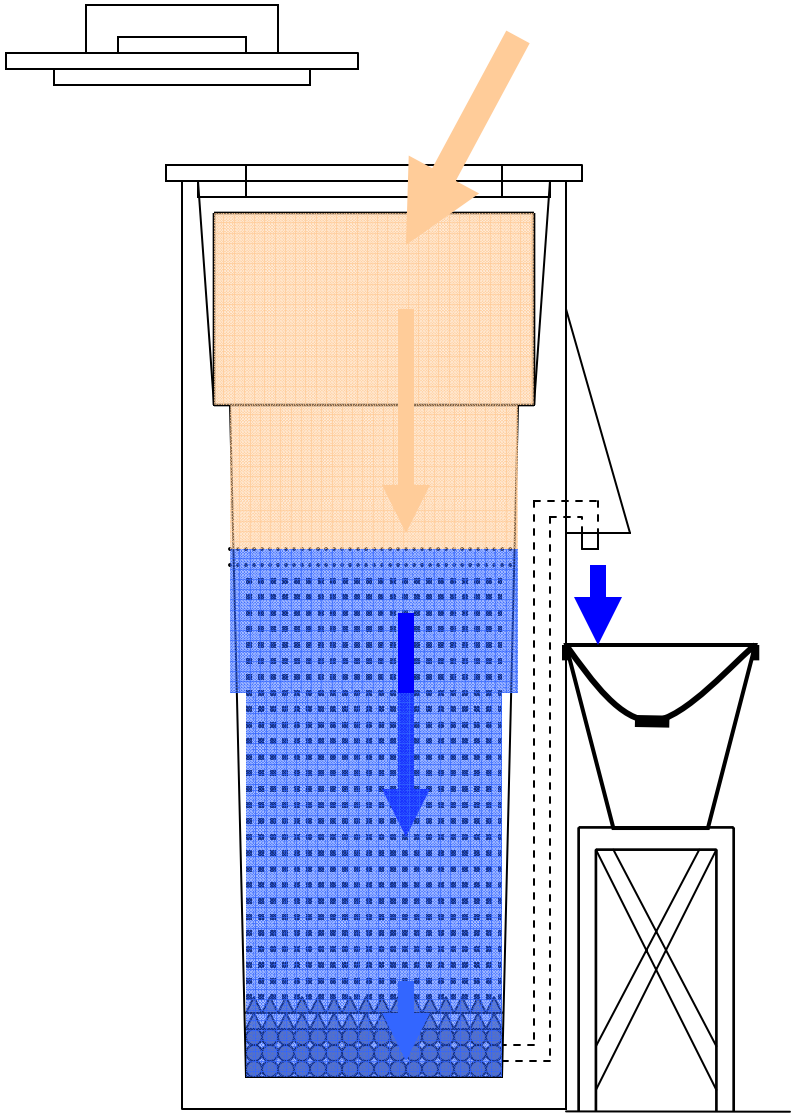


BSF Guidance Manual #5

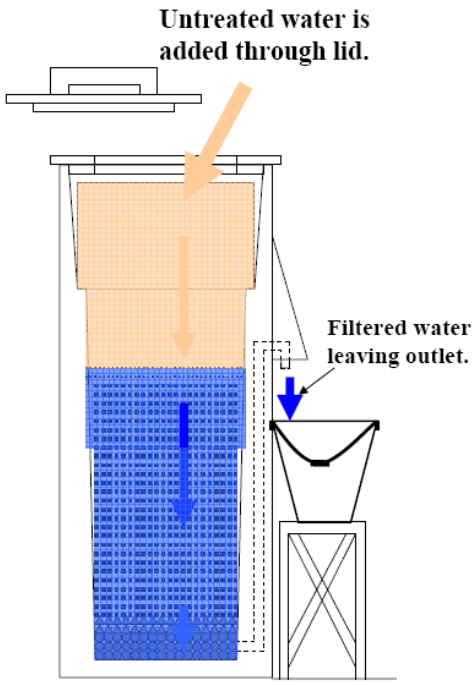
Performance Evaluation

Concrete BioSand Water Filter

January 2009

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

Performance Objectives of the BioSand Water Filter



The performance objectives of the BSF relate to the:

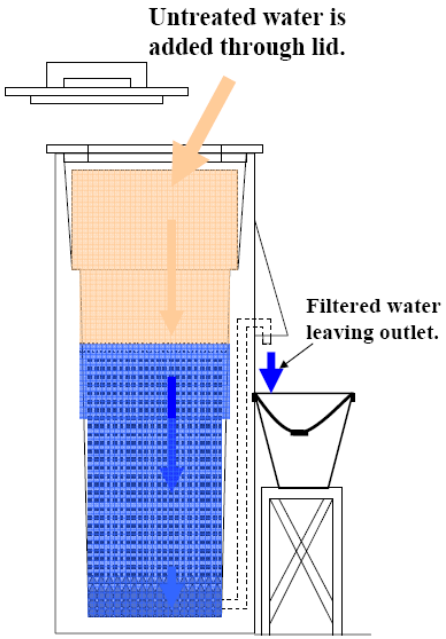
1. **Consumer.**
2. **Manufacturer.**
3. **Marketer.**
4. **Ease of technology transfer and technology support.**
5. **Funding technology transfer and support and filters themselves.**

These performance objectives are discussed extensively in the publication, 'BioSand Water Filter – Household Concrete Design' by Dr. David H. Manz published on this web site, www.manzwaterinfo.ca, in March 2007.

Those objectives associated with the consumer are the most important and of these the two considered most significant is the:

1. **Ability to remove pathogens.**
2. **Impact on the health of user/consumers.**

Ability to Improve Quality of Source Water to Render it Safe and Desirable for Human Consumption.

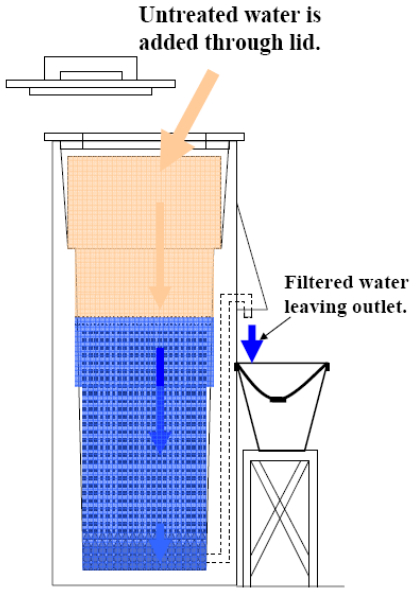


The ability to improve the quality of source water to render it safe and desirable for use by humans is the primary purpose of the BSF, (consistent with World Health Organization Water Quality Guidelines).

Ideally, this means that the BSF must be able to:

1. **Remove pathogens to the extent that remaining pathogens will be at sub -infectious concentrations. That is, the number of pathogenic organisms, of one kind, are not in sufficient numbers to cause illness. Pathogenic organisms include; helminthes, parasites, bacteria and viruses.**
2. **Reduce the concentration of toxic substances to below toxic levels.**
3. **Remove particulate matter, organic (living or dead) and mineral, to improve the utility of the water and it aesthetic appeal including colour, odour, and taste.**
4. **Remove dissolved substances to improve the utility of the water and its aesthetic appeal including colour, odour and taste.**

Capacity of the Concrete Household BSF to Improve Water Quality.

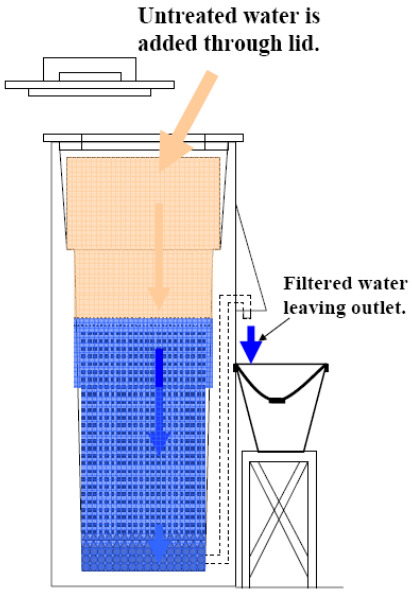


The concrete household BSF is more limited in its ability to treat water than the BSF technology in general. This is because of the simple design and operation. However, it reasonable and proven that the concrete household BSF can improve source water quality and satisfy all of its intended treatment objectives.

The BSF was proven to satisfy treatment objectives in the laboratory before 'experimenting' on consumers.

Ultimately, the BSF was proven to satisfy treatment objectives in the field; that is, in real households and communities around the world particularly when the filtered water is disinfected with chlorine (often not done).

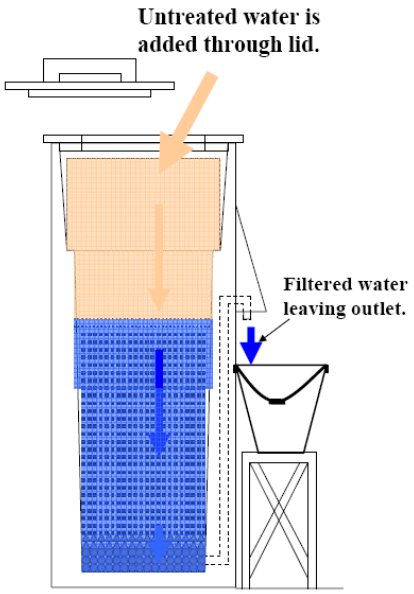
It is assumed in the 'developed world' that the provision of safe drinking water to a community, whether individually or collectively, will reduce the incidence of all forms of gastrointestinal diseases and their symptoms such as diarrhea. Proof that this is indeed the case requires some form of 'health impact assessment' usually performed as part of public health studies. In fact these kind of studies have been performed and may be examined on the web site: www.hydraid.org.



Performance Evaluation Protocols.

The procedures used to evaluate the performance of the BSF must conform to accepted protocols. The protocols must consider technical aspects issues concerning transparency and freedom of influence from vested parties. It is generally accepted that performance evaluations must be implemented by persons knowledgeable in performing required evaluations and knowledgeable of the technology being evaluated.

The exact procedures used to test for specific water quality parameters are well established (WHO Fact Sheets and AWWA, APHA and WEF Standard Methods for the Examination of Water and Wastewater). It is simply necessary to chose the most appropriate technique for the circumstances.



Pathogen Removal – Water Borne Pathogen Hazard.

Pathogen removal is the most important function of the BSF and is one of the most difficult to evaluate. See Table 7.1 on following slide taken from WHO, Guidelines for drinking water quality, third edition available free of charge on the internet.

Note that water borne pathogens will result in gastrointestinal, skin, eye and other problems.

It is useful to review the entire Chapter 7 of the WHO Guidelines for drinking water quality.

Taken from the Third Edition to the WHO Guidelines on Drinking Water.

Table 7.1 Waterborne pathogens and their significance in water supplies

Pathogen	Health significance	Persistence in water supplies[a]	Resistance to chlorine[b]	Relative infectivity[c]	Important animal source
Bacteria					
Burkholderia pseudomallei	Low	May multiply	Low	Low	No
Campylobacter jejuni, C. coli	High	Moderate	Low	Moderate	Yes
Escherichia coli – Pathogenic[d]	High	Moderate	Low	Low	Yes
E. coli – Enterohaemorrhagic	High	Moderate	Low	High	Yes
Legionella spp.	High	Multiply	Low	Moderate	No
Non-tuberculous mycobacteria	Low	Multiply	High	Low	No
Pseudomonas aeruginosa[e]	Moderate	May multiply	Moderate	Low	No
Salmonella typhi	High	Moderate	Low	Low	No
Other salmonellae	High	May multiply	Low	Low	Yes
Shigella spp.	High	Short	Low	Moderate	No
Vibrio cholerae	High	Short	Low	Low	No
Yersinia enterocolitica	High	Long	Low	Low	Yes

Table 7.1 cont'd.

Viruses					
Adenoviruses	High	Long	Moderate	High	No
Enteroviruses	High	Long	Moderate	High	No
Hepatitis A virus	High	Long	Moderate	High	No
Hepatitis E virus	High	Long	Moderate	High	Potentially
Noroviruses and sapoviruses	High	Long	Moderate	High	Potentially
Rotaviruses	High	Long	Moderate	High	No
Protozoa					No
Acanthamoeba spp.	High	Long	High	High	No
Cryptosporidium parvum	High	Long	High	High	Yes
Cyclospora cayetanensis	High	Long	High	High	No
Entamoeba histolytica	High	Moderate	High	High	No
Giardia intestinalis	High	Moderate	High	High	Yes
Naegleria fowleri	High	May multiply[f]	High	High	No
Toxoplasma gondii	High	Long	High	High	Yes
Helminths					
Dracunculus medinensis	High	Moderate	Moderate	High	No
Schistosoma spp.	High	Short	Moderate	High	Yes

Table 7.1 cont'd.

Note: Waterborne transmission of the pathogens listed has been confirmed by epidemiological studies and case histories. Part of the demonstration of pathogenicity involves reproducing the disease in suitable hosts. Experimental studies in which volunteers are exposed to known numbers of pathogens provide relative information. As most studies are done with healthy adult volunteers, such data are applicable to only a part of the exposed population, and extrapolation to more sensitive groups is an issue that remains to be studied in more detail.

[a] Detection period for infective stage in water at 20 °C: short, up to 1 week; moderate, 1 week to 1 month; long, over 1 month.

[b] When the infective stage is freely suspended in water treated at conventional doses and contact times. Resistance moderate, agent may not be completely destroyed.

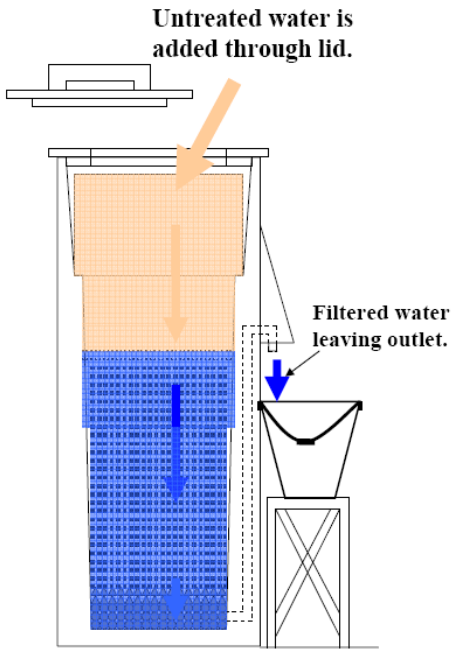
[c] From experiments with human volunteers or from epidemiological evidence.

[d] Includes enteropathogenic, enterotoxigenic and enteroinvasive.

[e] Main route of infection is by skin contact, but can infect immunosuppressed or cancer patients orally.

[f] In warm water.

Pathogen Removal – Standards.



Pathogen removal is the most important function of the BSF and is one of the most difficult to evaluate. Generally, the risk of the pathogen hazard of water to be used for human consumption is 'indicated' by the presence or absence of coli form bacteria. Fecal coli form or Escherichia coli form (E-coli) bacteria are present in very large numbers in the intestinal tracts of warm blooded animals (including humans). The presence of these bacteria is used as a measurement of the potential risk that the water might contain other types of water borne organisms (cholera, Giardia, Cryptospordia, dangerous forms of e-coli, etc.). Generally, safe drinking water should not contain any viable fecal coli form or e-coli bacteria.

Coli form bacteria are also present in the soil and air. The presence of any type of coli form bacteria in water, regardless of origin, is measured in terms of 'total coli form' bacteria. The presence of coli form bacteria, of any kind, indicates that the water 'might' have been exposed to pathogenic organisms. Safe drinking water is typically allowed to occasionally test positive for a 'few' total coli form bacteria.

Taken from the Third Edition to the WHO Guidelines on Drinking Water.

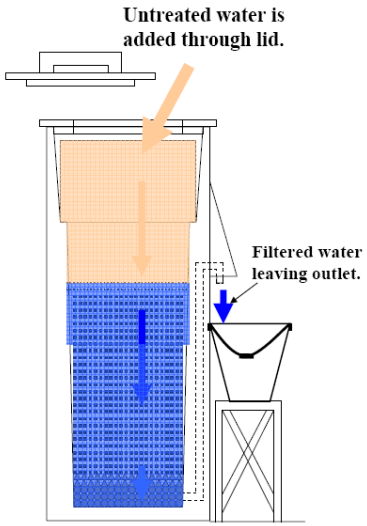


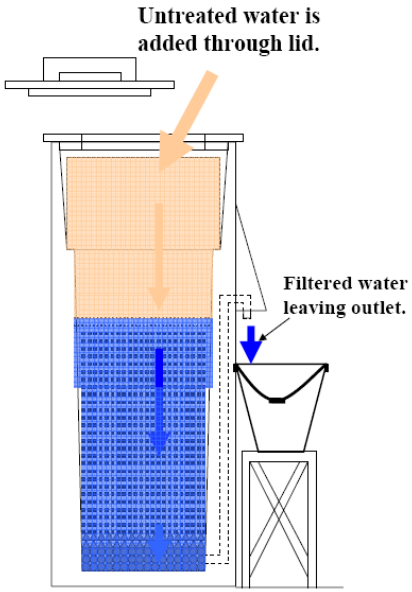
Table 7.7 Guideline values for verification of microbial quality[a] (see also Table 5.2)

Organisms	Guideline value
All water directly intended for drinking	
E. coli or thermotolerant coliform bacteria[b,c]	Must not be detectable in any 100-ml sample
Treated water entering the distribution system	
E. coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Treated water in the distribution system	
E. coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample

[a] Immediate investigative action must be taken if *E. coli* are detected.

[b] Although *E. coli* is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory tests must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of water supplies, particularly in tropical areas, where many bacteria of no sanitary significance occur in almost all untreated supplies.

[c] It is recognized that in the great majority of rural water supplies, especially in developing countries, faecal contamination is widespread. Especially under these conditions, medium-term targets for the progressive improvement of water supplies should be set.

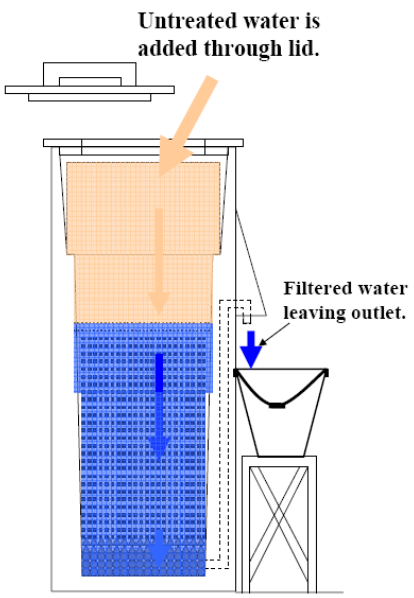


Pathogen Removal – Standards.

It is customary to consider water that does not test positive for any of the indicator organisms as safe for human consumption – unfortunately this is not always true. It is possible for certain pathogens, encysted parasites for example, to be present while indicator organisms are not present. This situation commonly occurs when water that contains parasites is only chlorinated. Indicator organisms and other bacteria and viruses may be killed or inactivated but the parasites will remain viable and infectious.

Well treated and chlorinated water supplies such as distributed in most small to major cities in warm climates is contaminated when the pressure in the distribution lines drops below the water pressure in the groundwater outside the line. Groundwater containing parasites is drawn into the distribution pipe and water unsafe for human consumption (testing negatively for indicator organisms) is provided to the consumers.

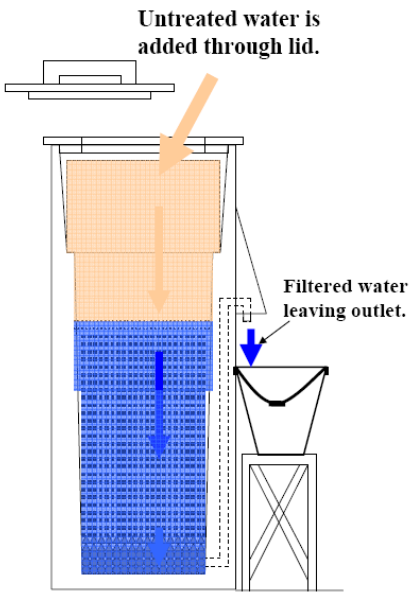
Pathogen Removal – Standards.



It is customary to consider water that does not test positive for any of the indicator organisms as safe for human consumption – unfortunately this is not always true. It is possible for certain pathogens, encysted parasites for example, to be present while indicator organisms are not present. This situation commonly occurs when water that contains parasites is simply chlorinated. Indicator organisms and other bacteria and viruses may be killed or inactivated but the parasites will remain viable and infectious.

Well treated and chlorinated water supplies such as distributed in most small to major cities in warm climates is contaminated when the pressure in the distribution pipes drops below the water pressure in the groundwater outside the line. Groundwater containing parasites is drawn into the distribution pipe and water unsafe for human consumption (might appear chlorinated and still testing negatively for indicator organisms) is provided to the consumers. This problem is evident whenever water is distributed on a rotational basis.

Pathogen Removal - BSF.



The BSF can be expected to remove close to 100% of parasites (protozoan) and larger organisms such as helminthes – a well developed biolayer is actually not required.

A newly installed and commissioned BSF can be expected to eliminate 60% or more of the bacteria and viruses from the source water.

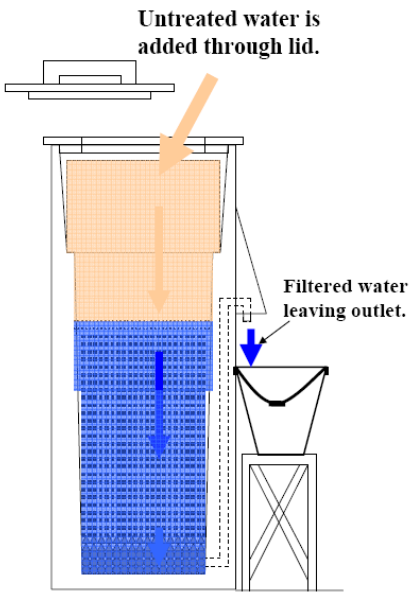
A BSF that has been operating for several weeks (time required for biolayer to develop) can be expected to eliminate 95% or more of the bacteria and viruses from the source water.

Disinfection of filtered water using dilute solutions of liquid chlorine or chlorine tablets will produce water with no hazard from water borne pathogens even if the filtered water is cloudy (from colloidal particles) or has significant colour.

Disinfection MUST be sufficient to provide a small chlorine residual that may or may not be detected by the odour of the water. Excess chlorine can be removed by simply allowing the water to stand for a few hours.

Disinfection, similar to that advocated by the US CDC, after filtration has always been recommended.

Laboratory Evaluation of the BSF.



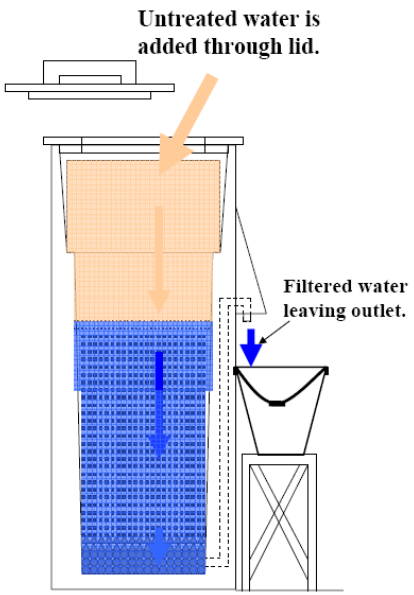
Though extensive laboratory evaluations were performed prior to the introduction of the BSF to the world community, there continues to be a significant need to pursue numerous studies on the BSF technology by many independent investigators in a laboratory setting. These studies focus primarily on pathogen removal, in particular removal of indicator organisms.

The basic guidelines for this type of activity are:

1. The filter being used for evaluation must the same concrete filter or have identical vertical dimensions to those recommended for concrete filters. The width or diameter should not be less than 15 cm to avoid 'side effects' and facilitate cleaning. The diffuser must fit identical to the field prototype with the same relationship to the paused water depth and the surface of the media.

2. Insure that the guidelines for installation and commissioning are carefully followed (See papers in web site www.manzwaterinfo.ca.). Any changes should be carefully explained and documented. Under no circumstances consider using any form of accelerant (such as sterilized waste water) for the rapid development of the biolayer. This procedure may or may not work and these substances will seriously contaminate the entire filter bed and render any further testing suspect – at least as far as testing the BSF technology is concerned. The ONLY water that should be added to the filter is the source water.

Laboratory Evaluation of the BSF – cont'd.

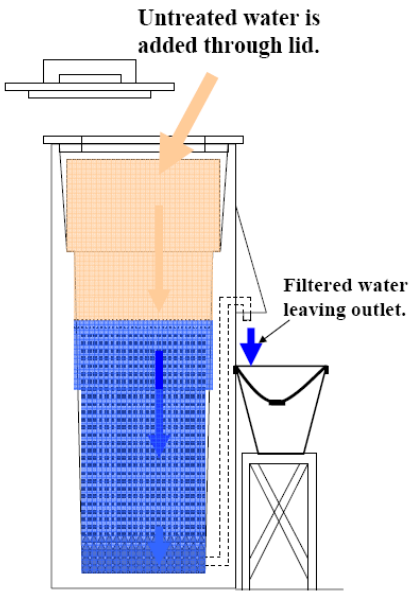


3. **Media used in the filter must be produced exactly as described in papers that may be found in the web site: www.manzwaterinfo.ca. Evaluations should be consistent with media selection and be carefully documented. The type of material that is used to produce the media must be thoroughly described. The process used to produce the media should be described. A complete particle size analysis is required to adequately characterize the media. The media should be tested for bacterial contamination and results recorded.**

4. **Water used to evaluate the filter MUST constitute a complete aquatic ecology, predators and prey, that includes the pathogens or indicator organisms being removed (cysts and oocysts and larger organisms may be exceptions to this guideline). Ideally the source water used for testing purposes is naturally occurring with very small variation in quality, biological, chemical or physical, from day to day. If it is desired to vary the quality of the water for purposes of testing a 'synthetic water' may need to be developed and evaluated as per suitability for use in evaluation process. While this may be reasonable in a developing country context it is often very difficult in a developed country context.**

5. **All apparatus used for testing should be photographically documented.**

Laboratory Evaluation of the BSF – cont'd.



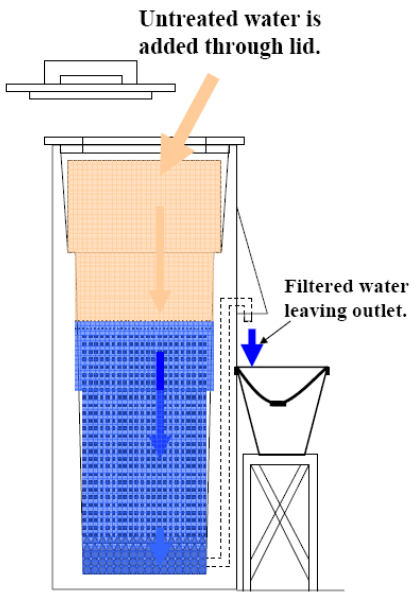
6. **If synthetic water is produced that is believed to have a complete aquatic ecology it is important to verify that the filter is performing similarly when treating synthetic water and natural occurring source water. (NOTE: A complete aquatic ecology means a micro-biological ecosystem that includes organisms that have predator – prey relationships. Natural occurring micro-biological ecosystems will normally have these relationships. The relationship may require allowing the laboratory produced source water to develop a stable ecology prior to using the source water for testing the BSF. A complete ecology is essential because these organisms are responsible for forming the biolayer and actively participate in the removal of bacteria and viruses. The introduction of indicator bacteria and viruses immediately before filtration may not result in a biolayer that includes predator organisms responsible for their removal.)**

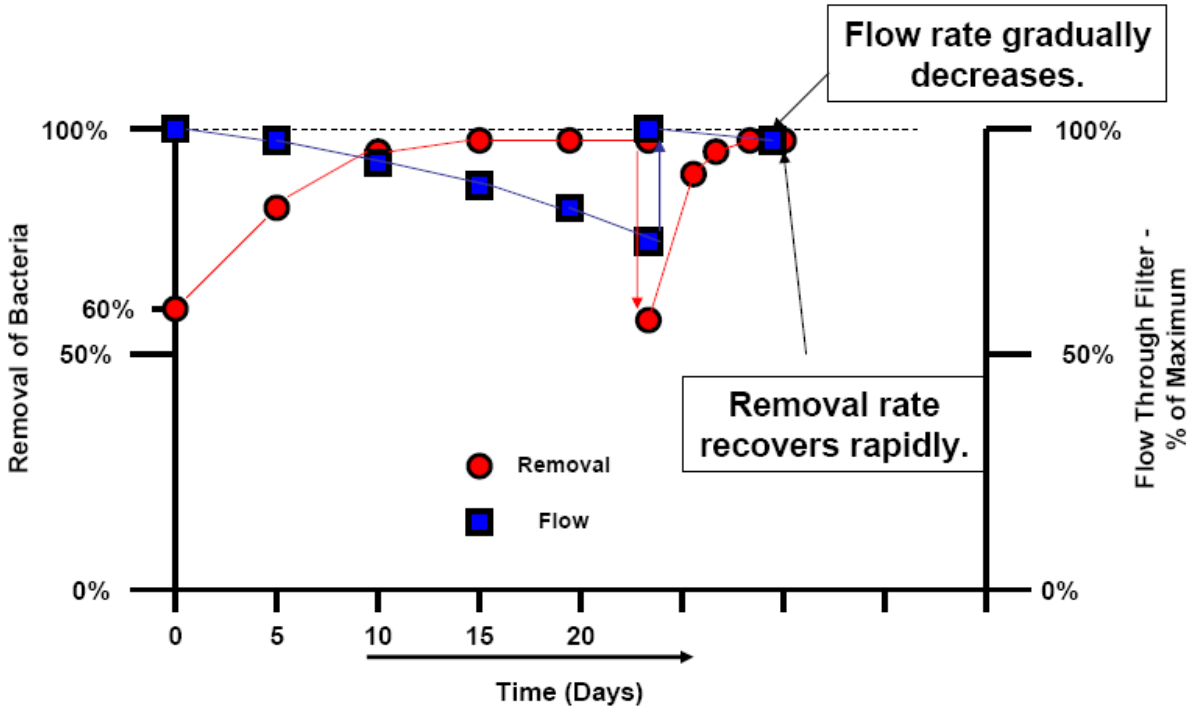
7. **Consideration should be given to the chemical, physical and biological characteristics of the water being treated, temperature, exposure to sunlight, and manner of operation including the amount and timing of water treatment.**

8. **The BSF should be operated, cleaned or maintained exactly as per guidelines presented in www.manzwaterinfo.ca. Maximum rate of filtration should be carefully monitored.**

Laboratory Evaluation of the BSF – cont'd.

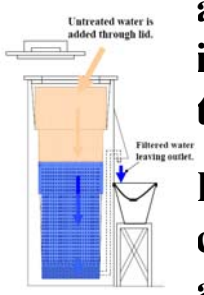
If the laboratory evaluations of indicator bacteria removal of the BSF are performed as just described the filter performance should be generally similar (with variations of course) to that shown below.





Sample Testing Using the Membrane Technique

It is strongly recommended that some form of membrane technique be used to enumerate indicator bacteria (total coli form bacteria and fecal coli form bacteria or e-coli bacteria) concentrations in the water poured into the filter, paused water and filtered water. Membrane techniques need to be field evaluated to determine the exact type that works best. Other bacteria and organisms may cause false counts, inhibit growth of target bacteria or overgrow the membrane hiding all useful results. Membrane techniques are usually limited to circumstances where there are no more than 200 colonies on the membrane. When it is suspected that the number will be greater than 200 (or the quality of the water is unknown) a series of dilutions should be performed. It is understood that there is additional cost associated with the dilutions but it should be recognized that there was significant cost incurred in the process of obtaining the sample and valuable information will simply be lost if the appropriate methodology is not used.



Equipment used for testing water samples using the membrane technique may be quite compact and easy to transport. Consumables may be purchased ready for testing and easily and safely disposed of. These kits are ideal when sampling locations are remote and it is difficult to maintain sample integrity before returning to a permanent laboratory. There are several suppliers of kits which include all of the equipment required to accurately use the membrane technique in the field. These kits may use local electricity, rechargeable batteries or may be operated using power from a vehicle with a cigarette lighter.

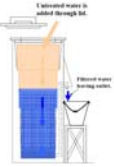
If a permanent laboratory is available with large autoclaves, cold storage, readily available supplies of pure water, laboratory space and benches and incubators it may be reasonable to prepare reagents, etc. and use reusable apparatus. This approach can be much less expensive in terms of the cost of the materials required to test each sample but it is much more labor intensive and requires a secure environment with reliable electricity.

Sample Testing Using the Most Probable Number Technique

Most Probable Number or MPN techniques, historically, have not provided the same quality of information as membrane techniques and are less useful because their resolution (ability to detect small changes) at low concentrations of bacteria is not very good. They are meant to be used to test water that might be very contaminated such as municipal wastewater. However, new commercially available techniques, such as the IDEXX Quanti-Tray and Quanti-Tray 2000 have been proven to be as or more accurate than membrane filtration technologies when appropriately used to quantitatively examine water and waste water for the presence of indicator bacteria.

Commercially available MPN technologies use a method that involves filling a plastic plate with 100 or so cells with water to be tested and incubated. During incubation the cells with coli form bacteria change color and the colored cells are counted. The number of colored cells is then related to bacteria concentration using a manufacturer supplied table. Fecal or e-coli are identified by using UV light which cause cells with these bacteria to phosphoresce. These cells are counted and their concentration is determined using the manufacturer supplied table. The greatest source of errors using the commercially available technique is that there might be bacteria present that behave very similar to the target indicator bacteria and the subjectivity associated with determining if a cell is indeed colored. The effects must be carefully accounted for in discussions with the manufacturer who can then advise on a course of action.

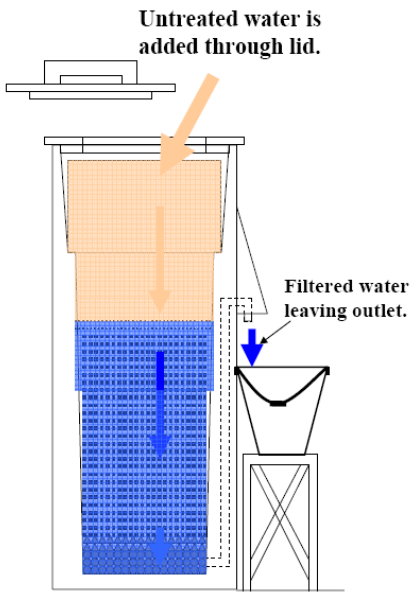
MPN methods that use traditional multiple tube technique have very low resolution and are really not intended to test water intended for human consumption.



MPN techniques are very useful when first determining level of bacterial contamination with a vie that further testing would be performed using the membrane technique.

If the MPN technique is to be used the results should be correlated with membrane techniques (that can be trusted) using water that is similar to that which will be examined during the actual testing program. This will insure that all potential interfering influences are accounted for.

Sample Testing Using Commercial Laboratories



Great care must be taken when having water samples tested for coli form bacteria by commercial laboratories. Commercial laboratories need to be given very careful instructions pertaining to exactly what type of test will be performed, how it will be performed, handling of the samples, certification of the laboratory, expected return of results of analysis and cost.

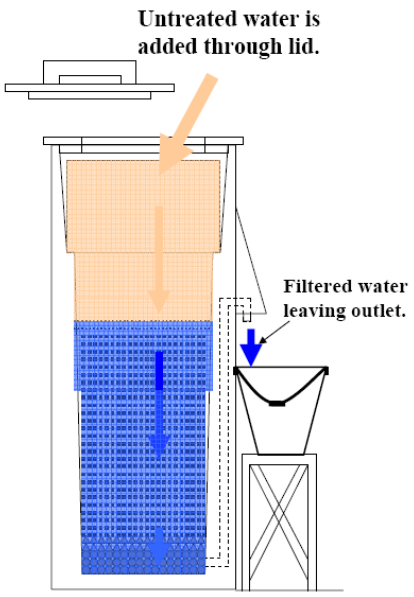
Commercial laboratories may use several methods for testing water for bacteria including the membrane and multiple tube MPN method. Care must be taken to determine which method is being used and how it is being used to assess whether reliable and useful results can be expected.

Commercial laboratories are expensive. It is not uncommon for a single test to cost US $25.00 to $50.00.

Typically, the commercial laboratory will not perform dilutions (but might if requested). It may be advisable to prepare dilutions before taking the samples to the laboratory.

If there is any doubt that a commercial laboratory is providing quality testing duplicate samples should be sent to different laboratories. Placebos, with known contamination, (such as bottled water), might also be sent in containers identical to those used for the actual sampling.

Sample Testing Using Medical and Other Laboratories



Medical laboratories should not be considered for purposes of testing water samples.

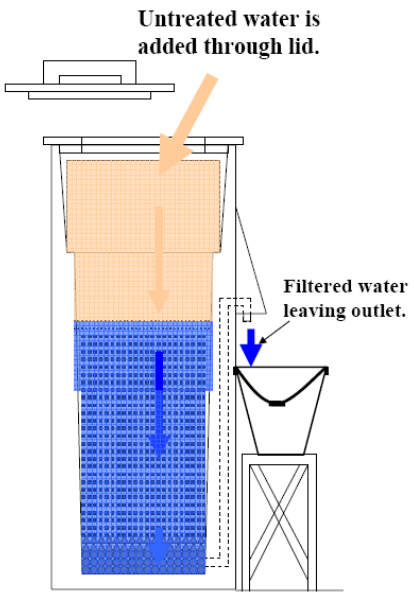
Medical laboratories test samples of blood and other body fluids that may be quite dangerous to human health.

The equipment used in a medical laboratory is very different from that used to test water.

It is not recommended that medical and water testing laboratories share the same space.

There are many industries that need to perform microbiological testing on water. The exact nature of the testing will vary greatly because of their different needs. Care must be taken to precisely ascertain what procedures are being used, the quality control being exercised, the precision of the testing procedures, access to laboratory, etc.

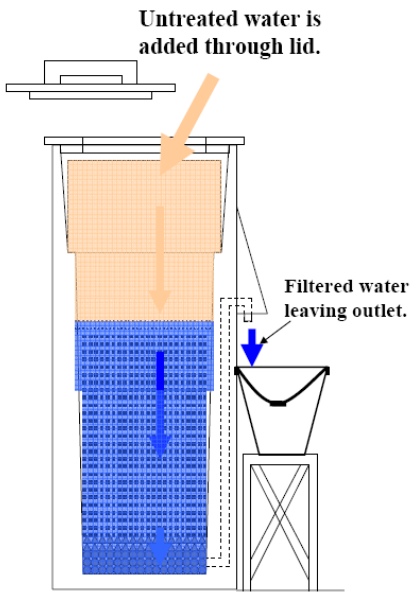
Comparison Testing



If there is any doubt as to the validity of a particular testing method or questions concerning the quality of testing a particular commercial laboratory it is advisable to do a number of comparison tests – different laboratory procedures, sending same samples to several commercial or government laboratories, comparing laboratory test results to commercial laboratory using the same water sample, etc.

There should be <u>complete confidence in the test results before any attempt is made to interpret</u> the results.

Taking and Transporting Water Samples



Water samples should be taken using sterile containers that cannot be contaminated during transport. Sterile bottles with tightly fitting screw tops are best though specially designed disposable plastic bags are also very good. Bottles need to be cleaned and sterilized after every use.

Great care must be taken not to contaminate the water while taking the sample. Best techniques will fill sample bottles or bags while the water is flowing as it is being added to the filter or when it is leaving the filter.

Often taking the water sample requires dipping some device (like a cup, dipper or soup ladle) into the water and then filling the sample bottles or bag with this water. The device MUST be sterile. DO NOT DIP THE SAMPLING BOTTLE OR BAG INTO THE WATER BEING SAMPLED.

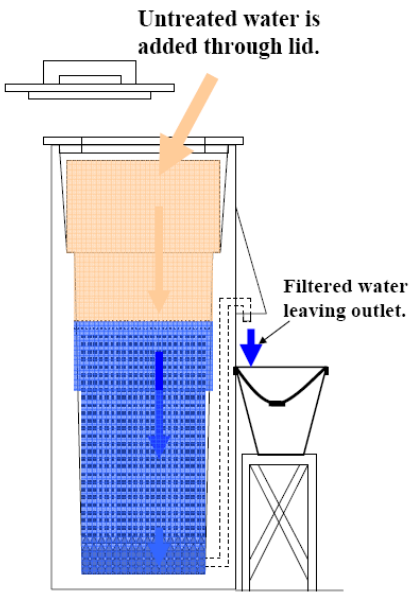
It may be important to insure that the filter outlet is clean – if you really wish to test filter performance rather than filter performance AND household sanitation practices together (useful but should be identified as a separate issue).

It is important that the person taking the sample have very clean hands or use fresh latex gloves when taking the samples. It is very easy to contaminate samples.

Water samples should be processed for testing as soon as possible – no more than a few hours. If this is not possible the samples should be kept very cold – using ice or ice packs – that might allow transport up to 12 hours or more.

If water samples are to be tested using a commercial laboratory it is important to use the sample containers and sampling procedures recommended by the laboratory.

CAUTION!



It is very important that ANY water testing program be carefully thought through and carefully executed.

The results of poor testing is BAD DATA, WASTED MONEY AND WORST OF ALL MISREPRESENTATION OF THE PROCESS BEING EVALUATED.

Once bad or poor data is published it is very, very difficult to get rid of. It tends to resurface at unexpected times and always needs to be explained away.

It is expected that the BSF performance will be evaluated – many times – as often as there are projects, at least. It is the responsibility of the people executing the performance evaluation to take EVERY precaution to implement their program correctly – not just adequately.

Trying one's best is a 'given'; but, collecting questionable information is not just useless, it is damaging – to everyone.

Taken from the Third Edition to the WHO Guidelines on Drinking Water.

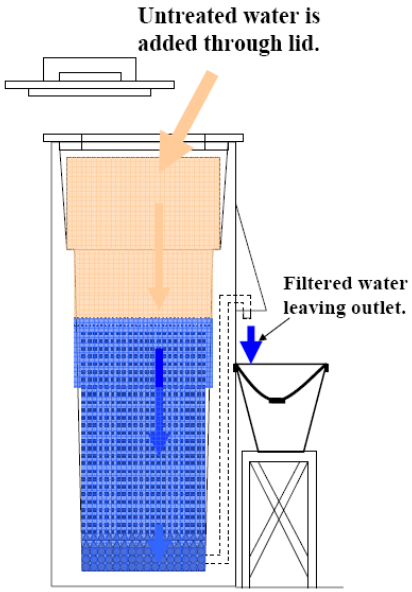
Table 7.8 International Organization for Standardization (ISO) standards for detection and enumeration of faecal indicator bacteria in water

ISO standard	Title (water quality)
6461-1:1986	Detection and enumeration of the spores of sulfite-reducing anaerobes (clostridia) — Part 1: Method by enrichment in a liquid medium
6461-2:1986	Detection and enumeration of the spores of sulfite-reducing anaerobes (clostridia) — Part 2: Method by membrane filtration
7704:1985	Evaluation of membrane filters used for microbiological analyses
7899-1:1984	Detection and enumeration of faecal streptococci – Part 1: Method by enrichment in a liquid medium
7899-2:1984	Detection and enumeration of faecal streptococci – Part 2: Method by membrane filtration
9308-1:1990	Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive *Escherichia coli* – Part 1: Membrane filtration method
9308-2:1990	Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive *Escherichia coli* – Part 2: Multiple tube (most probable number) method

Field Evaluation of the BSF.

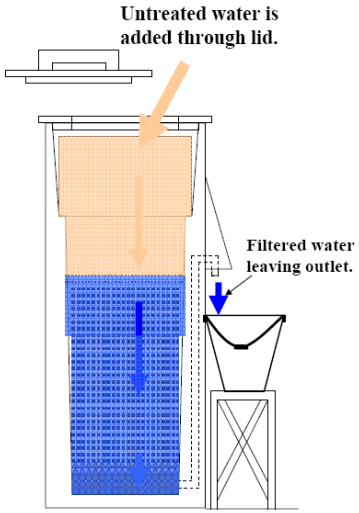
Field evaluation of the BSF can be very complex because many of the parameters that will effect the quality of the filtered water may be constantly and unpredictably changing.

The following guidelines are useful:



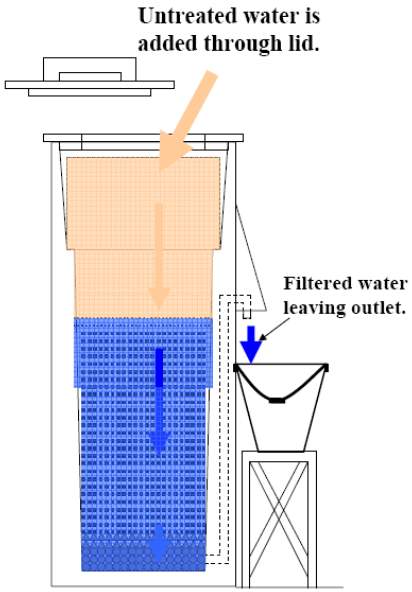
1. **Insure that the method of media preparation and filter installation and commissioning is known and hopefully is similar to that outlined in the guidelines provided in www.manzwaerinfo.ca. Deviations from the recommended guidelines are important and should be carefully documented.**
2. **Filters should be located such that they are protected from the environment, animals and humans. Every installation should be photographed.**
3. **Filter use, including source and volume and timing of use, should be carefully documented.**
4. **Consumers should be carefully trained in filter use, care and cleaning. Consumers should be visited at least one week after installation and again every month for 3 months. Consumers should be able to contact technical support if needed.**
5. **Consumers should be informed about the importance of the evaluation process and encouraged to be part of insuring its success.**
6. **Source water should be carefully documented including photographs and description of its variability.**

Field Evaluation of the BSF – cont'd.



7. **Filter outlet should be kept clean with minimum risk of contamination.**
8. **Lid and diffuser should be inspected and removed and condition documented prior to sampling paused water.**
9. **The condition of the surface of the media, including colour and odour, should be documented.**
10. **Source water should be thoroughly mixed prior to adding to filter to allow taking a well mixed sample of source water for testing. (Sediment, bacteria and other organisms rapidly settle in still water.) All of the source water will ultimately be added to the filter. Any bias will be eliminated by the mixing process.**
11. **Unless it known for sure that the quality of the source water is constant quality the paused water should always be sampled before the filter is tested. Knowledge of paused water quality is the only way to know how the source water quality has changed from the previous use. Measuring conductivity of paused, source and filtered water will provide considerable knowledge as how source water has changed and progressed through filter.**
12. **The sample of filtered water that corresponds to the water being added to the filter should be taken at the filter outlet when almost all of the newly added water (20 L or more sufficient to) has been produced. Samples taken before this time may not correspond to the water added but to previous containers of water of unknown origin.**

Field Evaluation of the BSF – cont'd.



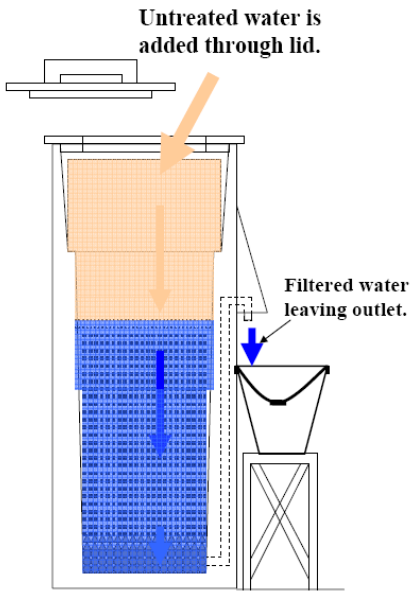
13. **It is strongly recommended that some form of membrane technique be used to enumerate indicator bacteria (total coli form bacteria and fecal coli form bacteria or e-coli bacteria) concentrations in the water poured into the filter, paused water and filtered water.**

14. **MPN techniques do not provide the same quality of information and are less useful. MPN techniques are useful when the quality of the water is completely unknown, rapidly varies and the number and nature of dilutions necessary to use the membrane technique render the technique impractical. Typically only the source and paused water would require several dilutions and only when the quality of the water is known to have dramatically changed.**

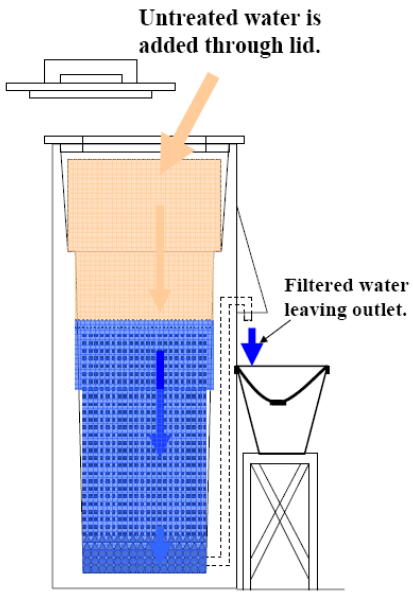
15. **Testing filtered water from a BSF should be performed with the knowledge of the length of time the filter has been in use and the quality of media used in its installation. If there is any question that the media used might be contaminated 'because there is no crushed rock' two months or more of normal filter use may be required before normal filter performance might be expected.**

16. **Occasionally the consumer may need to completely remove the top layer of media, wash it and replace it. This type of activity should be documented.**

Field Evaluation of the BSF – cont'd.



17. Filter outlet should be kept clean with minimum risk of contamination.
18. Field evaluations can easily include measurements of: turbidity, conductivity, colour, pH. These measurements can be made with light portable meters often without use of batteries. The additional information may aid interpretation of data.
19. Note that filtered water with elevated turbidity due to the presence of colloidal particles is still safe to drink. Colloidal particles which pass through the filter are typically much smaller than even bacteria; that is, bacteria cannot hide on or in them. Removal of bacteria is not impaired by the presence of colloidal particles but disinfection after filtration will be.
20. Note that filtered water with elevated colour is still safe to drink but may be much more difficult to disinfect.
21. Extra samples may be taken to perform chemical analysis for substances such as hardness, iron, manganese, arsenic and fluoride. Portable and reasonably accurate devices are distributed by Hach, Palintest and others.
22. Total and free chlorine analysis may be very useful when sampling filters in an urban environment.
23. Consideration should be given to establishing a 'control filter' that uses similar source water but is operated by the evaluating team themselves. The use of a control filter would aid in explaining unexpected results.



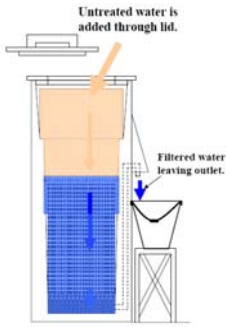
Evaluation of the BSF

when there are Few Bacteria in the Water .

In order to evaluate the performance of the BSF technology there should be more than 100 detectable bacteria present. Preferably, there should be several hundred bacteria so that removal rates can be more accurately determined.

It is inevitable that even when there are very few bacteria in the untreated water that one or two will manage to make their way through to the filter outlet and the resulting removal rate will appear to be low. When averaged with those times when no bacteria are detected the performance of the filter may not appear to be very good.

Third Party Evaluation of the BSF

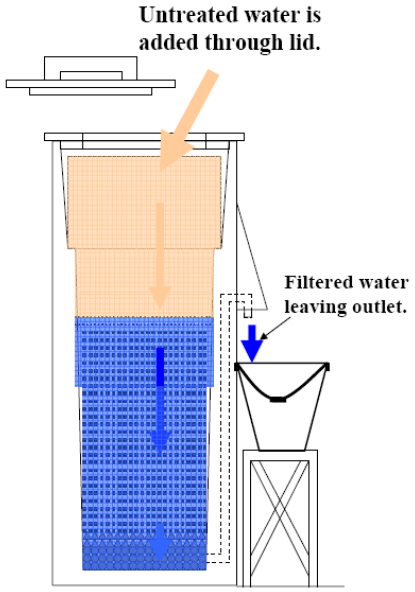


Third party evaluation means individuals or organizations perform the evaluation of the technology independently of those who established the intervention in the first place. The 'third party' should not have a vested interest in the outcome of the evaluation – they should be impartial – somehow distanced from any influence by those whose project they are doing the evaluation on. Often these kinds of evaluations are commissioned by the project implementers in order to establish the credibility of themselves and the technology. As well other interested parties, such as local government authorities, might initiate an independent study at their own cost without the knowledge of the project implementers. Other individuals and groups might initiate independent studies for reasons of their own.

It is apparent that every effort MUST be made to insure that projects are implemented correctly from the outset – not only because this is the preferred way to implement a project but also because one simply never knows when an evaluation will occur. One can only hope that the individuals doing the evaluation are knowledgeable about the method of performing evaluations and the BSF technology being evaluated.

If a third party evaluation is commissioned it is imperative (intelligent) that every effort is made to insure that the projects have been properly implemented and are performing to expected standards BEFORE the performance evaluation is initiated. It is foolhardy to simply expect that everything will work out fine simply because the BSF technology has received numerous positive evaluations numerous times. There are many reasons for a new project to have problems that need to be worked out. When there is a reasonable degree of certainty that all is well third party evaluations may be implemented. It is critical that the individuals or organization performing the evaluation thoroughly understand how the technology works and how it is used. It is assumed that they are 'professional' enough to not allow any attempt to bias the results in the favor of the implementing organization and to seek advise when required to perform their tasks well.

Evaluation of the BSF – Additional Comments

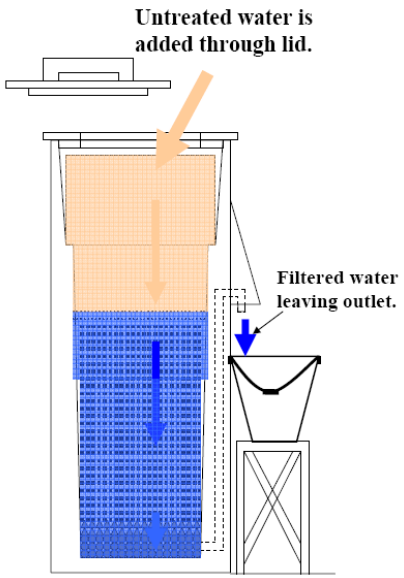


There is a view that BSF installations may be evaluated similar to the processes used in urban communities of developed countries. The argument being that the water used for consumption MUST conform to generally accepted drinking water guidelines that are similar to those found in developed countries; and, interestingly enough, probably similar to those of so-called developing countries (perhaps where the filters are installed) – 'just take as sample from the tap approach'. I call this type of evaluation the 'gold standard' and it would be entirely appropriate except that the assumptions inherent are not always correct for the following reasons.

1. The BSF technology is usually provided to 'improve' the water and make it as safe as possible for human consumption in the physical and operational context in which it is being used, compared to previous practice in the community and in light of the cultural biases of the community. It might be that the water borne pathogen causing most of the disease is a parasite – easily removed by a BSF. The filtered might still contain significant levels of indicator bacteria, still have significant turbidity and color; but, its use might have dramatically improved peoples health (as defined by them) and they are using the now ample supplies of 'improved' water for many other sanitary and personal hygiene purposes.

2. Many people will simply not put chlorine into their drinking water so this water still contains indicator bacteria. (There are many individuals and communities in developing countries that refuse to put chlorine in their drinking water.) Note that disinfection of any kind should preferably be preceded with filtration.

Evaluation of the BSF – Additional Comments cont'd.



3. **All evaluations must have a purpose beyond the generation of numbers. A properly implemented evaluation should be able to provide incite into why the numbers, 'good or bad' have been generated. Simple testing of water being used for consumption does not do this.**

4. **Over the years it has come to my attention that many of the so-called field evaluations, performed on be-half of some group wishing to fund safe water programs, wish to discredit programs in favor of their own approach. This is unfortunate. There are several ways to provide improved water and none are perfect or infallible – for a variety of reasons. I believe that evaluations of any type should always be transparent and performed in close collaboration with the original interveners and the community being evaluated. So-called independent, third party evaluations often go astray simply because they actually do not know exactly what is being evaluated.**

5. **Field evaluations of BSF technology might also include issues such as:**

   Cost of implementation.

   Cost of operation.

   Consumer acceptance.

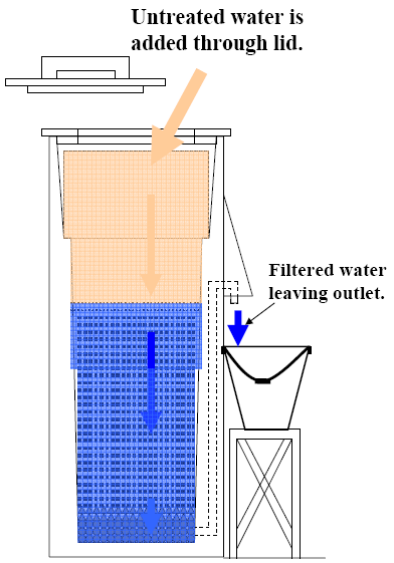
   Need and delivery of ongoing technical support.

   Need and delivery of additional product.

   Health impact.

   Sustainability; and, a number of other very important issues.

Evaluation of the BSF – Additional Comments cont'd.

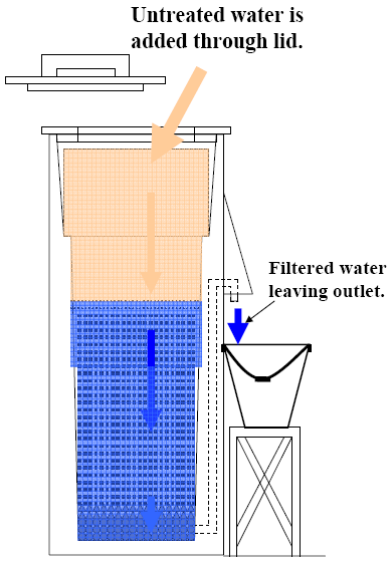


6. **Field evaluations of BSF technology for purposes of observing how it serving the consumers should closely consider the guidelines presented in this document – at the very least.**

7. **There is ample room for improving the BSF technology but it is imperative that these improvements consider the underlying principles of the technology. Considerable focused research is required to advance the BSF technology as it presently stands. More case histories need to be documented and adequately reported.**

8. **There is a need to better understand the exact water treatment capabilities of various point-of-use technologies in the developing country context. The fact that water with low turbidity and does not test positive for any indicator bacteria might still make you seriously ill, such as found in most large metropolitan centers around the world, highlights this problem.**

9. **Is the 'doing something is better than nothing' argument valid? I do not believe so. There is a minimum standard and I think the BSF technology in its simplest variation and implementation, though not a perfect treatment solution, should be the minimum standard against which other treatment technologies should be compared. There is little utility in treatment technologies that for example can remove only half of the parasites, seventy per cent of the bacteria and viruses, produce at best a bucket of water per day, require frequent replacement parts, are difficult or sensitive to operation, have limited availability, can treat a limited range of source water, has a short useful life, easy to break, is expensive to buy or requires frequent outside intervention to be sustainable.**


Untreated water is
added through lid.
Filtered water
leaving outlet.

Good Luck!