DACAAR Water Expertise
and Training Centre
(WET Centre)

Best Practice on Biosand Filter

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DACAAR

Contents

Introduction

Recent systematic review of water, sanitation and hygiene interventions suggest that the beneficial effect of improving household water quality at the point of use (PoU) in the reduction of the risk for diarrheal disease had been previously underestimated.

An up to date review estimates a 30-40% reduction in diarrheal disease by improving household drinking water quality at the PoU, making such treatment more effective than improvement at the source, which reduces diarrheal diseases by 25%.

The goal of PoU household water treatment and safe storage technologies is to empower people with no access to safe drinking water to improve water quality by treating and storing it safely at home. The biosand filter (BSF) is an emerging PoU water treatment technology that is currently being implemented and promoted internationally.

Laboratory studies have examined biosand filter (BSF) performance, including its ability to reduce the different classes of microorganisms. These studies show reductions ranging from 90% to 99% for faecal coliform (including E.coli), approximately 90% for viruses and approximately 99.9% for protozoa parasites.

DACAAR is committed to roll out the biosand household water treatment technology throughout the country and therefore, piloted and evaluated three projects in three different regions, namely East, North and North-East during 2010-2011. The key findings are as follows:

1. By the time of the study, the average length of time that BSFs had been in use was 10 months. The studies found that 96% of users were using the filters consistently for their drinking water and food preparation. The remaining 4% had stopped using their filter. Based on water quality analysis the filters were effective in removing 94% of the faecal bacteria and 96% of turbidity.

2. An average of 50 litres of water was filtered each day. All users felt that the filters provided enough water for the households. 100% of the regular users reported better taste, better smell, and better appearance. When asked about their perception of their family health, 100% stated it had improved.

3. All of the respondents said that they liked the filter mostly because “it cleans the water” and “it helps our health”. Overall, the perceptions of families using the filters were strongly positive, with 100% saying that they had recommended the BSF to others. When asked if they thought the filter saved them money, 100% of the household reported that they thought that it had saved money with comments such as; “didn’t get sick, didn’t go to doctor, and didn’t spend money on purchasing medicines or drugs”.

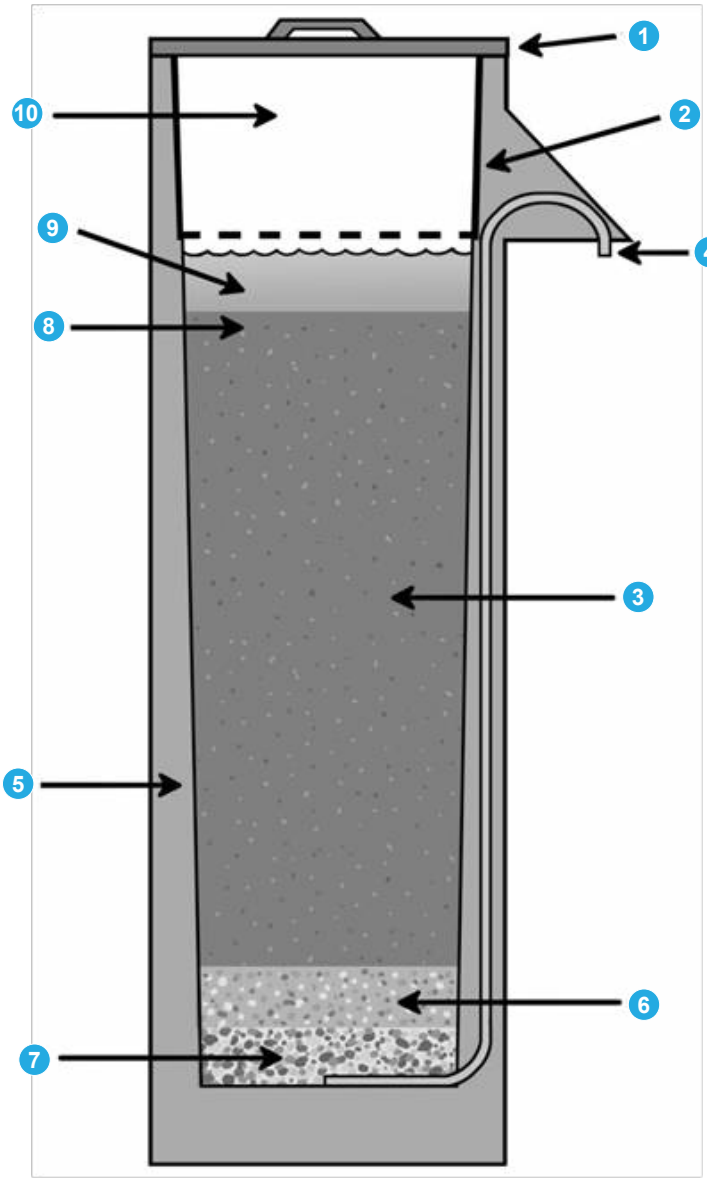
Based on our experience from BSF project evaluations, experience of our field staff implementing the BSF projects for more than three years, and Centre for Affordable Water and Sanitation Technologies (CAWST) resources and action researches, we identified the following best practices regarding biosand filter manufacturing, utilization and sustainable use.

1 History of Biosand Filter

Dr. David Manz developed the household biosand filter (BSF) in the 1990s at the University of Calgary, Canada. Dr Manz has trained many organizations on the design, construction, installation, operation and maintenance of the BSF. He also co-founded CAWST in 2001 to provide the professional services needed for the humanitarian distribution of the filter in developing countries. As of June 2012, CAWST estimates that over 400,000 BSFs have been implemented in over 50 countries around the world. DACAAR and several other NGOs have been implementing BSF projects in Afghanistan since 2009.

2 Components of Biosand Filter (BSF)

The biosand filter (BSF) is an adaptation of the traditional slow sand filter but the biosand filter is smaller and adapted for intermittent use, making it suitable for households. The filter container can be made of concrete or plastic and is filled with layers of specially selected and prepared sand and gravel.



Following are components of the concrete made BSF:

1. **Lid:** Tightly fitting lid prevents contamination and unwanted pests.
2. **Diffuser:** Prevents disturbing the filtration sand layer and protects the bio-layer when water is poured into the filter.
3. **Filtration Sand Layer:** Removes pathogens and suspended solids.
4. **Outlet Tube:** Required to conduct water from the base to the outside of the filter.
5. **Filter Body:** Holds the sand and gravel layers.
6. **Separating Gravel Layer**: Supports the filtration sand and prevents it from going into the drainage layer and outlet tube.
7. **Drainage Gravel Layer:** Supports the separating gravel layer and helps water to flow into the outlet tube.
8. **Biolayer:** The biolayer is the top layer of sand where very small microbes live. You cannot see them - they are too small. They eat the pathogens in the water that make you sick.
9. **Standing water:** When the water stops flowing, there should be 5 cm of water on top of the sand. This keeps the biolayer wet. The biolayer will die if it dries. But if there is much more than 5 cm of water, air cannot get through and the biolayer will die.
10. **Reservoir:** The top of the filter where water is poured in is called the reservoir. The reservoir can hold about 12 litres, or one bucket of water.

3 Good Quality Mould

Good quality moulds are vital to produce good quality biosand filter (BSF) boxes. Initially, it was difficult to build quality moulds in Afghanistan thus it was decided to train a number of metal smiths in production of quality moulds.

It is essential to conduct multiple supervisory visits by technical staff to the mould construction site in order to provide instructions and supervision while mould construction is on-going. Many of the problems noted during the production of concrete filter boxes can be attributed to bad mould construction.

The interior mould box must be square so that the thickness of all the concrete filter walls are consistent. Welds on any surface that contacts concrete must be ground down for smoothness. This is particularly important for the edges of the inner and outer mould to avoid breakage of filters during de-moulding.

The mould should be oiled (with edible, food grade oil such as vegetable oil) for storage so that it doesn't rust, and must be stored indoors. Before pouring concrete into a mould, the outer and inner moulds should be cleaned from the concrete left over particles from previous production and then oiled. Cleaning up and oiling is important in order to avoid concrete adhesion to the mould and to avoid breakage of the concrete filter while removing the hardened filter from the mould.

The construction, installation, operation and maintenance of biosand filter (BSF) need to be carried out according to the instructions provided in the CAWST Biosand Filter Manual -Version 10.

4 Selection of BSF Version

Based on studies conducted on different version of biosand filters (BSF), version 10 is recommended as it is more effective in bacterial removal than previous versions. The design of the version 10 BSF is included in CAWST BSF training manual available at DACAAR WET Centre and CAWST web site (www.cawst.org).

5 Selection of Filter Media

A mixture of sand grain sizes is required for the proper functioning of the filter. The first option is to use crushed rock or quarry sand as filtration sand since it has lower chances of being contaminated with pathogens or organic material and has less uniform size of the grains as well.

Crushed rock or quarry sand may be difficult to locate and more expensive. However, it is critical in providing the best water quality and is worth the extra time, effort and cost. Other options include sand from higher banks of a river (that has not been in the water), followed by sand found in the riverbed itself. The last option is beach sand.

Both river and beach sand are usually well sorted and do not have a good variety of grain sizes from very fine to large grains, therefore it is best to use crushed rock. River sand is usually contaminated with pathogens (from human and animal excreta) and contains organic material (e.g. leaves, sticks). Putting contaminated sand in the BSF may actually result in even worse water quality than the original source water used. This happens because the organic matter is a food source for pathogens and helps them to grow and multiply in the filter until all of the food is consumed.

When river sand is selected as the only source nearby, then washing and carefully removing organic materials is a must. When river sand is used as filtration sand it needs to be disinfected by chlorine or placing it in the sun.

Beach sand usually contains salt, organic material and other contaminants that will dissolve into the filtered water. Flush beach sand with fresh water to remove the salt, disinfect the sand to kill the pathogens and then remove the organic material. Drying the washed filtration sand under the sunshine will also kill the pathogens.

6 Diffuser Plate and Box

The purpose of the diffuser is to prevent any disturbance of the sand surface and bio-layer when water is added at the top of the filter. The diffuser is essential for the correct operation of the filter so that pathogens do not penetrate far into the sand bed and do not disturb the bio-layer.

There are several types of diffusers that can be built, each with its own advantages and limitations. The one that you choose to build will depend on your skill level, the tools and materials that are available, and the preference of the user.

BSF project evaluations reveal that in some cases the diffuser plates were rusted, tilted and bent due to the poor quality of the sheet metal (in other words 30 gauge galvanized sheet metal was not used). Likewise, in other cases where the quality of sheet metal was good the bio-layers were still disturbed due to water travelling from the gap along the walls of the filters. Therefore, it is recommended that no gaps must be left between the edges of diffuser plate and walls of the filter.

Another recommendation is to use the metal diffuser box design instead of diffuser plate as it does not let water to travel down the walls of the filter and disturb the bio-layer.

In using metal diffuser box, it is also recommended to make the lid from galvanized sheet metal instead of wood. This lid will fit nicely over the entire filter, including the metal flaps of the diffuser box that will hang off the top edge of the filter. The holes in the diffuser plate have a bearing on the disturbance of the top layer, big holes are not good and few holes are not correct either.

7 Integration of Hygiene to the BSF Project

Integration of hygiene education with the biosand filter (BSF) project is vital for effective working of the filter and safety of filtered water. The recruitment of female staff for hygiene promotion is more logical as they can contact directly with the users who are mostly women and girls. They don't need permission to enter the house as opposed to male staff who will need permission for entry to a household due to the conservative Afghan culture. Therefore, female staff will be able to undertake more follow up visits and conduct more hygiene promotion sessions.

Providing safe water to a family that does not know how to handle, store and utilize it, will not be effective and will be a waste of money and time spent on the provision of safe drinking water. Therefore, the integration of hygiene education mandatory to the successful implementation of a BSF project.

8 Need Assessment Survey

Prior to the implementation of biosand filter (BSF) projects a need assessment survey is crucial to identify the most needy communities, which in turn help in the sustainability of the BSF projects. Contact with Rural Rehabilitation Directorate, NGOs existing in the province and Community Development Councils can help in this regard.

So the first step is to send a site engineer and BSF technician to identify those communities which do not have access to safe water, but have enough sources of surface water such as stream, canals, rivers, or pond. Further criteria for selection of a community for a BSFproject are:

- No access to safe water at all;
- Permanent access to abundant source water;
- Strong commitment for utilization of BSF;
- No possibilities for bore hole due to deeper water table i.e. more than 60 meters;
- Hard ground strata;
- Underground water salinity;
- Water table less than six meters;
- Scattered families which can't fulfil the criteria for construction of a water points and;
- Open well or dug well;

9 Mobilization of a Community

Proper mobilization of intended community is key to successful and sustainable implementation of a biosand filter (BSF) project. Community hygiene promoters can do it through different approaches such as meeting with community elders during need assessment surveys, briefing session on importance and utilization of BSF, and in introductory meeting with women. It is recommended to use visual educational materials for all meetings with community in order to present the BSF and its importance in an effective manner.

10 Acceptance of BSF Technology

Introduction of biosand filter (BSF) as household water treatment technology is easy and well accepted by rural communities in Afghanistan, as the technology is understood. In demonstration projects, users of BSF recommended the technology to others, they were 100% satisfied with filters and there was a high demand for this technology during demonstrations of the filter in neighbouring communities as well.

11 Selection of Household for BSF

Once communities are identified in need assessment survey for the biosand filter (BSF) project implementation, it's time to select households for BSF distribution and installation.

Again the Site Engineer together with BSF technician go to communities and gather the community elders in a guest room or in a public gathering place and brief them on the importance of and procedure for the distribution and installation of the filters to the households.

Site Engineer and BSF technician explain to the communities that this is a demonstration project and we will allocate xx number of filters to your community as we can't cover the entire community, first priority should be given to:

- Those with strong commitment for utilization of BSF
- Women headed families;
- Poor families;
- Families with disabilities; and
- Families with no access to safe water sources at household or nearby.

The staff will then ask the community elders to nominate households that fulfil the aforementioned criteria for BSF for final selection the next day. The following day, nominations are discuss for selection, and if no agreement can be reached an alternative village can be selected that follows the criteria for BSF distribution and installation.

12 Location for Installation

It is important to determine a good location for the biosand filter (BSF). Placing the filter inside the house (room or kitchen) is important not only for filter effectiveness, but also for the convenience of the users and avoiding filters from freezing due to cold winters in most parts of Afghanistan in which case the content of the filter can freeze, resulting in malfunction and even cracking of the filters. If the users can access the filter easily, they will be more likely to use and maintain it. Once filled with sand, the filter should not be moved and should be placed in following recommended places:

- In a protected location away from sunlight, wind, rain, animals, and children;
- Preferably inside the house (room or kitchen) on level ground of concrete or wooden plate to avoid the filter from sliding to one side, bending or tilting during operation;
- Near the food preparation or kitchen area (depending on the space and layout of the house)
- Where it will be used and maintained easily
- Where there's adequate room for carrying and pouring buckets of water into the filter, as well as storing the filtered water.

13 Distribution of Water Container with Filters

Distribution of safe water storage container together with filter is important as it will help people to keep their filtered water from recontamination. If resources are available, two containers (20 litres each) should be distributed to each household, one to be used for collection of source water and the other for storage of filtered water. The containers should be narrow mouthed and preferably a tap at bottom to get the drinking water from. Evaluations done by DACAAR show that filtered water was re-contaminated when improper storage container was used.

14 Pre-treatment of Source Water

Since many BSF users make use of turbid water from rivers, ponds, streams and canals as source water, this can clog the BSF and decrease the flow rate very quickly. To avoid aforementioned situation, it is important to collect source water in a drum or in a big container and let the particles settle at the bottom of the vessel for some time (could take hours or a day) before pouring into the filter.

Another way to decrease the turbidity of the source water and prevent the clogging of filter is straining which involves putting a permeable cloth on the top of the filter at the time of pouring water in. A cloth is effective when larger particles and organic materials are found in the water collected.

15 Education on Operation and Maintenance

Proper operation and maintenance of a filter is vital for enhancement of filter effectiveness. Therefore, education on operation and maintenance should be carried out periodically and at different times such as, during installation of filter at household, hygiene promotion sessions and follow up visits.

Women's role in operation and maintenance is obvious as they are the main users of the filters, therefore the female hygiene prompter should pay more attention in educating women and girls in the operation and maintenance of BSF during their hygiene promotion sessions and follow up visits.

It is to be mentioned that the hygiene promoters should be properly trained on biosand filter at both aspects, theoretical and practical. But the more important component they should focus on is the operation and maintenance component as they teach this component directly to the users.

16 Follow up Visits

It is essential to conduct follow-up visits with the users to ensure proper use and maintenance of the filters. There should be a series of follow up visits with a household, one during the first two weeks of use and other visits during the project lifetime.

These follow up visits by hygiene promoters should be conducted at least three times in the life of the project. BSF technician should also conduct follow-up visits in the beginning and middle of the project.

17 Key Practices for Enhancement of BSF Effectiveness

- Install filter inside the house (kitchen or other room)
- Good quality sheet metal for diffuser plate and box
- Integration of hygiene promotion with BSF projects
- Proper operation and maintenance
- Not letting the filter to dry out
- Collect water from one source always
- Pre-treatment of the source water
- Straining of the source water
- Separate container for collection and storage of water
- No spout and pipe attached to the BSF outlet pipe
- No displacement of the filter

18 Key Operating Parameters to Be Considered

- Water source
  - Not very dirty (turbidity not greater than 50 NTU)
  - Same source (if possible)
- Developing the bio-layer
  - May take up to 30 days to grow
  - Not visible
- Flow rate
  - Controlled by sand size - sieving and washing
  - 0.6 litres/minute or slower (V9)
  - 0.4 litres/minute or slower (V10)
- Pause period
  - Microorganisms consume pathogens
  - Use filter daily at least once for the best efficiency
  - Up to four times per day
  - Minimum pause period for 1 hour, maximum of 48 hours
- Water depth
  - Too shallow – bio-layer dries out
  - Too deep – insufficient oxygen for bio-layer
  - Water level of 5 cm above the sand during the pause period
- Oxygen level
  - During the pause period the standing water should not be more than 6 cm to let oxygen from the air diffuse through the standing water to the bio-layer.
- Filtered water quality
  - 90-99% pathogen removal efficiency
  - Disinfection recommended
- Maintenance
  - Sand becomes clogged with dirt over time
  - Do the 'swirl & dump' when the flow rate is too slow

19 Replication of BSF Technology

One way to replicate the technology is to involve the small entrepreneur and BSF technician from the very beginning of the project implementation. This will encourage them to start their small businesses in their own communities. It makes sense to equip them with at least two quality moulds and a BSF tool kit.

Production of poor quality BSF and provision of poor quality media for the filters by local entrepreneurs are some of the challenges to be dealt with. One way to tackle these is to assign an experienced BSF technician to work closely with the entrepreneurs and pay several surprise visits during their production and installation until satisfied with the quality of their work.

20 Conclusions

The biosand filter for single household can be a good solution for families who especially collect surface water from rivers, kandas, other surface water sources and shallow wells. The filter has many advantages and is a water treatment technology that can be effectively used by consumers for acquiring safe drinking water at home, provided that they have a dedicated container that is narrow mouthed in order to store filtered drinking water and prevent re-contamination.

The filter must be maintained properly for the local circumstances. Hygiene education and training in taking care of the sand filter is essential. The ladies of the household will be the most appropriate target group to maintain the filters. It is also important to take care that the pouring of the water is done without disturbing the plate and sand top layer (bio-layer).

In order to prevent water from passing between the edges of the diffuser and walls of the filter it is recommended that no gaps must be left between the two. Another recommendation is to use the metal diffuser box design instead of diffuser plate as it does not let water to travel down the walls of the filter and disturb the bio-layer. In using metal diffuser box, it is also recommended to make the lid from galvanized sheet metal instead of wood.

The quality of the filter will have an effect on the consumer, so the production must be checked. Training of artisans in the production of the filter on its own will not be sufficient to guarantee that good functional boxes are produced and can be used. The selection of sand and the training aspect will have to go along with the production and selling of the biosand filters. The amount of holes in the diffuser plate is another important point as too big holes (more then 3mm diameter) and too few holes (less then 36 holes) will disturb the bio layer.

End

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