

Bio-sand water filter - Construction

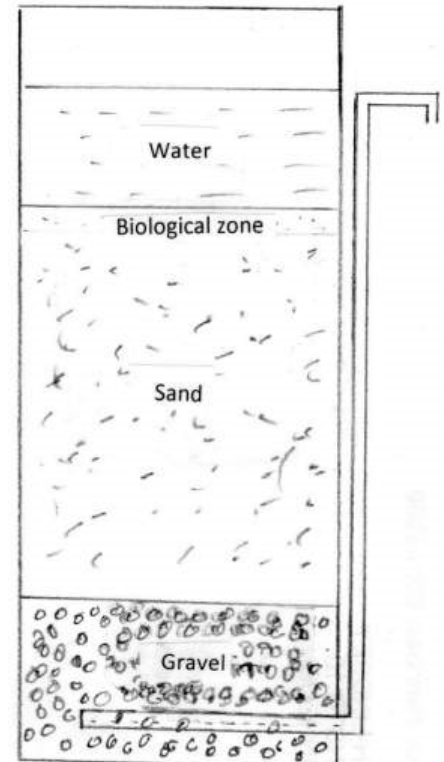


Bio-sand filters may be constructed out of locally available materials for less than 25 dollars. They are not difficult to build, and easy to maintain and repair.

Before using such a filter, it is important to protect the water source, and, if there is sediment in the water, to allow the sediment to settle out. The filtered water must be kept in clean containers.

Bio-sand filters have been shown to remove more than 90% of faecal coliform (i.e. bacteria originating from faeces), 100% of protozoa (organisms which cause many diseases such as malaria and diarrhea) and helminthes (parasitic worms), 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 agricultural chemicals such as pesticides and fertilizers.

The “bio” refers to the top 5 to 10 cm of the sand layer in which, over a period of about 30 days, a high population of microorganisms collects and grows. It is this layer that enables the whole filter to remove an estimated 99% of the pathogens. It is to protect this “biological zone” that the filter must be full of water at all times.



Materials required:

- A water-tight container, at least 60 cm tall and at least 60 litre in volume.
- Metal or plastic pipe, about 80 cm long and about 15cm in diameter, and at least two right angle elbows.
- Gravel with particle size between 6 and 12 mm. The gravel layer must be 5 to 10cm deep.
- Rustproof, very fine wire netting or a piece of finely woven synthetic material (e.g. curtain material) to separate the gravel and sand.
- Fine sand. The sand layer must be at least 40cm deep.
- A shallow bucket of size such that it just fits inside the container – to make the diffusion plate above the sand layer.
- A fitting to secure the outlet pipe if the pipe is outside of the container.
- About 60cm of 2cm square wood.
- A piece of wood, plastic or metal to act as a lid to keep dust and dirt away.

For the construction process one also requires

- a container in which to wash the sand and gravel
- a large container in which to boil the sand and gravel
- a sieve for the sand with a 0.7mm mesh.
- plumber’s tape to ensure water-tight connections

- at least 60 litres of clean water
- a long, straight stick at least 10cm longer than the height of the container.

Tools required

- Strong knife
- Hacksaw and maybe spare blades
- Drilling machine and drill
- File
- Tape measure
- Marker
- Matches

The diffusion plate is important: it prevents the sand from being disturbed. The outlet pipe must be between 1 and 8 cm above the level of the sand in order that the filter is always full of water and that there is always a shallow layer of water above the sand. This allows the “biolayer” to form which contributes biologically to the water purification process.

The outlet pipe may be constructed in one of two ways:

Option 1: The vertical part of the outlet pipe is situated inside the container, with the exit a little above the top of the sand.

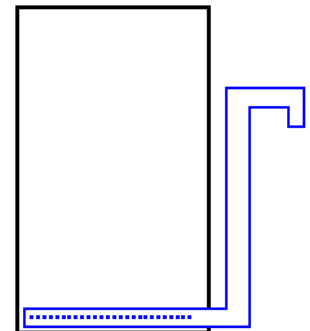
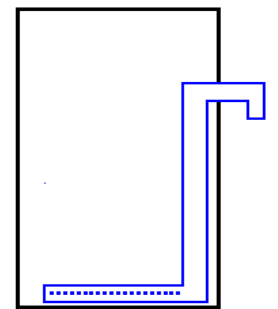
Advantage: The pipe is protected from damage.

Disadvantage: If the pipe fills with sand, it cannot be cleaned – the entire filter must be dismantled.

Option 2: The vertical part of the outlet pipe is situated outside of the container. A right-angled bend piece is attached to the straight collector pipe in the base of the filter unit. Then a vertical piece is attached to go just above the upper surface of the sand, and then another angle piece is required.

Advantage: If the pipe fills with sand, it can be easily cleaned.

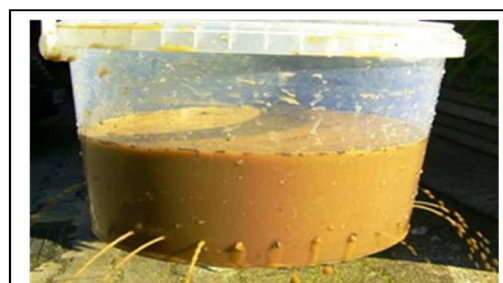
Disadvantages: 1) The pipes are not protected, and so can easily be damaged. 2) It is essential that the point at which the pipe comes out of the container is 100% watertight.



Instructions

1. Check that you have all the necessary materials and tools.
2. Check that the container is strong, absolutely clean and completely watertight. It must not have been previously used for toxic materials, e.g. petrol.
3. Wash the container thoroughly with soap and hot water, and then thoroughly rinse.
4. Depending on the position of the outlet pipe (see above)
 - Option 1: Drill a hole in the side wall of the container about 55cm above the base in a 60cm tall container, i.e. about 5cm above the sand surface.
 - Option 2: Drill a hole in the side wall of the container about 1 cm above the base.
 In each case, the hole should be slightly less than the diameter of the outlet pipe.
5. Cut the pipe into the required lengths, and clean the cut edges.

6. Drill clean holes of about 4mm diameter in the piece of pipe that collects the filtered water in the base of the container. Clean the pipe inside and out of any remaining metal or plastic debris. The holes should be in the side or underneath the pipe when in place.
7. Assemble the entire pipework with the elbows, and check that it is watertight.
8. Fit the pipework into the container. Completely fill the container with water and check for leaks. In option 2, this is particularly essential – otherwise water may leak out and the filter will not function. If necessary use plumber’s tape and check again.
9. Option 2: Attach vertical the pipe to the container with string or wire.
10. Prepare the diffusion plate. Drill as many holes of 2 – 3mm diameter as possible in the base of the bucket at intervals of about 2 cm.
11. Place the gravel in a container, and fill with about twice the volume of water. Mix very well, and pour the water away. Repeat this process several times until the water is clear. Spread the gravel out on a clean cloth to dry in the sun, or place in a solar oven – this destroys any germs.
12. Sieve the sand so that it is uniformly fine and less than 0.7mm particle size. This is most easily done when the sand is dry.
13. Repeat the washing process with the sand. The sand should not however be washed until the water is clear. To check whether the sand has been washed enough, put some of the sand in a jam jar, together with some clean water. Shake it well, and then allow to settle. After 3 to 4 seconds it should be possible to see the surface of the sand. Spread the sand out on a clean cloth to dry in the sun, or place in a solar oven, again to destroy any germs.
14. Mark the stick 5 cm from the bottom end and place in the container. Add gravel until the depth is between 5 and 10 cm, taking care to distribute the gravel evenly around and under the pipe.
15. Make the surface of the gravel very smooth, and lay the very fine wire mesh or material on top of the gravel. Around the edge bend the wire mesh or material upwards.
16. Place the sand slowly and carefully on top of the mesh or material – such that no sand can possibly go down into the layer of gravel. Otherwise the drain pipe will quickly become blocked.
17. Carefully add the rest of the sand, compacting it regularly with your hand.
18. The diffusion plate comes next. It should not sit directly on top of the sand but about 2cm above it. Small pieces of 2cm square wood may be used as spacers.
19. Finally, pour water slowly into the filter – and wait for the purified water to emerge from the outlet pipe. Prepare the celebration!



This picture shows a diffusion plate in the form of a polythene container.
The holes are shown in the side but should actually be in the bottom.

To check the rate of filtration

Materials required:

- 2 x 1 litre bottles
- 1 litre of impure water

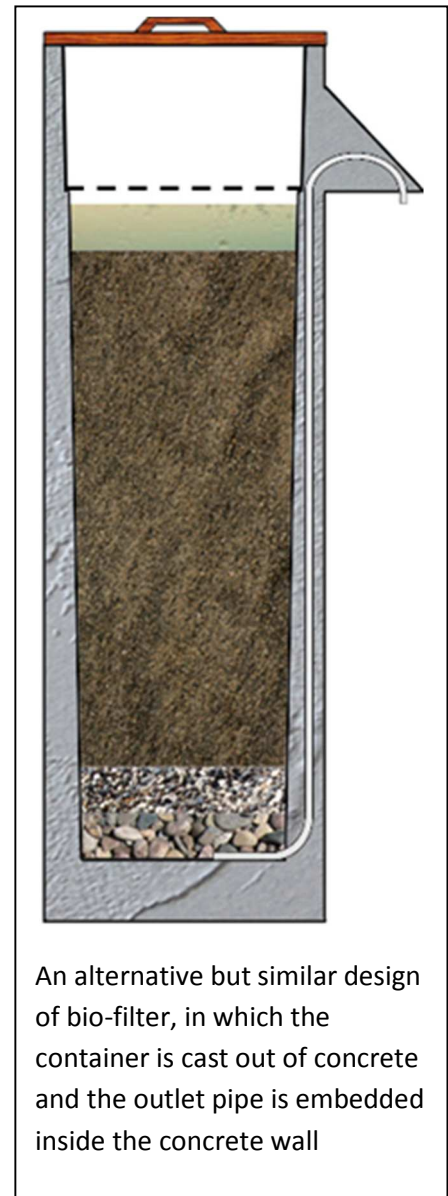
- A watch with a second hand.

Procedure

1. Fill the filter unit as normal with water.
2. The water now pouring out of the spout is not required for this test.
3. As soon as the water stops flowing, put an empty bottle under the spout.
4. Pour 1 litre of impure water into the filter. Measure the amount of time required to collect 1 litre of water in the empty bottle under the spout. This should take between 50 and 80 seconds.
5. More than 80 seconds is too long. This means a) the sand is too tightly packed, b) the sand is too fine or c) the biologically active layer is too deep. In this case the quality of filtration is fine, but the process takes too long. This problem can be remedied either by using coarser sand, or by building a larger unit.
6. Less than 50 seconds is too short. This means a) the sand is not packed well enough or b) the sand is too coarse. In this case the water is not being filtered properly. The remedy is either to use finer sand or to pack the existing sand more densely.
7. This test should be repeated every two or three weeks.



A home-made water filter in Germany which shows both types of outlet pipe



An alternative but similar design of bio-filter, in which the container is cast out of concrete and the outlet pipe is embedded inside the concrete wall

Keith Lindsey, February 2013

Please send me your comments and experiences so that I can improve this information sheet.