Technical Note #43

Biosand Water Filter

What's Inside:

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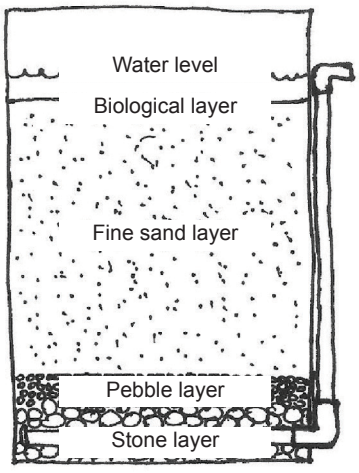
Access to clean drinking water remains one of the greatest challenges in the world. The BioSand Filter is one method that can be used for purifying water at the household level. With this filter, contaminated water is filtered through a natural biological layer and then layers of sand, pebbles and stones. The BioSand Filter can be made using local materials and is a low-cost system that removes suspended sediments and other impurities from water in order to make it safer for human consumption.

Household Water Treatment

Inadequate water and sanitation services result in an estimated 4 billion cases of diarrhea and 2.2 million deaths each year (WHO/UNICEF 2000). In areas where there is no access to potable water, household water treatment can contribute significantly to reducing water related health problems. The most effective water treatment methods follow a process of sedimentation, filtration, and disinfection to remove bacteria, viruses, helminthes, and protozoa.

Filter Details



The first known sand filter was made in Scotland in 1804 and since then slow sand filtration has been a common filtration method in the water treatment process. The BioSand Filter has adapted this technology to work at the household level, providing clean water at a maximum flow rate of 0.63qt (0.6lt) per minute. In the BioSand Filter, contaminated water is poured in at the top and is cleaned as it passes through a biological layer, a fine sand layer, a pebble layer, and a small stone layer. When additional water is poured in at the top, the filtered water is forced into the bottom PVC and up to the outlet. The BioSand Filter uses both physical and biological mechanisms to remove the following contaminants: more than 96% of fecal coliforms, 100% of protozoa and helminthes; 50-90% of organic and inorganic toxicants; more than 75% of iron and manganese; and suspended sediments (CAWST). BioSand Filters are typically made from plastic containers or poured cement.

A key part of the BioSand Filter is the formation of a biological film on top of the fine sand layer. When contaminated water is poured in, particles are trapped on the surface of the fine sand and colonized to form a biological layer or "schmutzdecke." Once established, this biological layer acts as a physical barrier by simply trapping particles in the film. It also actively destroys contaminants by consuming bacteria and other pathogens. It needs

moisture, oxygen and a supply of nutrients to remain active. To provide moisture, the filter outlet is positioned at least 1in (2.5cm) above the layer of sand so that the water level never drops below the sand layer. To provide oxygen, the filter outlet is positioned so that the water level never exceeds 2in (5cm) above the sand layer. To provide nutrients, it needs a regular supply of contaminated water (preferably from the same source). This biological layer takes 1-3 weeks to develop in a new filter or to reestablish if disturbed.

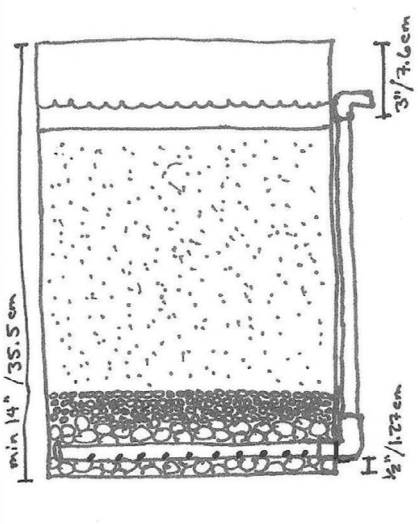
The layer of fine sand acts as a physical barrier to trap suspended particles, protozoa and helminthes. These contaminants become trapped between the grains of sand and fill in the spaces allowing the filter to trap smaller particles over time. For best results use fine sand (particle size of 0.0059- 0.0138in; 0.15-0.35mm) to form a layer that is at least 16in (40cm) deep. As sand particle size increases, the depth of the sand layer should also be increased. The pebble and stone layers help to further filter the water and to keep the fine sand from washing out or plugging the outlet.

Materials Needed For Construction

- One plastic container with lid to be the filter container; should be at about 24in (60cm) tall
- One plastic container that can sit on the lid of the filter container to be the supply container; best if it has a raised bottom, not a flat bottom
- One piece of 3/4 inch (2 cm) PVC pipe about equal to the height of the filter container
- One piece of 3/4 inch (2 cm) PVC pipe about equal to the bottom width of the filter container
- One 90 degree 3/4 inch (2 cm) PVC fittings
- One 90 degree 3/4 inch (2 cm) threaded, female PVC fittings
- One 3/4 inch (2cm) threaded, male PVC connector
- Two washers cut from inner tube or other rubber
- Rubber strapping, string or wire
- Small stones (marble size), enough to fill half of the supply container
- Coarse sand or small pebbles, enough to fill 1/4 of the filter container
- Fine sand (0.0059- 0.0138in; 0.15-0.35mm), enough to fill 2/3 of the filter container

Filter Construction

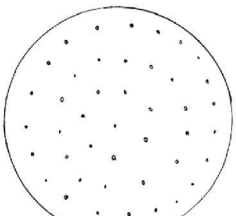
Filter Body:



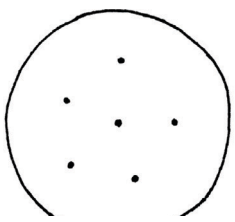
1. In the filter container cut a hole for the male PVC connector 1/2 in (1.27cm) from the bottom of the container.
2. For the bottom PVC pipe, pierce holes or cut slits along one side for the water to enter and plug one end with a cap or other material.
3. Put a washer on the male PVC fitting and then put the fitting inside the container and through the hole.
4. Put a washer on the male fitting on the outside of the container and connect the threaded female PVC fitting so the elbow points up. Use more washers if needed to make a water tight seal.
5. Connect the bottom PVC pipe inside the container to the male threaded PVC fitting; make sure the holes on the inner PVC are toward the bottom of the container.
6. Cut the side PVC pipe so the top of the pipe will rest 3in (7.6cm) from the top of the container.
7. Connect the side PVC pipe to the outside elbow fitting and top with the remaining elbow fitting.
8. An additional short section of PVC pipe can be attached to the top elbow fitting for the outlet and the pipe can be secured at the top with rubber strap, string or wire.

Diffuser Lid and Supply Container:

1. Place the supply container on the lid of the filter container and trace around the base.
2. Inside this area on the lid pierce small holes to make the diffuser lid (pattern shown below at left; holes can be made with a hot nail or drill).
3. Put 2-6 holes in the bottom of the supply container to make the filter supply (pattern at right). To prevent overflow between containers, start with 2-3 small holes and add more if needed.



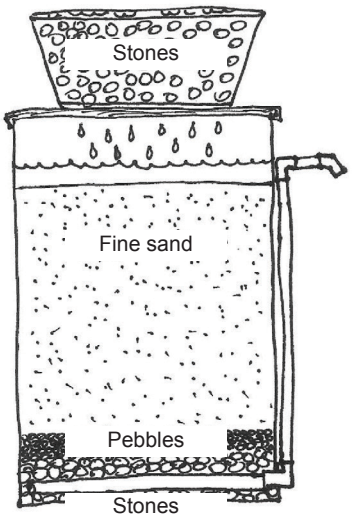
Diffuser lid



Filter supply

Filter assembly:

1. Collect and rinse the fine sand, small pebbles and stones.
2. Put a thin layer of stones in the bottom of the filter container, under and around the bottom PVC (be careful not to disturb the water tight seal).
3. Cover layer of stones with 2in (5cm) of coarse sand or small pebbles.
4. Fill remainder of the filter container with the clean fine sand to 2in (5cm) below the top of the outside PVC pipe and seal with the diffuser lid.
5. Put the remaining stones in the supply container and place on top of the filter container; this serves as a pre-filter to remove any large particles.



Filter Use

The filter is now ready to be filled with water. Water should be added gradually to the supply container to prevent overflow from the area where the two containers are connected. As water fills the filter container, gradually add more to the supply container until water comes out of the outlet PVC.

To establish the biological layer in a new filter pour about 1 gallon (4 liters) of water through the filter each day for 3 weeks. In these first 3 weeks the water coming out will appear clean but will not be sufficiently filtered and should not be consumed without further disinfection. Once the biological layer is established the filter can be used as needed. For best results use water from the same source to maintain the biological layer; keep the filter protected from dust and sunlight; keep the outlet clean; use a clean container for catching the filtered water. If the water to be filtered has lots of sediment or is very cloudy it should be allowed to settle before pouring it into the filter.

The BioSand Filter removes most contaminants but a further disinfection step, such as SODIS or chlorination, is recommended- especially for households with infants, elderly, or those with weakened immune systems.

Filter Maintenance

Over time the top of the fine sand layer will become clogged with sediment and debris and the flow rate will decrease. To clean the filter, the surface of the sand is stirred which moves the captured material into the water and this dirty water is removed using a small cup or can. Fresh water is added and this process is repeated until there is no more debris. Cleaning frequency will depend on the amount and quality of water used- if the water is relatively clear the filter will run for several months before cleaning is required. After cleaning, and any time the top biological layer is disturbed, it must be allowed to reestablish by pouring 1 gallon (4 liters) of water through the filter each day for 1-3 weeks, depending on how severely the biological layer was disturbed. Again, during this time the water is not sufficiently filtered and should not be consumed without further disinfection.

Additional Resources

www.cawst.org

www.biosandfilter.org

www.who.int/household_water/en/

www.lboro.ac.uk/well/index.htm