Water for the World

Constructing a Slow Sand Filter
Technical Note No. RWS. 3.C.3

A slow sand filter is a type of water treatment system suitable for use in small, rural communities. A well-designed, well-constructed slow sand filter removes sediment and pathogenic organisms from contaminated water in a single treatment process. Only when very turbid water is treated must another treatment step, for example, plain sedimentation, come before filfration.

Slow sand filters offer other advantages which make them attractive for water treatment in rural areas. They can be built with locally available materials and their construction does not require skilled labor. Most of the work can be done by local people. Operation and maintenance does not require the use of machinery. As long as many people are available to work, slow sand filters can be maintained manually by local workers.

This technical note describes the construction of small slow sand filters made from materials such as bricks, mass concrete and ferrocement. Larger filters, which should be made from reinforced concrete, are not discussed here because their construction requires skilled labor and because they should not be built without technical advice from an engineer.

Useful Definitions

BUTTERFLY VALVE - A valve used to accurately regulate the flow of water through a pipeline; a butterfly valve can be opened and closed slightly to regulate flow.

FERROCEMENT - An economical and simple-to-use type of reinforced concrete made of wire mesh, sand, water and cement.

SCHMUTZDECKE - A layer of biologically active microorganisms that forms on the top of a filter bed; the microorganisms break down organic matter and kill bacteria in water.

WEIR - A barrier placed in moving water to stop, control or measure water flow.

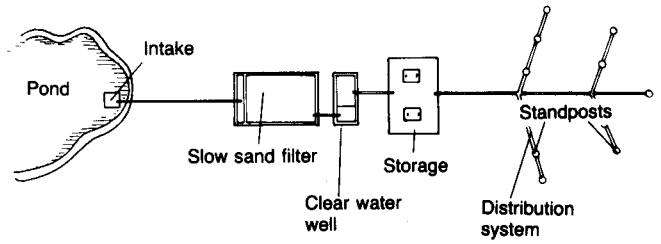

Figure 1. Location Map

Materials Needed

Before construction begins, the project designer should give you the following items:

1. A map of the site where the filter will be constructed similar to Figure 1. The map should include the location of the water source, other parts of the treatment system, and the water distribution system. It should indicate important landmarks, elevations and any other information relevant to the project.

2. A list if all labor, materials, and tools needed as shown in Table 1. Ensure that all needed materials are available and at the work site before work begins. Make sure that adequate quantities of materials are accessible to prevent construction delays.

3. A plan view of the filter with all dimensions. Figure 2 is an example of the type of plan necessary. The dimensions in Figure 2 are average dimensions for a filter with an area of $26m^2$.

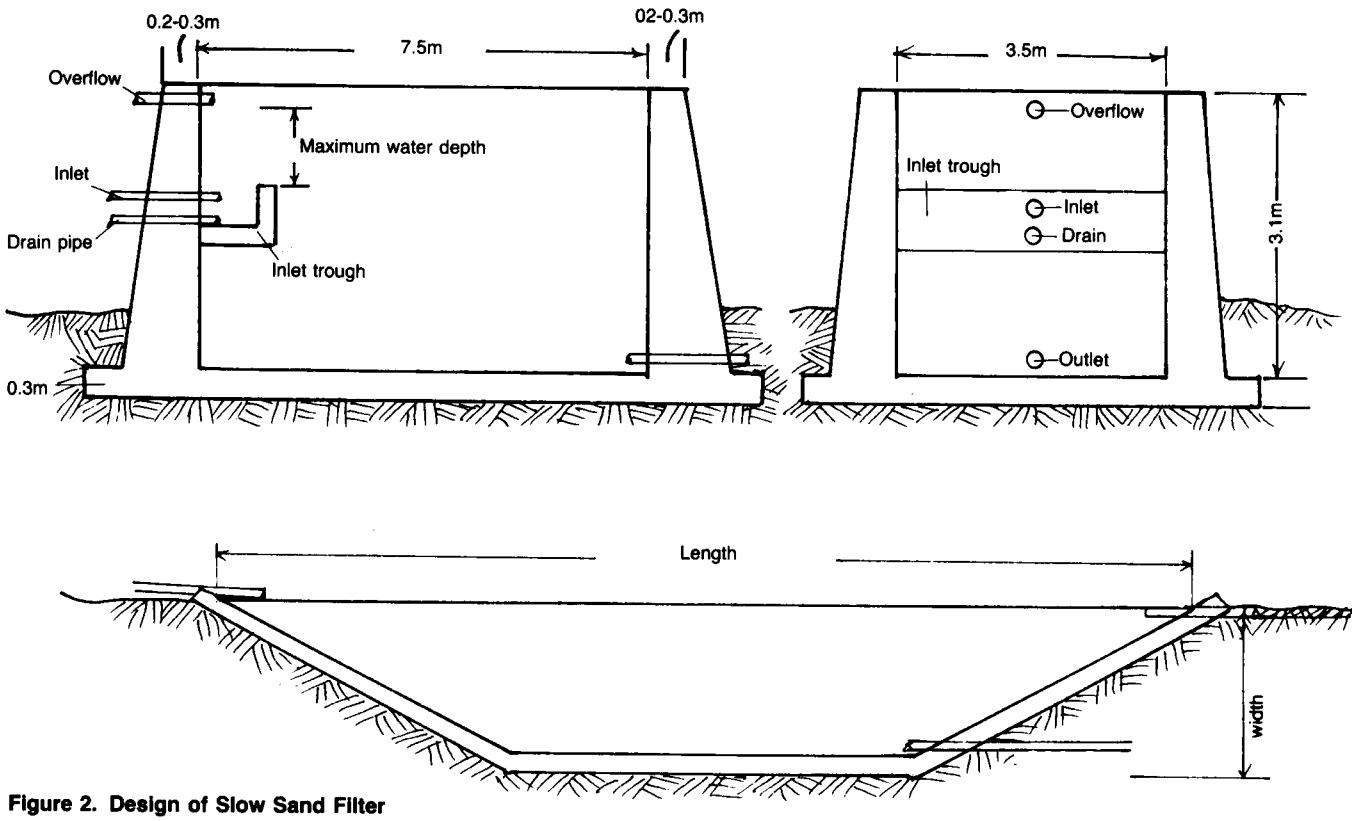

Figure 2. Design of Slow Sand Filter

General Construction Steps

Follow the construction steps below. Refer to the diagrams noted during the entire construction process.

1. Begin marking out the site of the filter with stakes and rope. Mark out the length and width of the filter and the trenches planned for the inlet and outlet pipes. The entire area should be staked as in Figure 3 before constuction begins.

Table 1. Materials List for Slow Sand Filters

Item	Description	Quantity	Estimated Cost
Labor	Foreman Laborers	____ ____	____ ____
Supplies	Bricks Cement Gravel, 60-100mm Sand, 0.15-0.35mm Gate valves Butterfly valve PVC pipes Wooden stakes Rope Fipe glue	____ ____ ____ ____ ____ ____ ____ ____ ____ ____	____ ____ ____ ____ ____ ____ ____ ____ ____ ____
Tools	Digging tools Small saw Sieve Hammers Nails Measuring tape Trowels Wheelbarrow Mortar box	____ ____ ____ ____ ____ ____ ____ ____ ____	____ ____ ____ ____ ____ ____ ____ ____ ____

Total Estimated Cost = ____

2. Dig out the base for the foundation. If a vertical wall structure is chosen, the foundation should be at least 0.3m deep. If conditions permit, dig the foundation deeper to provide more support for the walls. The foundation cannot be dug deep if the water table is high or if a subsurface rock layer is located near the ground surface. All parts of the system should be constructed carefully. Take care to provide for correct elevations so that gravity flow through the filter, valves and piping is maintained.

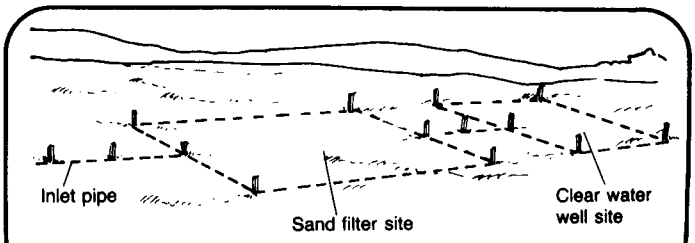

Figure 3. Staking Construction Site

If a slope wall structure is chosen, excavation should continue down to the full depth of the filter. The walls should be sloped as digging occurs so that the sides do not cave in.

3. Ferrocement filters can be built either above or below ground. The filter base can be built below ground

for added structural support. After reaching the desired depth, level the floor of the excavated area. At this time, begin to excavate a trench for the filter outlet so that installation will be easier as work progresses. Do not make the trench too wide but leave sufficient room for one person to work comfortably. When completing the excavation, begin setting up the form work for the foundation and walls, 0.25m thick. If mass concrete is to be used, use wooden forms and oil them thoroughly before pouring any concrete. For ferrocement structures, the form work will be the wire itself.

When setting up the form work, be sure to leave a place for an inlet pipe and, if you are building a rectangular filter, a small trough for receiving the inflow. See Figure 4. The trough prevents disturbance of the filter bed and schmutzdecke, which can be caused by the jet of water from a pipe.

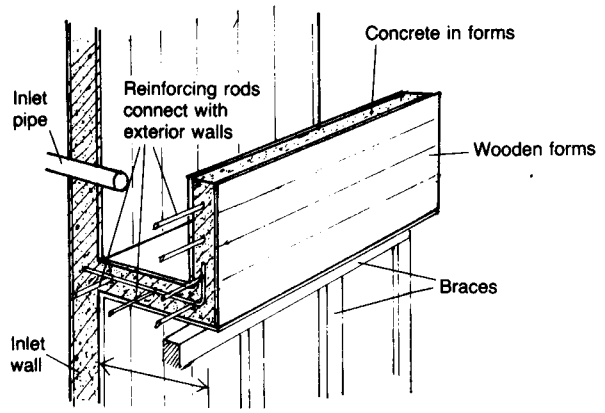

Figure 4. Inlet Trough

For rectangular filters, a concrete raft foundation like that in Figure 5 should be constructed. The raft foundation provides for equal settling of the filter box and prevents water loss through the joint between the wall and the foundation. When laying the foundation, use 8mm diameter reinforcing rods placed 200mm apart. The reinforcing bars should be placed in a grid pattern at the top and bottom of the floor as shown in Figure 5. For all concrete work, mix ingredients in the proportion of 1 part cement to 2 parts sand to 3 parts gravel.

After pouring the foundation, the rest of the filter structure can be built. For mass concrete filters, use the same mixture of ingredients used for the foundation. Fill in the forms completely and let the cement cure for at least 10 days. For increased strength, the concrete should cure at least two weeks. Keep the concrete moist during the curing process to prevent cracks and to allow it to gain full strength.

If bricks are used to build the walls, be sure to keep them vertical. A plumb bob should be used to check the walls after each two lines of bricks are laid. Make sure that vertical joints do not line up. After all bricks are laid, prepare a mixture of mortar using 1 part cement and 3 parts sand. Plaster the walls of the basin with the mortar to form a lining 300mm thick. For a circular ferrocement tank, use mesh to form walls 0.06-0.12m thick. To cover the wire mesh, prepare a mixture of cement using 1 part cement to 2 parts sand. Add water to form a paste-like consistancy, or add approximately 0.4 parts water by weight. Apply the mixture to the mesh with a trowel. Ferrocement should be kept moist during the seven days required for curing.

Sloping wall structures follow similar wall construction techniques. The walls should be excavated for a 1:2 slope and a lining should be applied to the walls. Lining thickness range from between 0.05-0.1m.

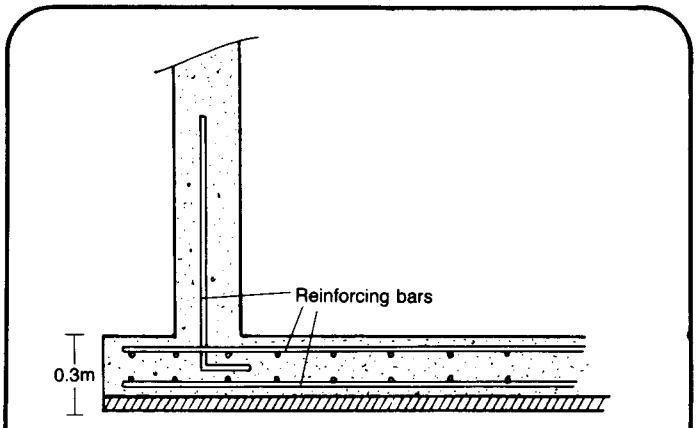

Figure 5. Raft Foundation for Filter Walls

Underdrainage System

Once the basic structure is completed, prepare the system of underdrains for the sand filter as shown in Figure 6. Several different types of materials can be used for the

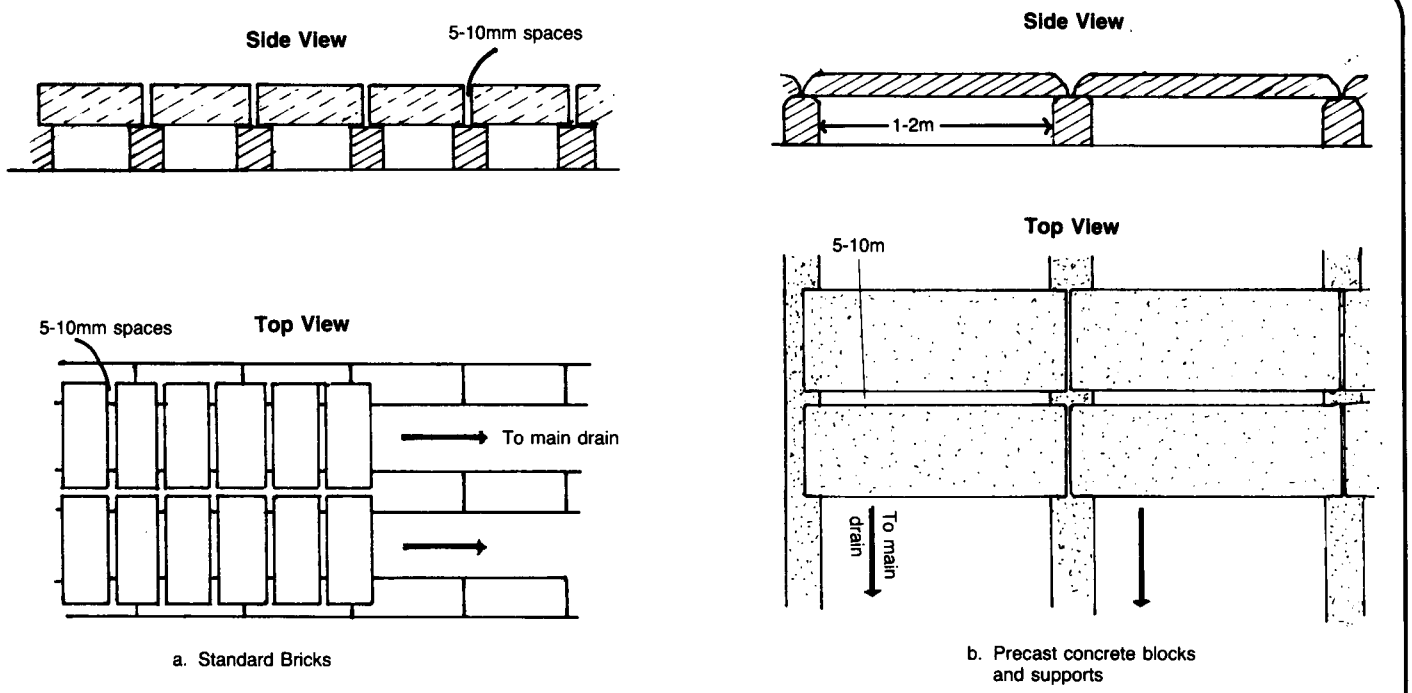

Figure 6. Underdrain System

lateral drains. Porous or perforated drainage tiles, open-joint tile and cement pipe, and perforated concrete or perforated PVC pipe are all acceptable materials. Pipes should have a diameter of 100mm. Bricks may be used for the construction of lateral drains. Drains made with brick should have a width of approximately 230mm.

In small filters and especially in ferrocement filters, perforated pipe can be used for the main drain. In larger filters, use concrete. One of the best methods is to build a concrete drain bedded into the floor of the filter bed.

When placing laterals, space them at 1-2m. The hole sizes in the laterals should be no greater than 2-4mm and have a space between them of 0.1-0.3mm. Figure 7 shows a drainage system using bricks for drains. The velocity of water through the lateral and main drain will be approximately 0.3m/second.

After the drainage system has been put in place put several layers of gravel over the drains. Use stones that are hard and as round as possible. Place a 120mm layer of coarse gravel sized 18-36mm over the top of the drain. Then place three 60mm layers of fine gravel on top of the bottom layer. Use 6-12mm gravel in the second layer, 2-4mm gravel in the third and 0.7-1.4mm gravel in the top layer. Once the gravel is in place, the underdrainage system is complete. Be sure that the drainage system is well-constructed. Once the gravel and sand layer is placed on top, it is difficult to reach the drains for repairs.

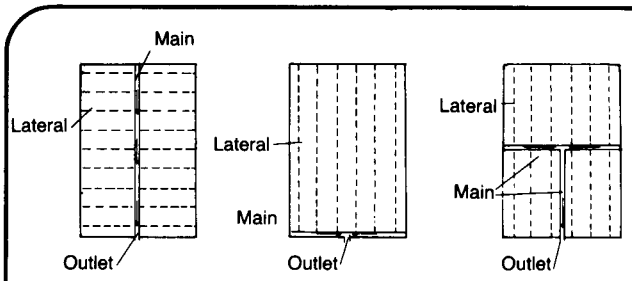

Figure 7. Common Arrangements for the Main Drain of a Slow Sand Filter

The Sand Bed

Construction of the sand bed is one of the most important parts of slow sand filter construction. Correctly sized sand should already be at the site when construction begins so all that should be necessary is to be sure the sand contains no clay, loam or organic matter.

In some cases, it may be necessary to wash the sand to ensure its quality. If so, place the sand to be washed in a box and let water flow through it from the bottom. Rake the sand to distribute it evenly and ensure that all of it is washed. Wash the sand until the water overflowing the box is clear.

Fill the filter box with sand. The depth of the filter bed should range between 1.0-1.4m so that frequent changing of the sand is unnecessary. When the filter bed is thick enough, level the sand.

Filter Control Systems

The filter control system regulates the flow of water into and out of the sand filter and allows effective operation and maintenance. Refer to Figure 8 when reading these directions. Put piping in place as walls are built.

- Install the inlet pipe A. Use a 50-100mm diameter pipe and attach a cut-off valve to it to control the flow of water into the tank.

- Install an overflow pipe B, approximately 1.25m above the filter bed surface. The height ensures that the water in the tank will be 1.2m deep.

- Place a drain pipe C at the bottom of the inlet trough so that the filter can be drained for cleaning. The drain pipe should have a tap that is protected from children.

- At the outlet end of the sedimentation basin, place an outlet pipe of equal diameter to the inlet. The filter outlet structure needs a cut-off or control valve, E. The best choice for a control valve is a butterfly valve as it permits a more precise regulation of flow through the filter. A gate valve can be used. These valves are important in controlling water flow in the filter, especially as resistance builds up in the filtration process.

- Install another valve at point D. This valve permits the drainage of all water in the sand layers before the water goes to storage. This valve is important for cleaning out the filter.

- Construct an overflow weir and clear water well. For small systems, the clear well may serve as storage for the completed system. In larger systems, a storage tank should be constructed. Build the clear well and weir from the same materials as the filter and follow similar construction steps. The tank should be at least 2.5m deep and hold 30-50 percent of daily water production. Ventilation, or preferably an access opening, should be provided as shown in Figure 8.

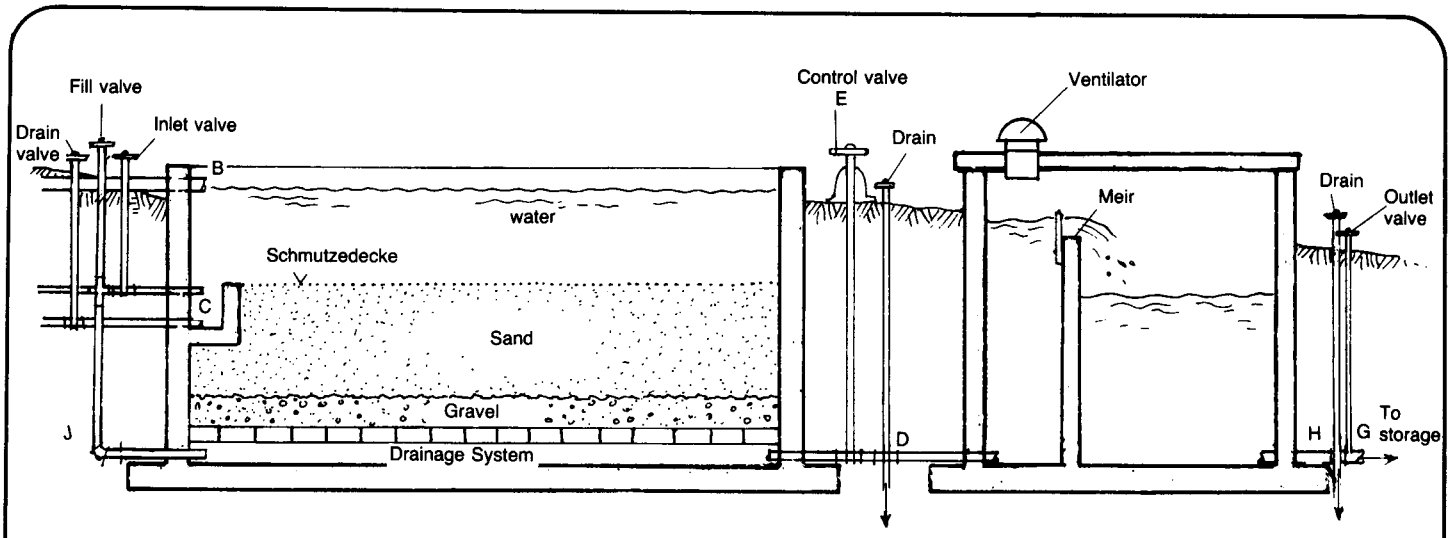

Figure 8. Slow Sand Filter with Valve System and Clear Water Well

The overflow weir should be constructed so that its crest is above the sand layer. This weir serves the purpose of maintaining a certain level of water in the filter and providing for aeration of the water.

Finally, three more valves should be installed in the filter system. Valve G is a cut-off valve which controls water flow from the clear water well to storage and distribution. Valve H allows raw water to run from the filter to waste. A valve for backfilling the filter should be installed at the base of the underdrain system as shown by J. This pipe is used to refill the filter after cleaning. By forcing water up from the bottom, air caught in the filter bed is forced out.

Ferrocement filters are usually of small capacity and they will generally not require as complicated a control system as the larger rectangular filter. General construction steps should be followed, however, for the filter bed, underdrain and outlet structure to storage.

Summary

Most small-to medium-sized slow sand filters can be constructed using local labor and materials as long as good supervision is available. Larger filters should only be built if an engineer or a person experienced with filter construction is available for technical support. A well-designed and well-constructed filter will provide good quality water if properly maintained. For information on the proper care and maintenance of a slow sand filter, see "Operating and Maintaining a Slow Sand Filter," RWS.3.0.3.