BIO-SAND WATER FILTERS

One approach to household water treatment that has become more popular in recent years is the bio-sand water filter. It is a relativly simple approach that can be established using local materials and manufacturing to produce a water treatment technology that works in the home.

The bio-sand filter should be considered as part of the solution to clean water for families that do not have access to other sources. It should be adopted in conjunction with other treatments. The general approach is to consider the treatment of water in the following stages.

- Protect the water source
- Sedimentation
- Filtration
- Clean storage

This systematic approach is explained further in the Practical Action's technical brief *Household Water Treatment Systems* This brief focuses on bio sand filters in the home.

Practical Action has used bio-sand filters in Peru and Bangladesh and this technology has been promoted in many other countries by other organisations. This bio-sand household filter is a fairly recent innovation in Bangladesh and Peru, but has undergone extensive testing at the University of Calgary in Canada since its inception by Dr. David Manz. The filter is a small, household sized adaptation of the slow sand filter allowing it to be run intermittently.

The filters were first used in Haiti in 1999 and their usage is still spreading throughout the country as people become aware of their low-cost effectiveness. The following description is of the domestic scale bio-sand filter used by Practical Action.

The bio-sand filter's simple technology, its proven effectiveness and availability of production materials are what make it a viable option for remote households. In areas where education is limited, people of all ages, including young children, are able to use the filter and understand how it works.

Figure 1: Domestic bio-sand filer used in Bangladesh. Photo: Practical Action Bangladesh.

Figure 2: A domestic bio-sand water filter being used in Peru. Photo: Soluciones Prácticas.

technical brief

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The system has proven effective and has become one of the most widely distributed devices for household water treatment in developing countries.

The filter consists of a layer of gravel overlain with prepared sand media contained within a filter body or box.

The difference in a traditional slow sand filter and the newer bio-sand filter is that the drain is piped back up to between 1 and 8 cm above the sand level allowing a shallow layer of water to sit on top of the sand, where the biofilm (schmutzdecke) is created. This ensures that the sand within the system is always covered by water even when no water is added to the system. Experimental evidence shows that oxygen will still reach the organisms in the sand.

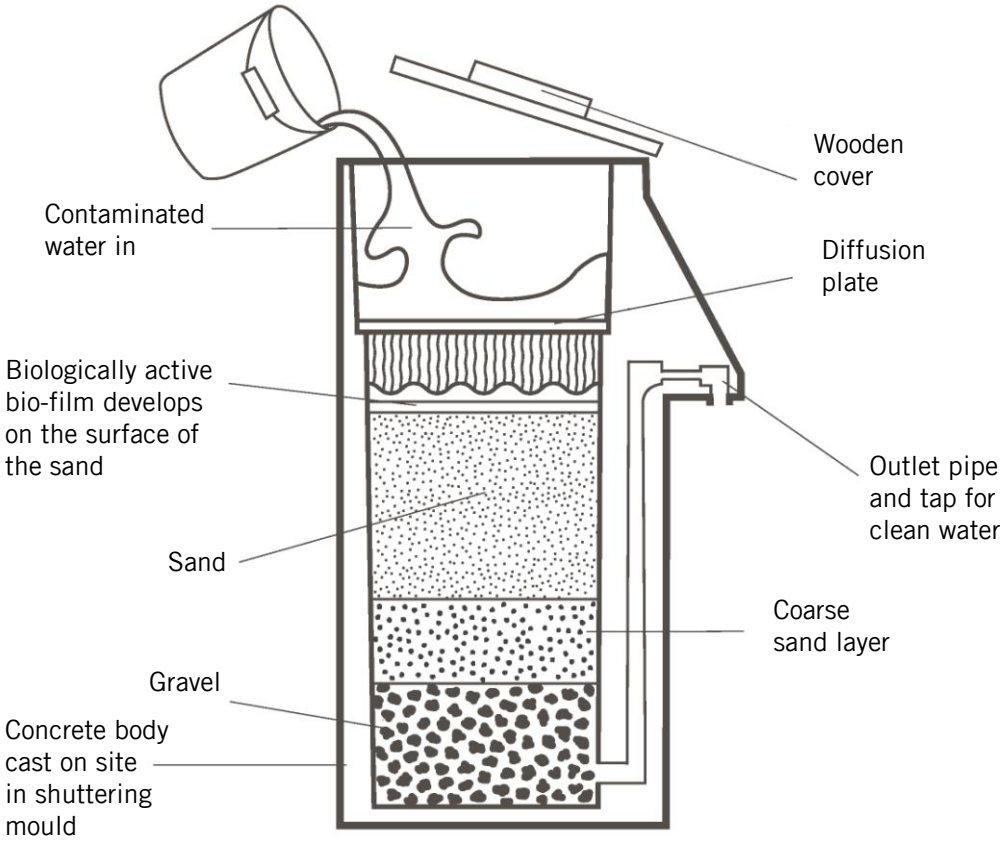

Figure 3: A typical bio-sand filter cross section. Illustration: Practical Action.

Bio-sand filters can be fabricated locally because they use common materials. The filter consists of a layer of gravel overlain with prepared sand media contained within a filter body or box. One of the initial activities is the selection and preparation of the sand and the gravel that is used in the bio-sand filter, this activity is important for the effective and efficient operation of the filter. Poor selection and preparation of the sand and the gravel can result in the filter performing badly and resulting in more work rectifying the problem.

The body is often constructed from concrete using a metal mould. Construction guidelines are available form http://www.cawst.org and http://www.biosandfilter.org/. However, other deigns use oil drums or plastic containers and

Figure 4: Removal of the concrete filter from the metal mould. Photo: Soluciones Prácticas.

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these do not require a mould. The use of a mould makes it difficult to mass produce the filters as they are made on site on an individual basis.

Operating the filter

- The lid in removed,
- A bucket of water or other container is poured into the top of the filter.
- The diffusion plate slows the force of the water.
- Water then travels slowly into the biological layer at the top of the sand.
- Water continues slowly through the sand bed.
- After passing through both levels of gravel, the water is propelled up and out.
- Then treated water is collected in a clean container.

Amount of water treated

Household bio-sand filters typically provide 30 to 60 litres of water per hour, which is sufficient for a family of five to ten members. The flow rate may decrease over time as the filter becomes clogged, but can be restored with cleaning.

Contaminant removal

Bio-sand filters have been shown to remove more than 90% of faecal coliform, 100% of protozoa and helminthes, 95 to 99% of zinc, copper, cadmium, and lead, and all suspended sediments. Bio-sand filters have also been shown to remove 76 to 91% of arsenic, reducing it to an acceptable concentration. These filters do not sufficiently remove dissolved compounds such as salt and fluoride or organic chemicals such as pesticides and fertilizers. The biological layer's effectiveness is influenced by temperature. Ammonia oxidation stops below 6° Celsius and alternative treatment methods are required below 2° Celsius. Additionally, because bio-sand filters are not able to handle high turbidity, they may become clogged and ineffective during monsoon or rainy seasons.

Ease of use

Bio-sand filters require daily fillings during the 2 to 3 weeks when the biological layer is growing. Bio-sand filters also require regular cleaning, which involves agitating the water above the biological layer. The filter will require 1 to 2 weeks of non-use after agitation to allow for the regrowth of the biological layer. On occasion, the sand in the filter needs to be cleaned as well. There are several different methods to clean the sand, though all of them require significant labour, significant training, or high cost. User error has also been found to affect the filter's efficacy, especially because of the required 2 to 3 week non-use period for growing the biological layer. The users of the filter must have a maintenance guide (for example, a plasticized leaf). This guide can be adhered to the filter or it is possible to be placed on the wall near the filter.

Figure 5: Bio-sand filters are easy to use. Photo: Soluciones Prácticas.

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Benefits & drawbacks

Advantages

- Removal of turbidity, colour, odour.
- Good microbial removal.
- High flow rate.
- Can be constructed of local materials.
- Income generation.
- Durable.
- Minimal maintenance.

Drawbacks

- Not 100% microbial removal; may require post-disinfection.
- Limited transportation due to weight.
- Turbidity should not exceed 100 NTU.

Costs

- Capital Costs: approximately US$ 20.00 – 26.00 (Tk. 1450.00 – Tk. 1900.00 in Bangaldesh)
- Operation and Maintenance: Minimal.

There may be educational and training costs associated with teaching users how to properly maintain their filters. Costs will vary across regions depending on the availability of materials and labour.

Arsenic removal by Bio-sand filter

Bio-sand filters may be used to remove arsenic from well water based on the principles of the co-precipitation and filtration method.

A variety of technologies have been used for the treatment of arsenic in water, including conventional co-precipitation with ferric chloride, lime softening, filtration using exchange resins and adsorbents.

The divalent iron concentration is in the range of 0.2-12 mg/l and is positively correlated with arsenic concentration in the groundwater. Fe/As ratios of greater than 40 (mg/mg) is required to reduce arsenic to less than 50 mg/l in Bangladesh well water. Arsenic removal by the bio-sand filtration process included precipitation of arsenic by adding a packet of iron nails to the top chamber.

Figure 6: The improvement in water quality can be dramatic. Photo: Practical Action Bangladesh.

After mixing the water with the iron for a few minutes, the iron will be oxidized to form ferric hydroxide that passes through the sand bed by gravity removing the precipitates; clean water is collected from the outlet of the filter in the conventional way.

Also see *A Small-scale Arsenic and Iron Removal Plant* Practical Action Technical Brief

Further information

- *Household Water Treatment Systems* Practical Action Technical Brief
- *A Small-scale Arsenic and Iron Removal Plant* Practical Action Technical Brief
- *Water Treatment Systems* Practical Action Technical Brief

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Bio-sand filters
http://www.cawst.org/en/resources/pubs/category/23-technical-updates
The full bio-sand filter construction manual
http://www.cawst.org/en/resources/pubs/category/12-biosand-filter-project-implementation

Manz Water Info
David Manz, PhD.
University of Calgary
http://www.manzwaterinfo.ca/
Concrete Bio-Sand Water Filter Construction Manuals, Dr. David H. Manz, P. Eng., P. Ag. (May 2008) ACAD Drawings of BSF Steel Mould, Dr. David H. Manz, P. Eng., P. Ag. (April 2010) BioSand Water Filter Guidance Manuals, Dr. David H. Manz, P. Eng., P. Ag. (January 2009, updated July 2010)

Bio Sand Filters
Set up by the people who own BushProof, a UK registered company that provides socially beneficial products and services specifically tailored for use in developing countries.
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BSF testing concept
Field sand sieve analysis instructions
Bio-sand filter Construction guidelines
Bio-sand filter Mould Construction guidelines

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