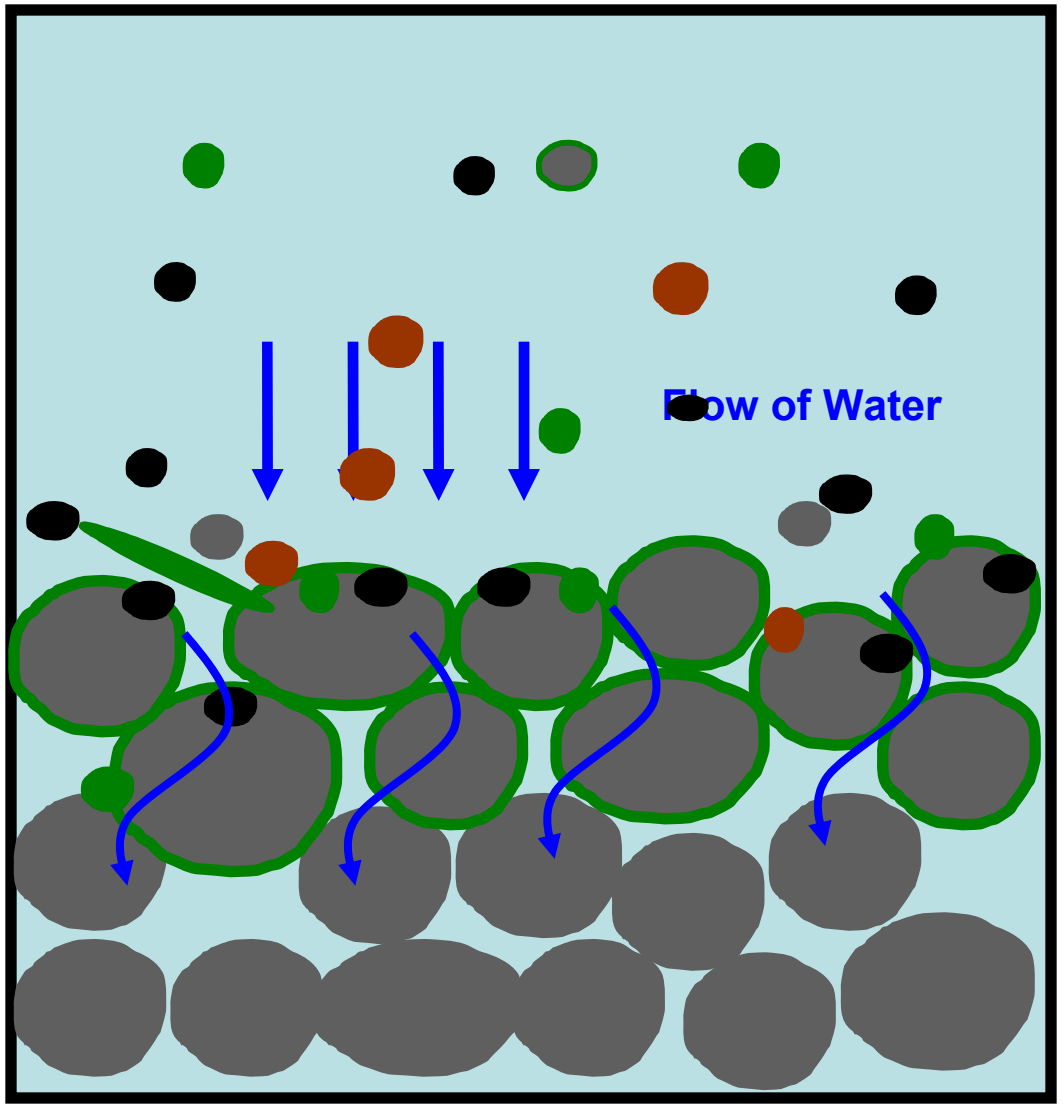


Biolayer (Mineral particles covered with a biofilm).

Formation of biofilm on the mineral particles is exactly the same as that observed in 'trickling filters' used for aerobic treatment of wastewater.

Operation of BSF.

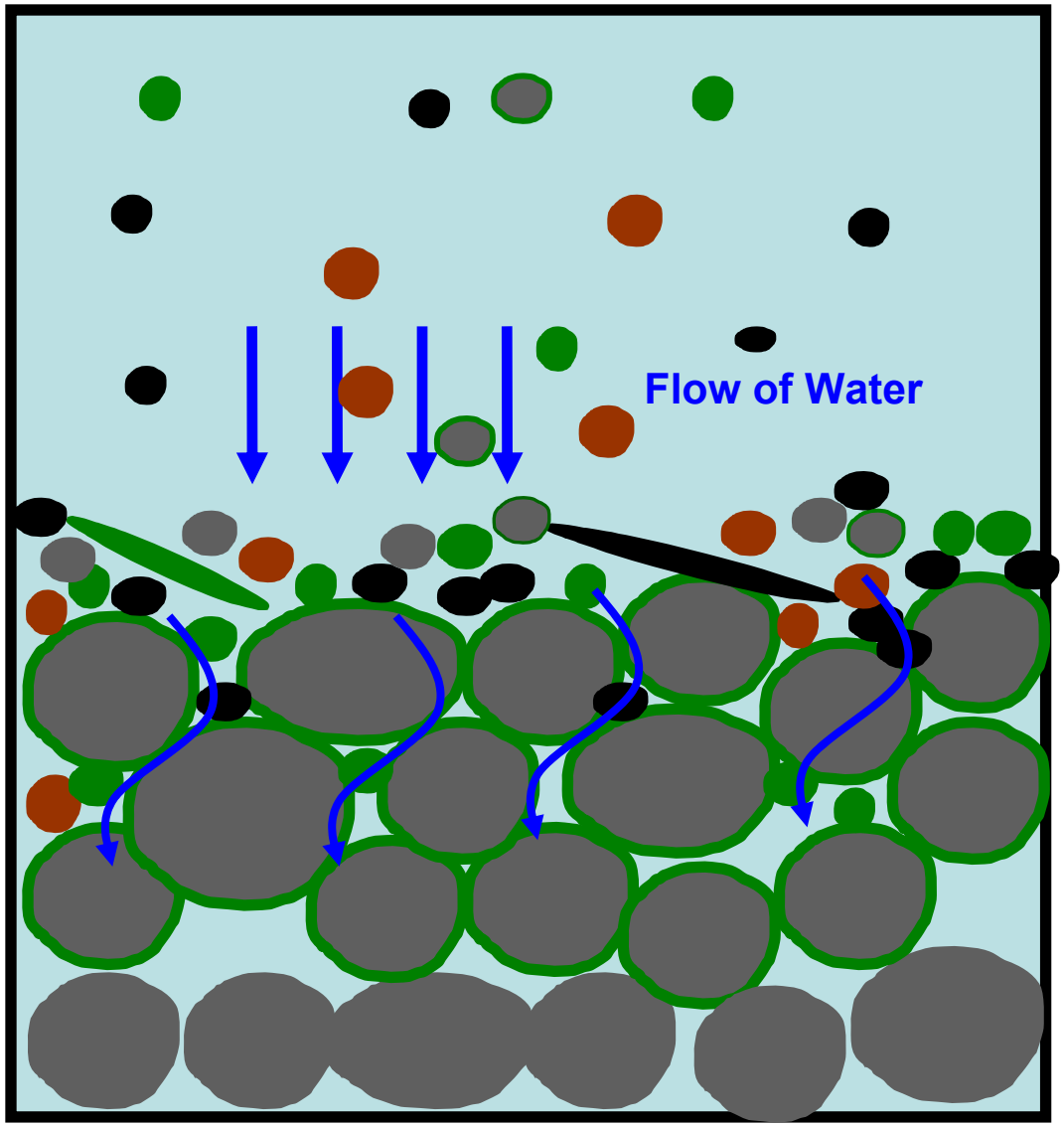
Biolayer thickens with use and time.



Biolayer thickens.

Operation of BSF.

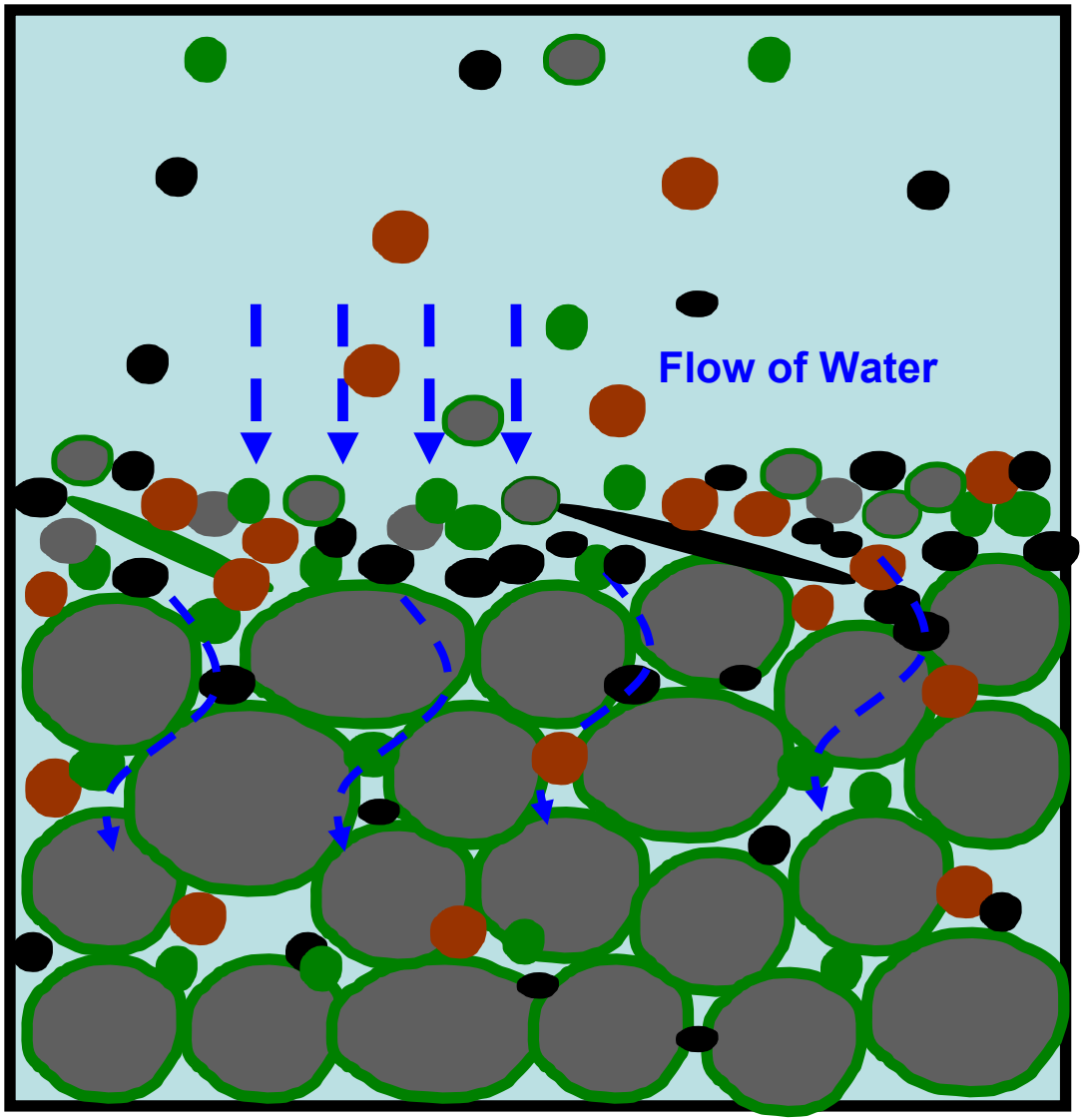
Biolayer thickens with use and time.



Biolayer thickens and captured material accumulates.

Operation of BSF.

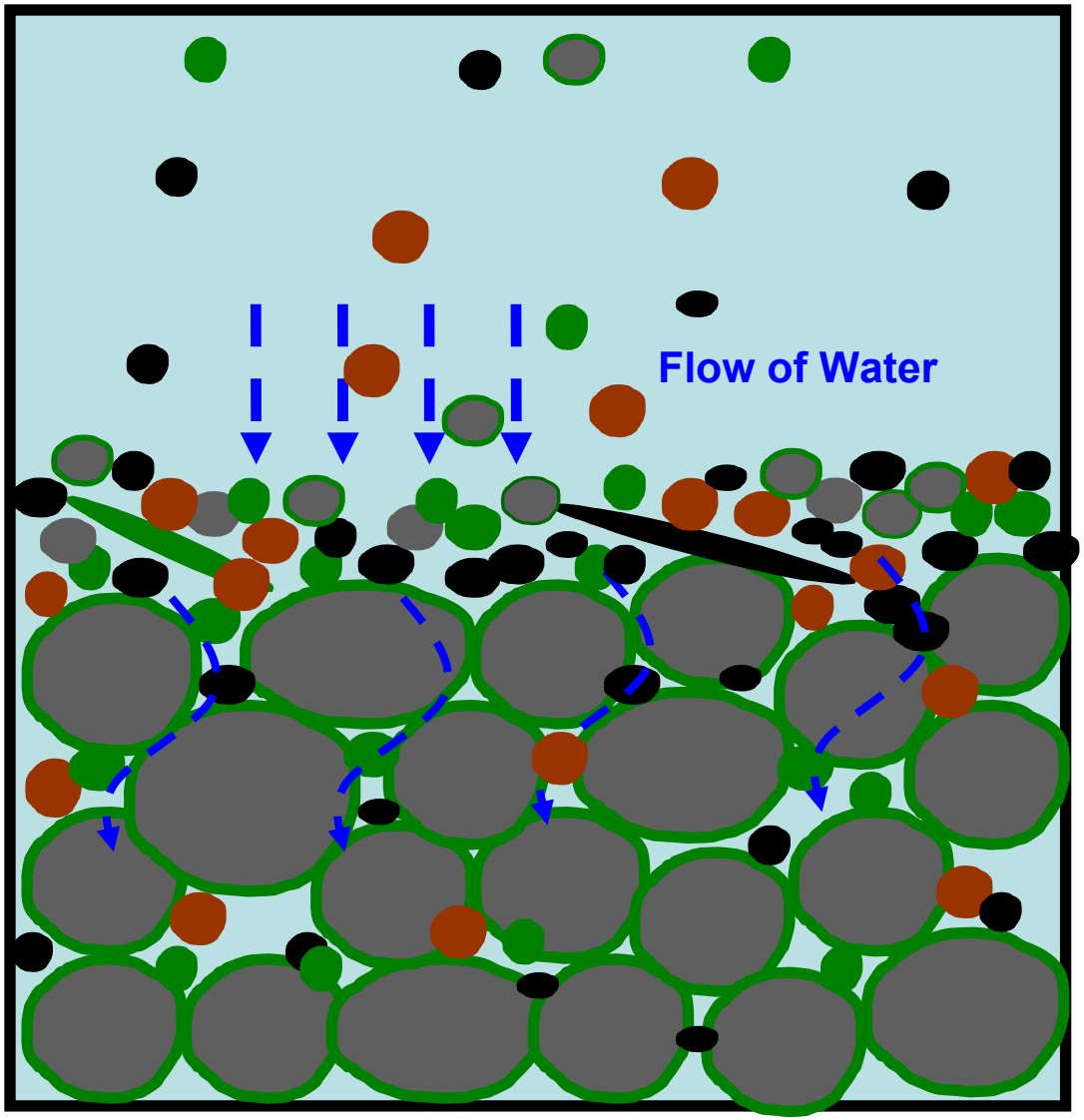
Biolayer thickens with use and time.



Biolayer thickens and captured material accumulates and starts to restrict flow.

Operation of BSF.

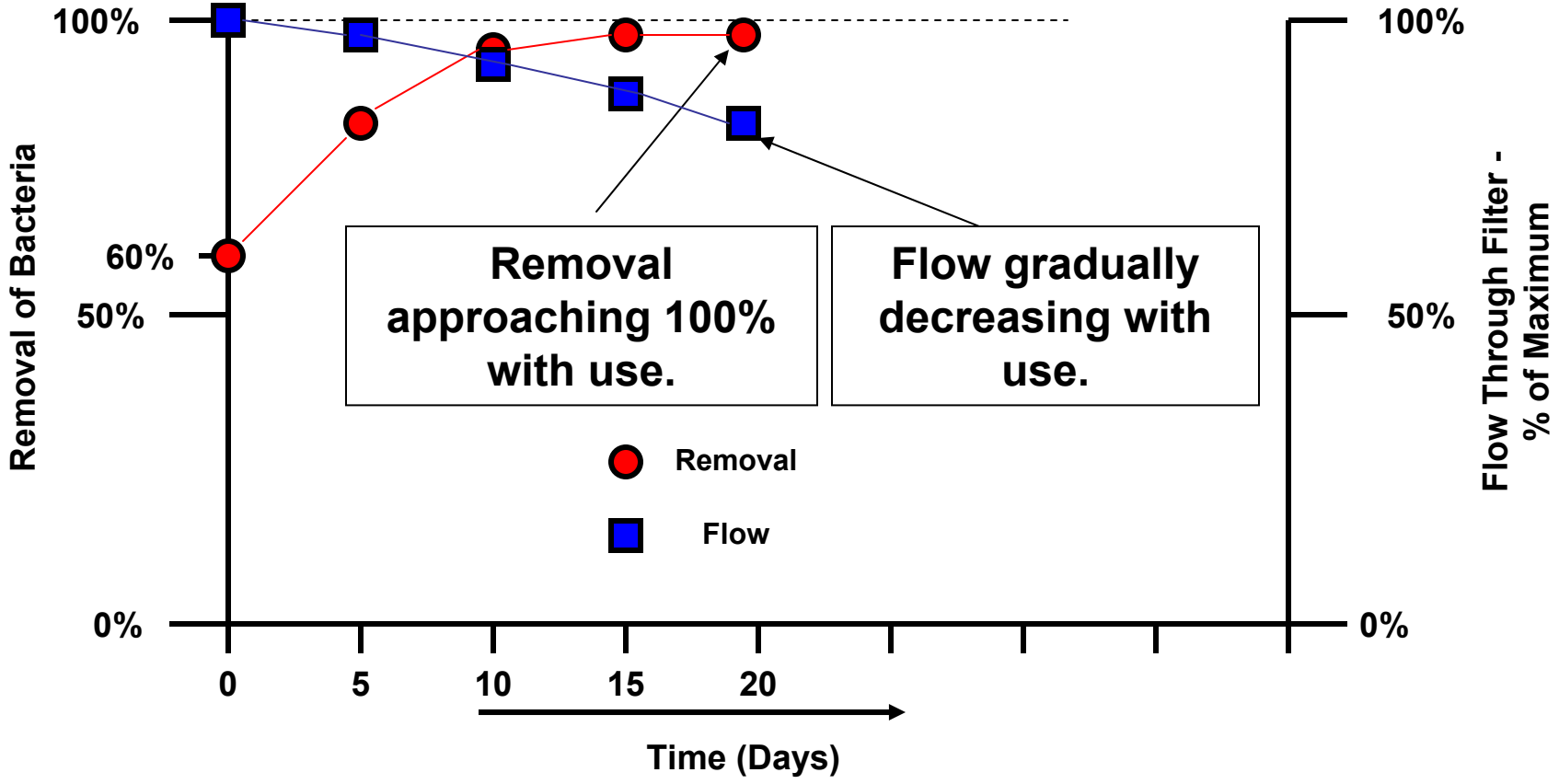
Biolayer thickens with use and time.

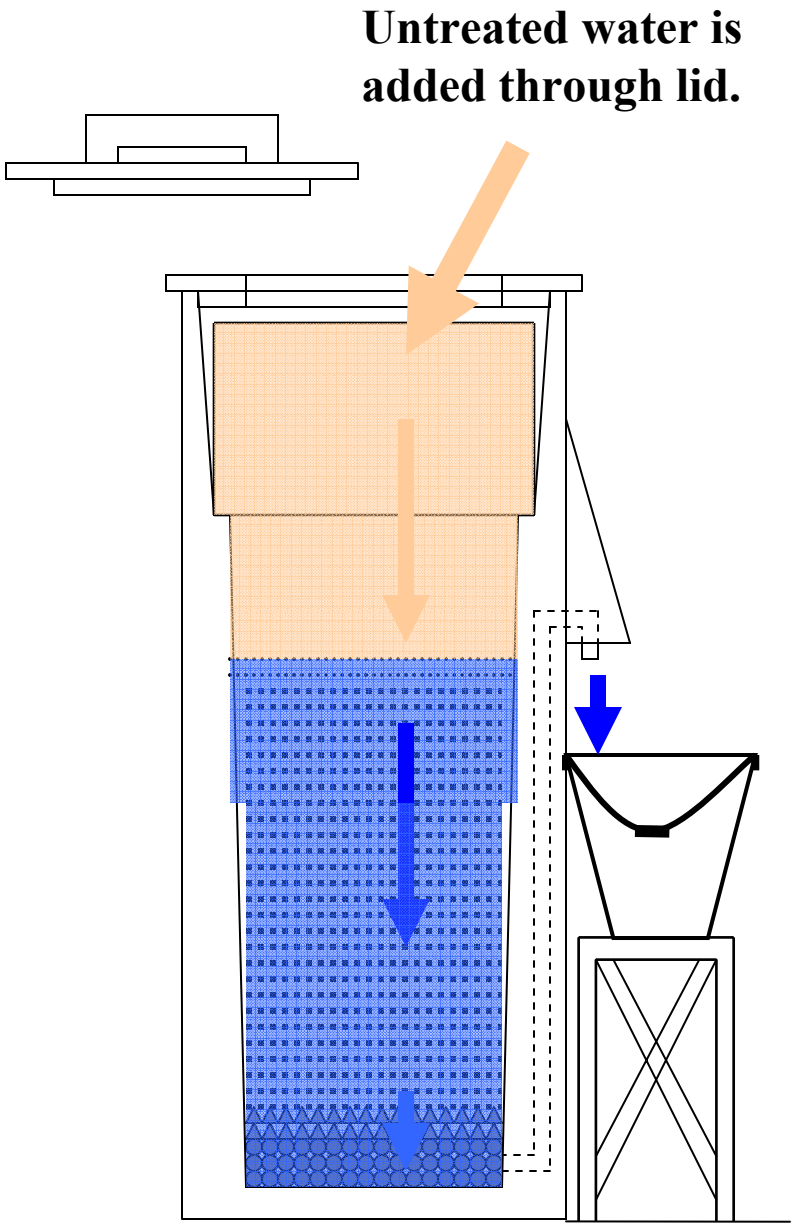


Formation of biolayer will depend on the ecology of the water being treated and the quantity of water being treated. The greater the concentration of aquatic life and the greater the quantity of water being treated the faster the biolayer will form.

Biolayer thickens and captured material accumulates and starts to restrict flow.

Typical Performance of a BSF Water Filtration Technology



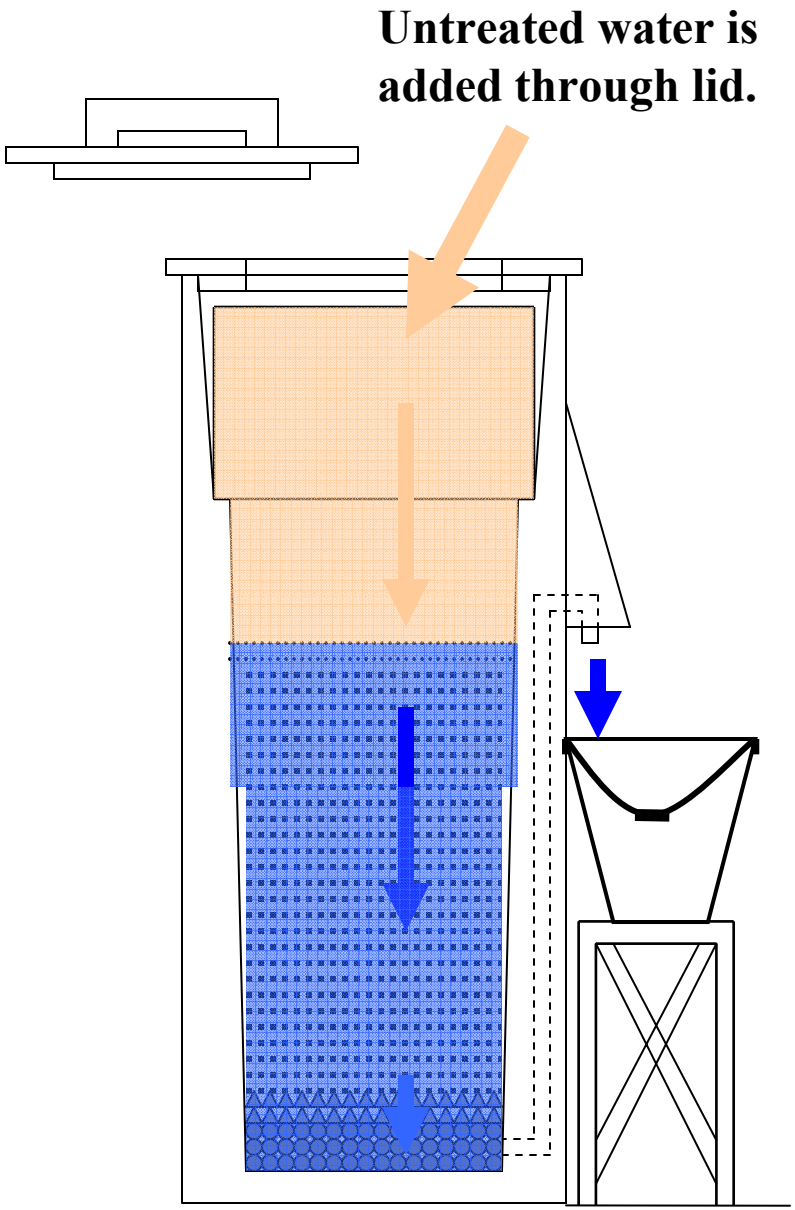


Performance – Other Effects

Filter performance as measured by the removal of bacteria from the water will be affected by changes in filter use (amount of water treated per day) and changes in source of water that is filtered.

Switching between sources may disturb the ecology of the biolayer and may affect performance.

Parasites and larger organisms are always removed.

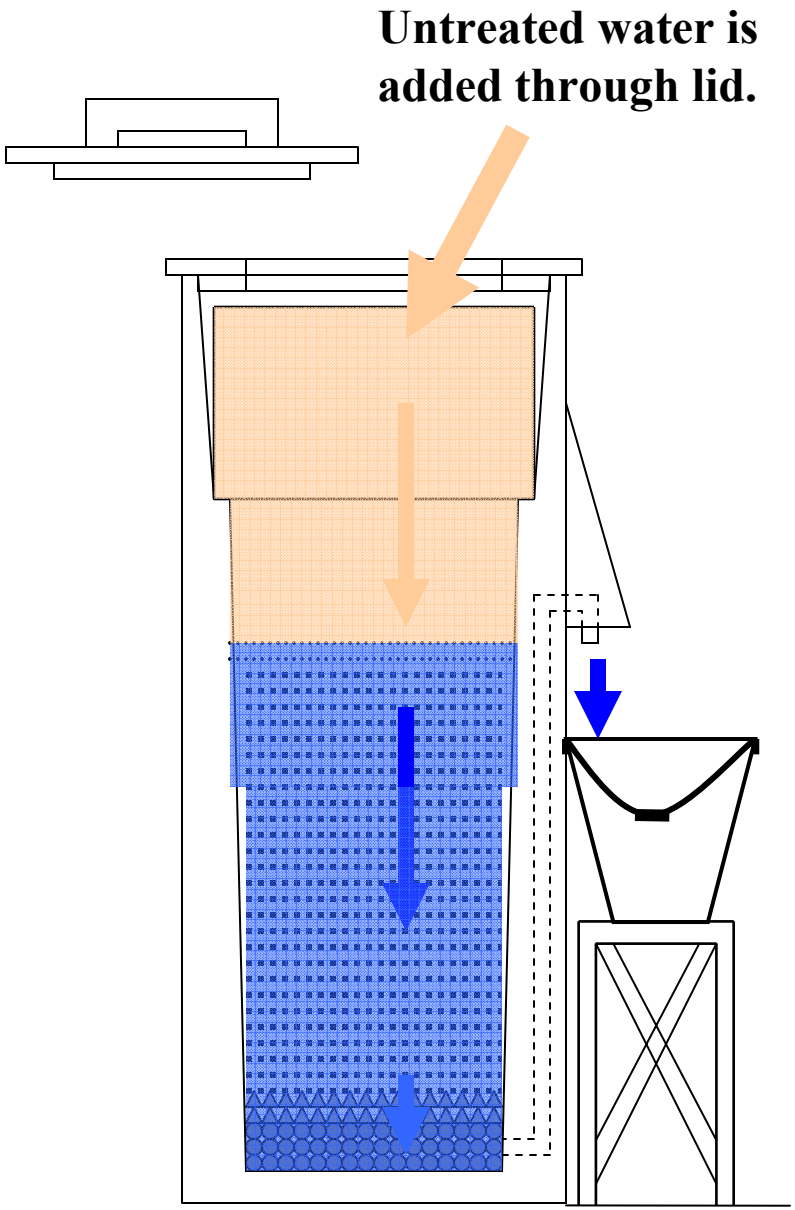


Use of BSF and Impact on Biolayer.

The BSF may be used to treat one or more buckets of water per day as required. Ideally, the same amount of water is treated each day. Only that portion of the biolayer near the surface of the media will receive sufficient oxygen to survive.

A biolayer will form naturally if the water being treated contains aquatic organisms. The aquatic organisms form a natural ecology including many predator – prey relationships. Some of the very largest organisms are visible to the naked eye while organisms on the scale of parasites and smaller are not discernible. It is important to observe that different water supplies will contain different aquatic ecosystems (at the micro-organism scale).

The nature and depth of the biolayer will depend on the nature of the aquatic ecosystem contained in the water being treated. A filter treating a water supply containing very few aquatic organisms may require a longer time to develop a biolayer. Water with higher turbidity (due to presence of filterable particles) may develop a biolayer very quickly. Parasites and larger organisms are always removed.



Cleaning the BioSand Water Filter

Eventually the surface of the media in the filter will become plugged off and the flow will decrease to unacceptable levels. The filter will then need to be cleaned or maintained as per the instructions outlined in the presentation on cleaning and maintenance.

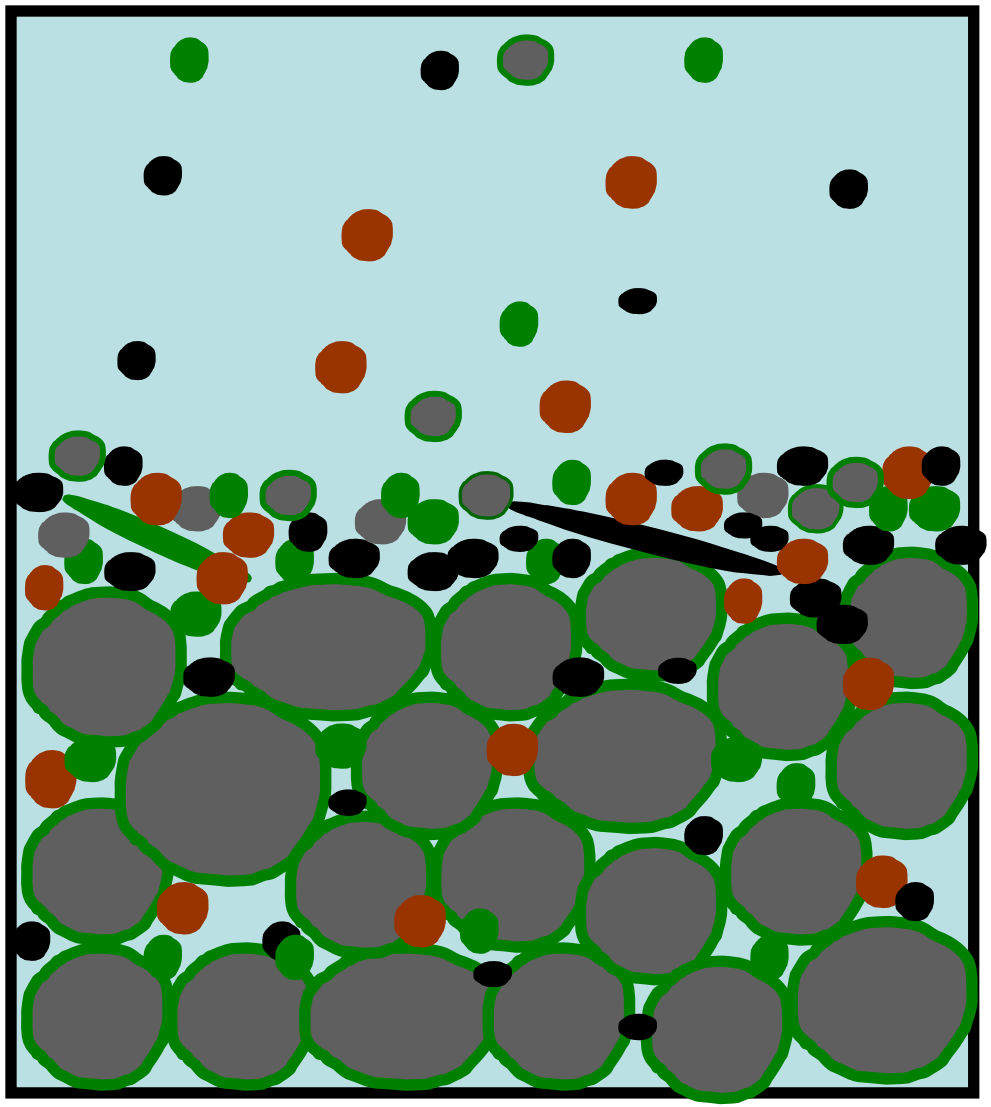
The time between cleanings will depend on the amount of turbidity in the source water that is caused by particulate materials. The particulate materials may be organic or of mineral.

The impact of cleaning the filter on performance is minimal provided cleaning is performed in the correct fashion. Under no circumstances should deep cleaning or harrowing be practiced on a BioSand water filter.

See following slides illustrating the cleaning concepts and impact of correct normal cleaning of a BSF.

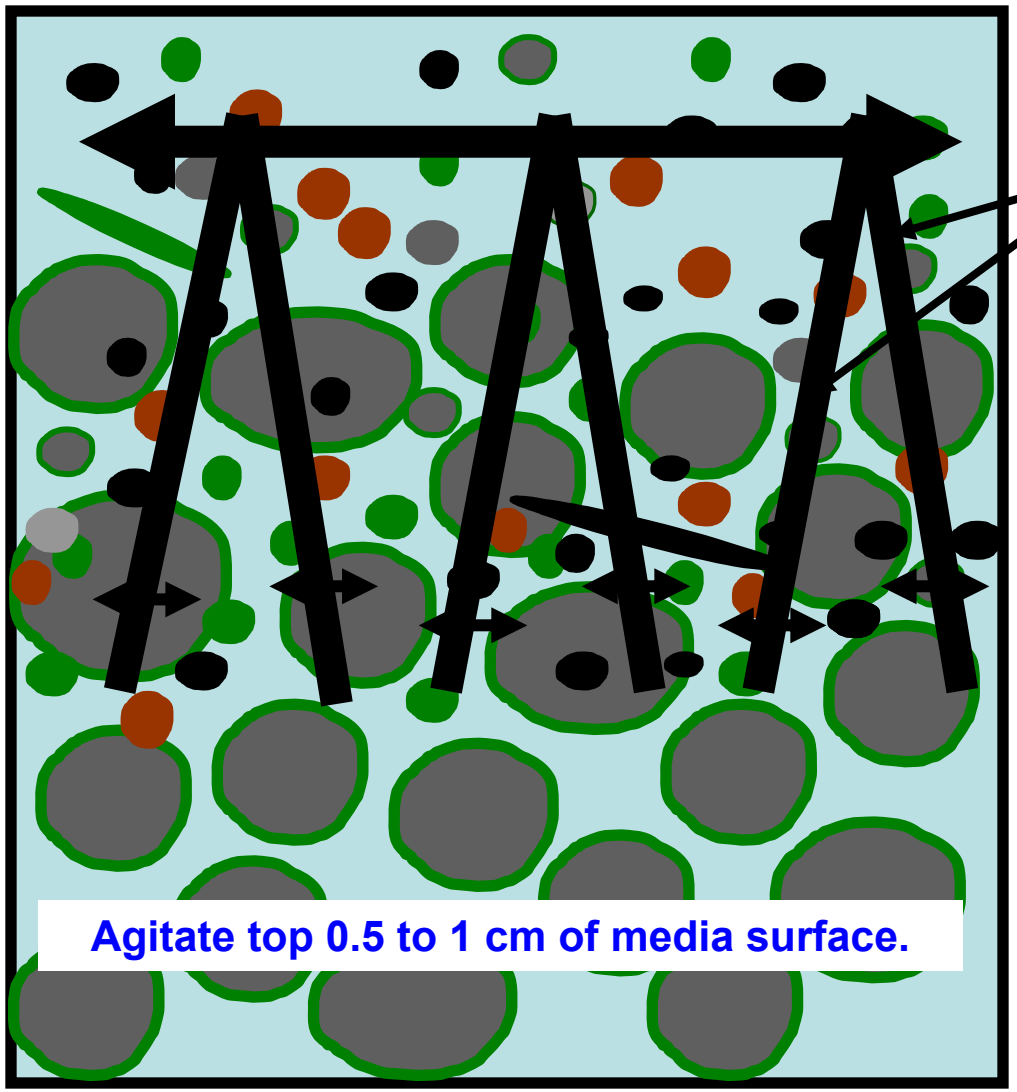
NOTE that the BSF may be cleaned as often as required without negative impact on filter performance. It is practical to filter water with very high particulate concentration or use of pretreatment using coagulants.

Normal Cleaning the BSF.



If the water in the filter has been lowered to the paused depth (5 cm) additional untreated water should be added from the top through the diffuser.

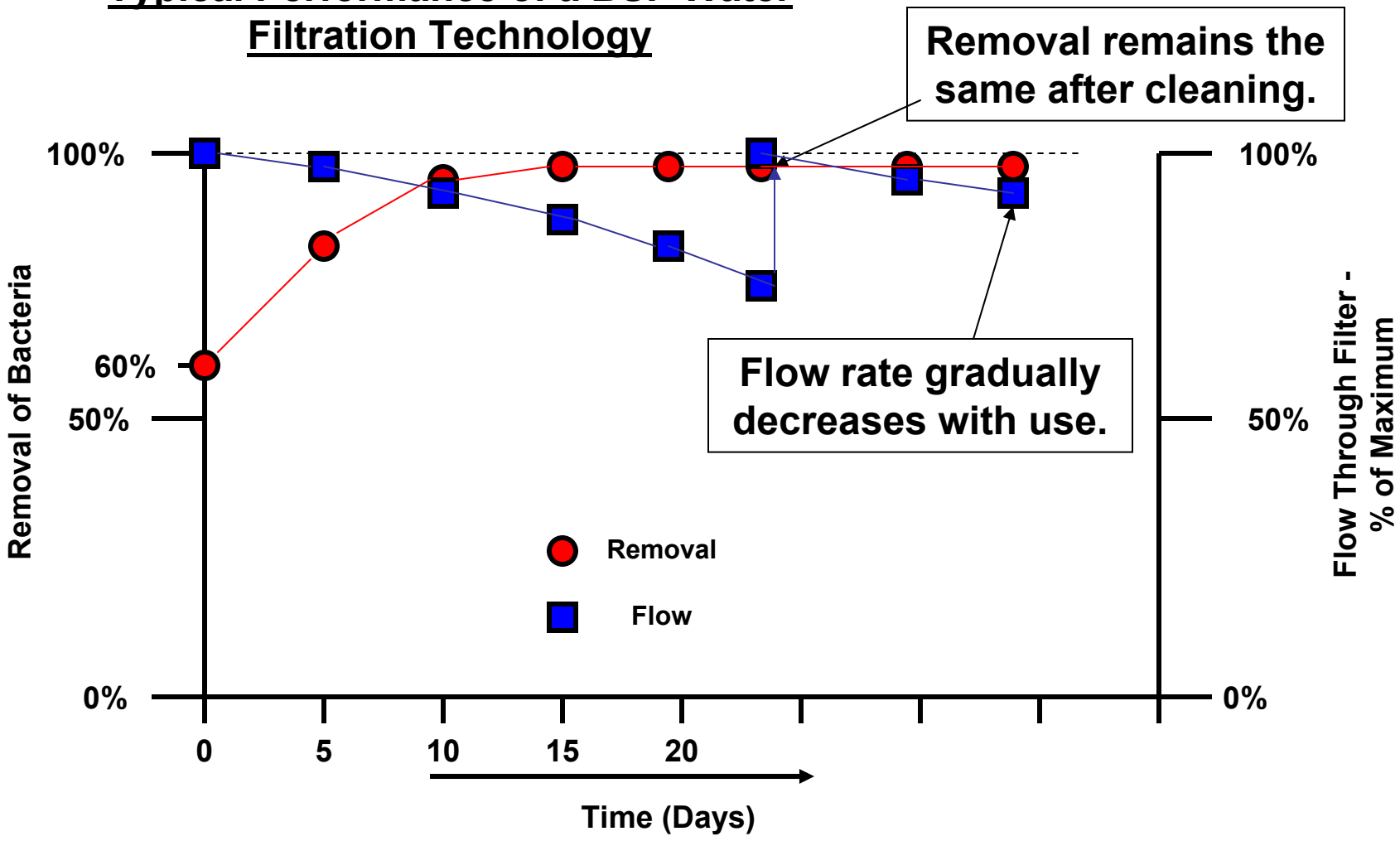
Normal Cleaning the BSF.

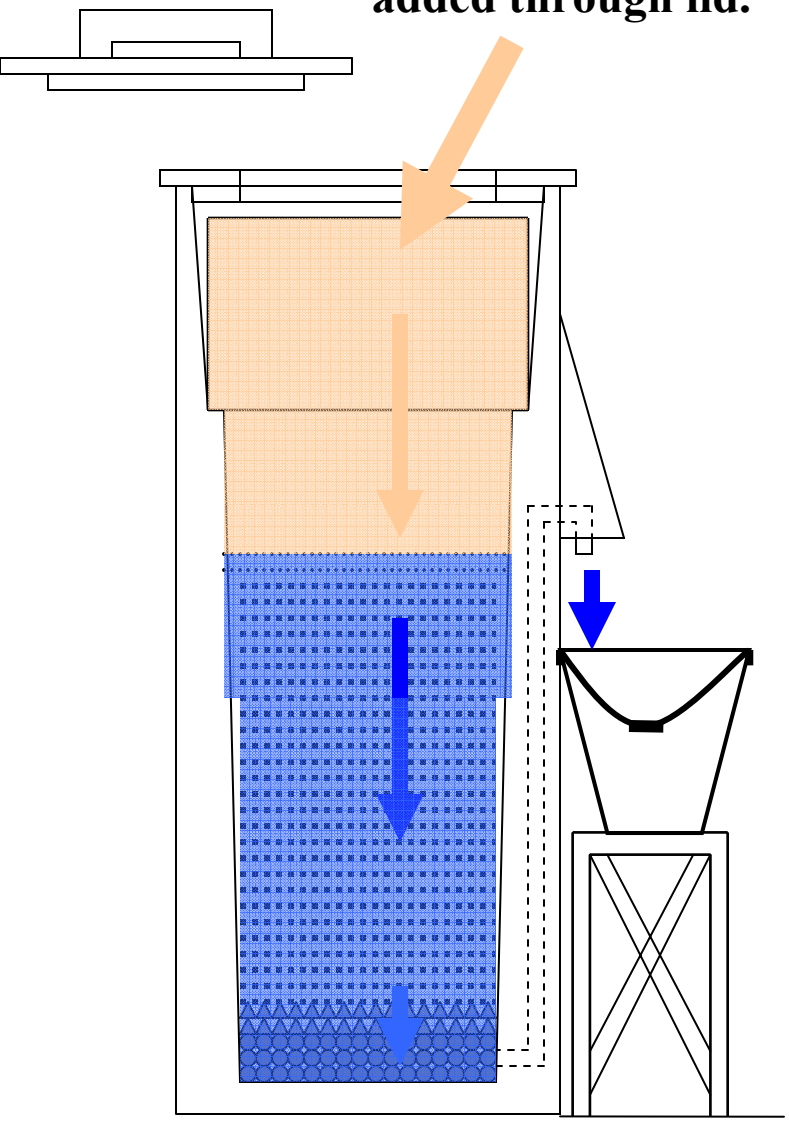


Wire 'fingers', real fingers or a spoon can be used to agitate very top of filtering media where the particles restricting flow are located.

Surface agitation should NOT be confused with 'harrowing' used to extend period between cleanings of TSSF. Harrowing a BSF will seriously impair performance. See further discussion in 'Maintenace and Cleaning of the BSF'.

Typical Performance of a BSF Water Filtration Technology



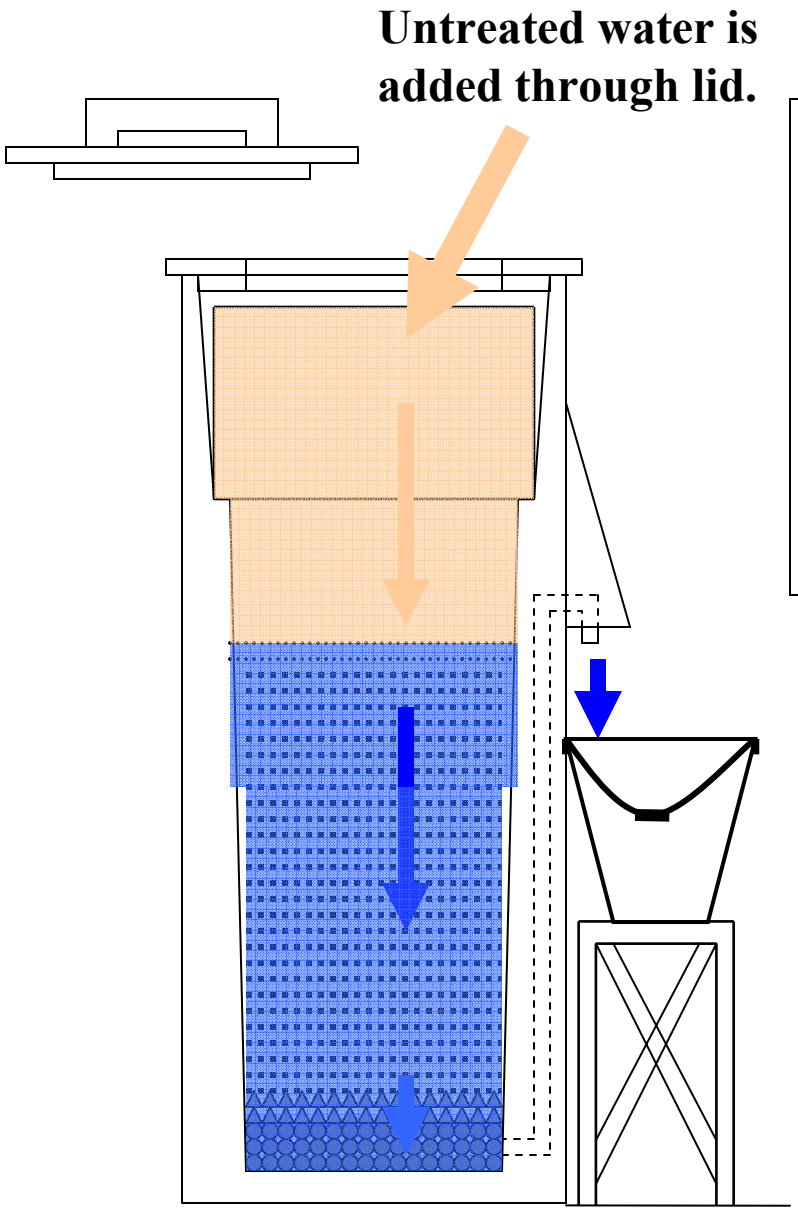


Some Effects of Switching Water Supplies

The implications of switching water supply from one with high concentration of pathogens to one with relative low concentration of pathogens is that he filter will temporarily appear to be LESS efficient at removing bacteria – in fact it might actually appear to be ADDING bacteria to the water. This is because the water that forms the 'paused water' that is immediately above the surface of the media is from the previous water supply and the entire depth of media is filled with filtered water produced from the more contaminated source. Until all of water in the paused water and the filtered water from the first source is 'flushed' from the filter the concentration of bacteria in the water produced from the filter might appear very poor when compared to the quality of water from the second source.

Performance will initially appear to be very good when switching from using source water with low concentrations of pathogens to one with high concentration of pathogens.

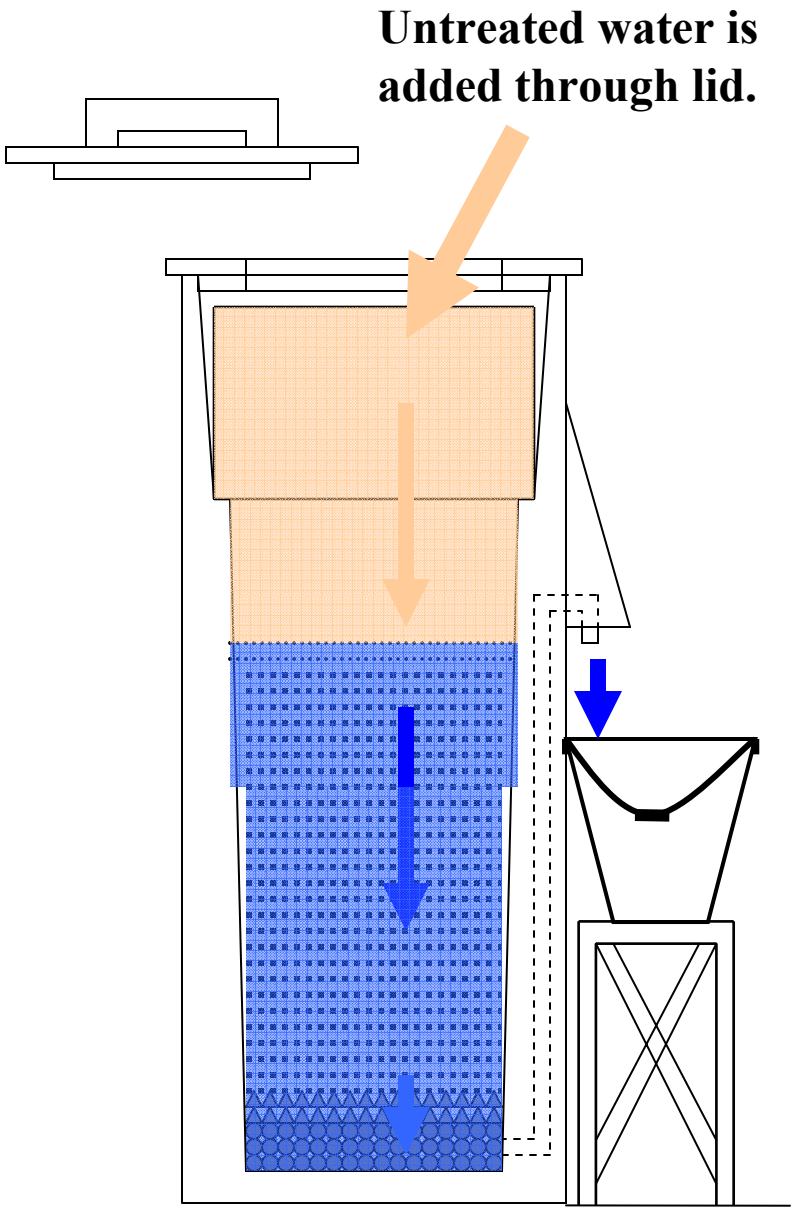
Performance evaluations MUST be very sensitive to this phenomena. Changes in source water quality can be detected by sampling the paused water BEFORE adding water to the filter (discussed further in performance evaluation).



Control of Flow from Filter

It is important not to add any devices to the filter outlet to control (in particular stop) the flow from the filter once water has been added to the filter.

The water must always be allowed to drain to the paused depth when not filtering. This insures that the biolayer is kept supplied with oxygen from the air above it.



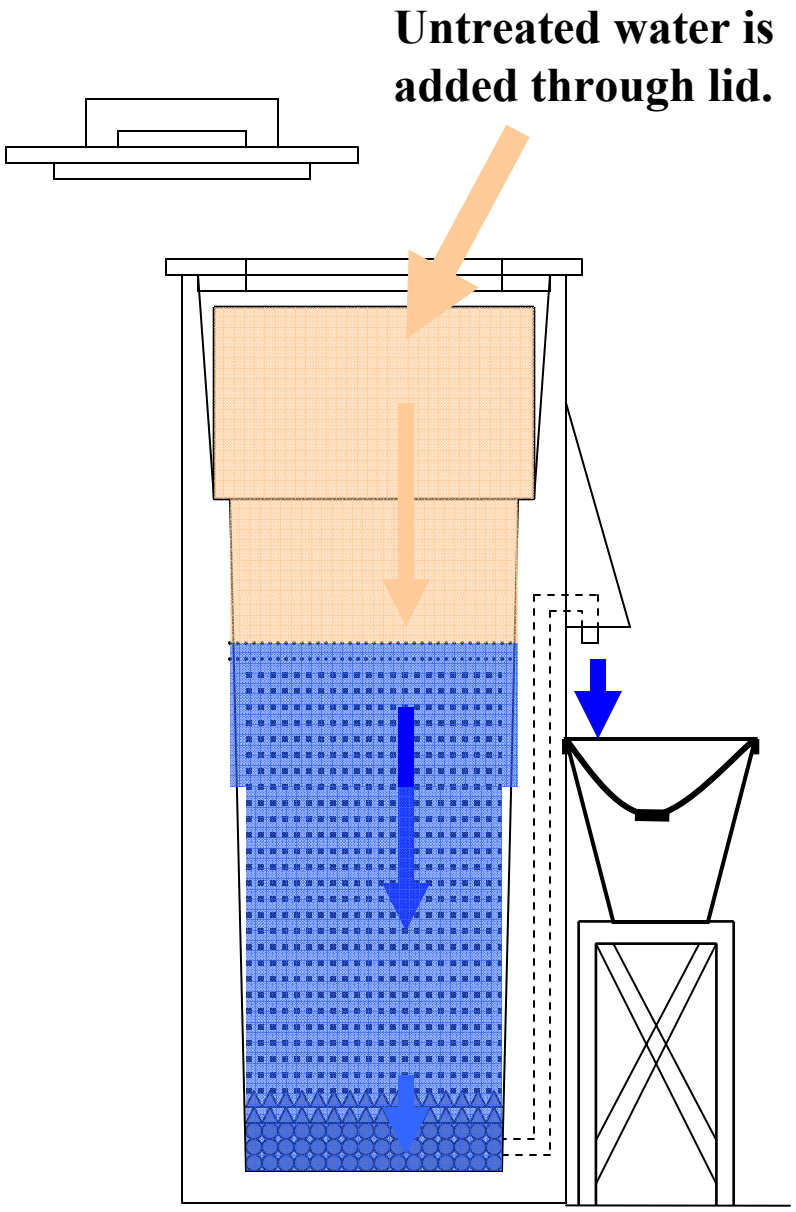
Connection to Storage Device

The filter outlet should not be directly connected to a storage device using a rigid or flexible pipe without providing aeration at or near the filter outlet to prevent any possible syphoning action that would result in draining the water in the filter below the surface of the media.

If small diameter tubing (less than 1.25 cm or so) is used the risk of syphoning is much greater.

It is possible to evaluate the risk of syphoning action through direct experimentation.

Should the water be syphoned below the depth of the surface of the media, the filter media might become air bound and the flow through the filter might be seriously limited. If it is suspected that air binding has occurred it might be necessary to add filtered water by connecting a device similar to that used for initial disinfection (See Installation and Commissioning.. Enough water should be added to cause water to pond on top of the filter media.



Pretreatment and Source Selection

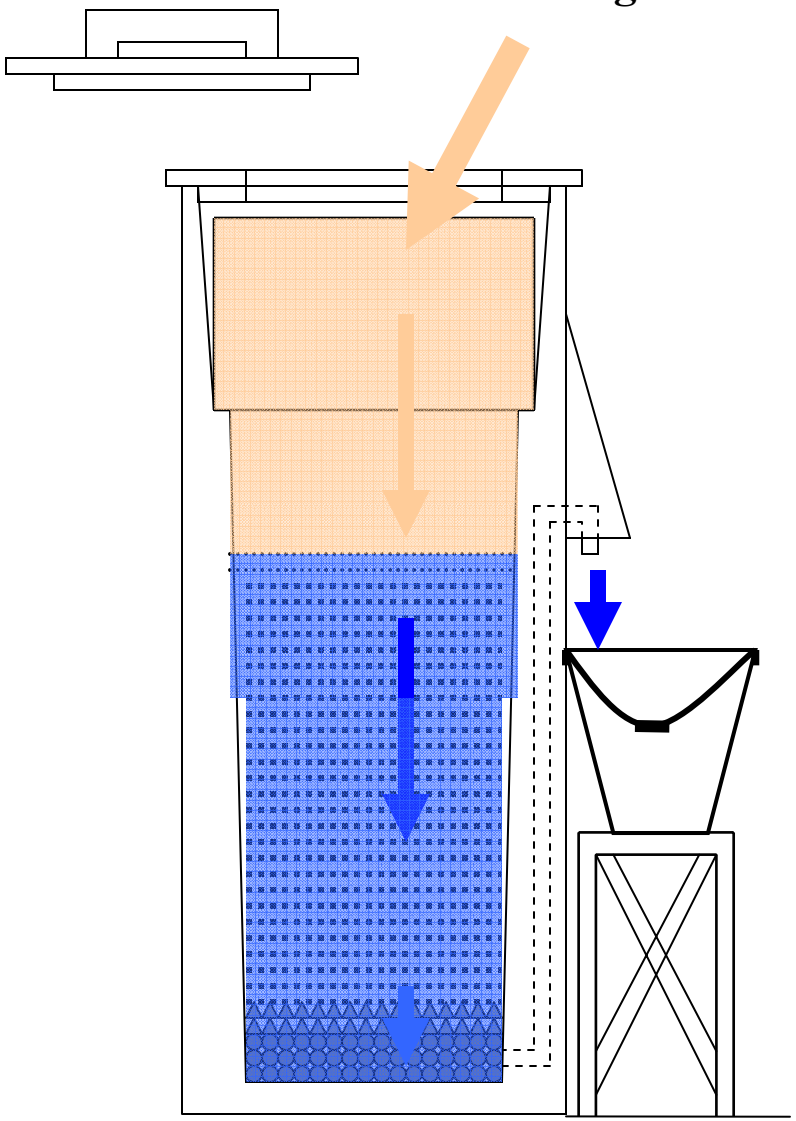
The BSF may be used to treat water from both surface and groundwater sources. Because the BSF is very easily cleaned without loss of ability to remove pathogens or media it is practical to use the BSF to treat water that exhibits:

1. **Very high concentration of suspended solids.**
2. **High concentration of iron.**

Or requires:

1. **Pretreatment using coagulants.**
2. **Pretreatment using oxidants such as chlorine.**

It is important to select water sources that can best be treated with a BSF. This can involve development of infiltration wells, switching to rainwater harvesting to avoid high turbidity water and other measures as opportunities are available (See Source Selection).

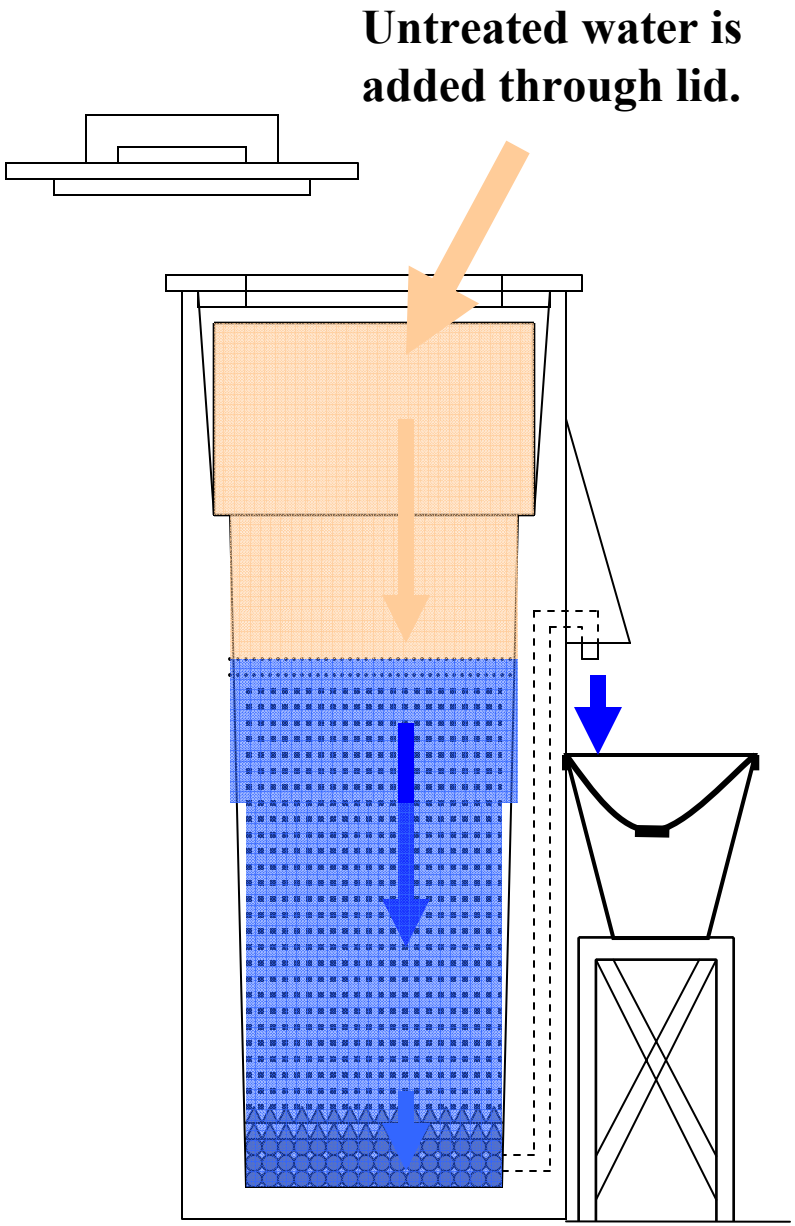


Water from Piped Distribution Systems (Chlorinated Water)

The BSF may be used to treat water from distribution systems. The water delivered to most of the consumers in urban communities in warmer regions of the developing world is unsafe to drink. The water is usually very safe when taken near the source or the treatment plant. However, the water is contaminated by interaction with the shallow groundwater as it is distributed throughout the community. When received by the consumer the water may or may not have a detectable chlorine residual. Since chlorine will not kill or deactivate parasites the water is unsafe whether a chlorine residual is present or not.

It is important to observe that the contamination of the distributed water is primarily due to parasites which the BSF will remove with or without the formation of a biolayer. If chlorine is present it will kill bacteria and viruses but will not kill the parasites that are removed by the BSF.

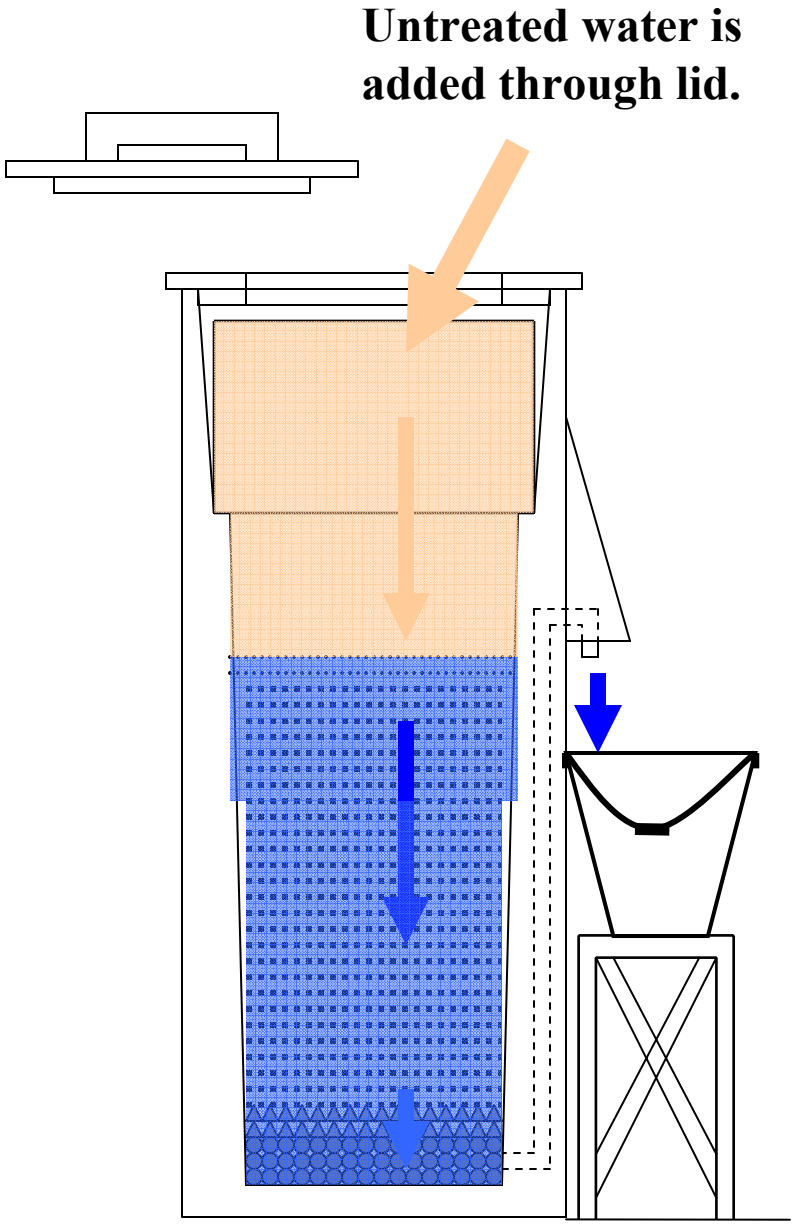
The BSF can effectively treat distributed water and render it safe for human consumption.



Locating and Moving the BSF

The BSF must always be located in a protected environment away from the effects of weather, animals, children and vandalism. It is very important that the location be selected in close collaboration with intended consumers.

Once located a BSF should not be moved – unless absolutely essential. It is very difficult to move a concrete BSF (plastic are easier but not much). Moving is very difficult and the filter container may break. It is practical to remove the media in the filter, as best possible, and then move the filter container itself. The media can then be reinstalled. This process is much easier than initially thought.

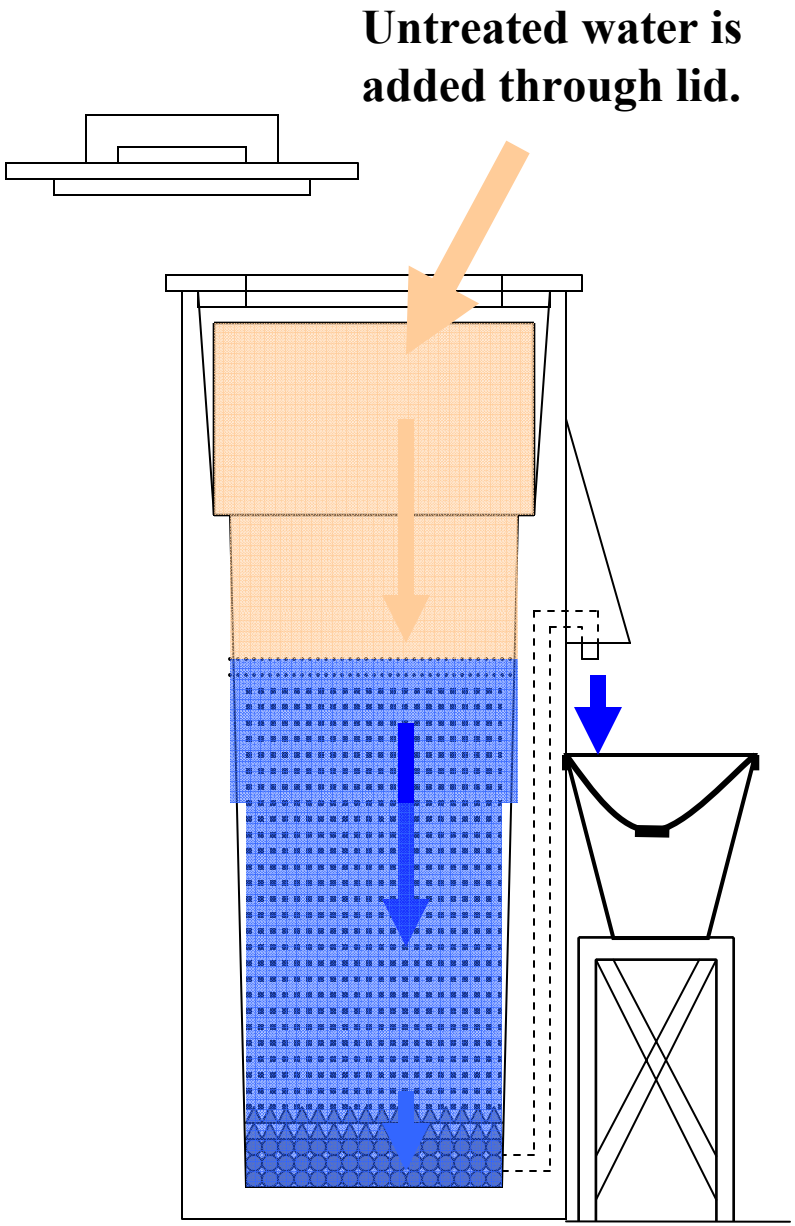


Contamination of the BSF

It is possible to destroy the effectiveness of the BSF by contaminating the filter with substances not normally contained in the untreated water supply.

The diffuser should not be used as a food storage device – cooler as this will attract various insects and spillage may contaminate the media.

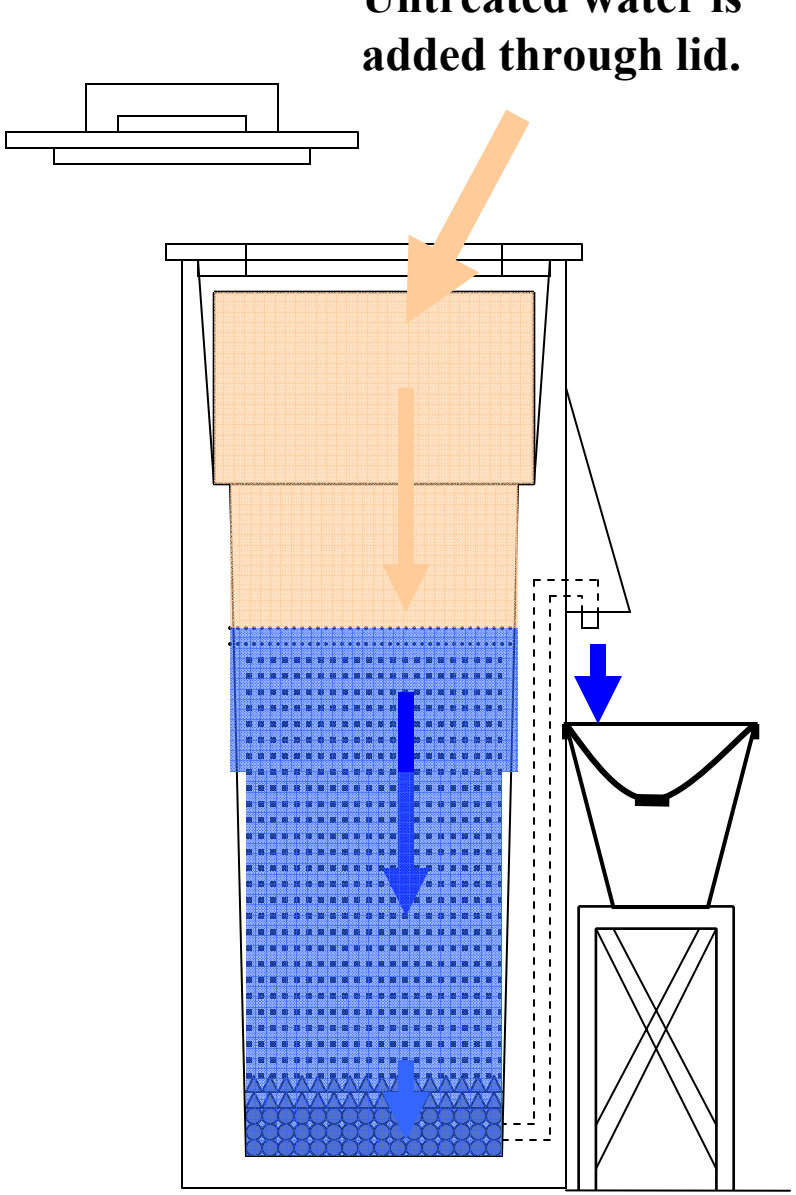
Any liquid substances such as milk, soda pop, beer, etc that is spilled into the filter will ultimately destroy the filter performance. Should this type of spillage occur the media must be replaced. Simply washing the media will not be sufficient as the particles will be coated with 'bug food' and will provide 'homes' for microorganisms until it is all consumed.



Filter Hygiene (Cleaning)

It is important that the BSF be kept clean. It is a food processing and storage device.

The lid and filter outlet should be periodically cleaned and disinfected.



Source Selection

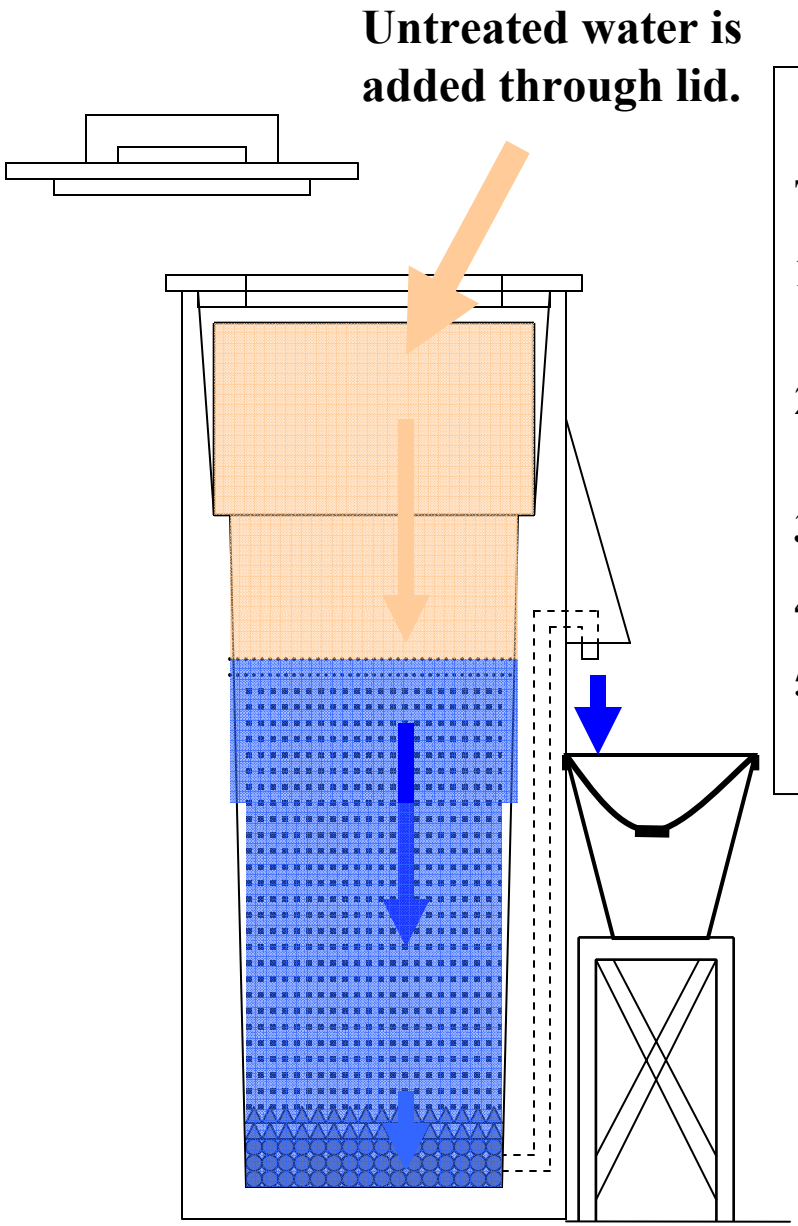
It is very important that the best available source of water be chosen as the water supply to be treated using the BioSand Water Filter.

Best to worst:

1. **Rainwater.**
2. **Distribution system (town or city).**
3. **Deep tube wells.**
4. **Shallow wells.**
5. **Springs.**
6. **Streams at high altitude in mountains or hills.**
7. **Large lakes or reservoirs.**
8. **Streams and rivers.**
9. **Ponds fed by streams.**
10. **Rain fed ponds or reservoirs.**

The source used may vary from season to season.

Infiltration wells may be constructed next to streams, lakes and ponds to provide some pre treatment of the water before filtering. These can be constructed as required.



Typical Use of the BSF

Typically:

1. **Filters are used in single households or equivalent (frequently shared).**
2. **Filters are carefully protected from the environment, children and animals.**
3. **Only water from one source is used.**
4. **Filters are properly cleaned and maintained.**
5. **Filters are valued by the consumer.**

Good Luck!