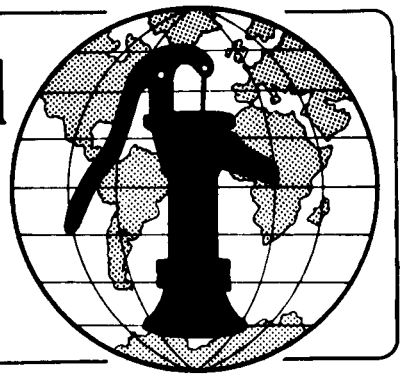
Water for the World

Designing Basic Household Water Treatment Systems

Technical Note No. RWS. 3.D.1



Basic household treatment systems are used to ensure the quality of individual water supplies that are subject to possible contamination. They are designed for supplies that cannot be included in a community treatment system due to lack of resources or distance from a central water supply. Basic household treatment systems are simple to use and relatively inexpensive. This technical note discusses the design of several simple household treatment methods useful for most water supplies. Read the entire technical note before deciding on the design that can meet your needs best.

Useful Definition

CHLORINE DOSAGE - The amount of chlorine added to a water supply for disinfection.

Hand or Batch Chlorination

Small amounts of clear, slightly contaminated water can be treated effectively by simple hand chlorination. First, you must know what type of chlorine is available and the amount of chlorine which must be added to treat the water adequately.

Find out what type of chlorine is available locally. In most rural areas, two basic types of chlorine are available for use in treatment: sodium hypochlorite and calcium hypochlorite.

Sodium hypochlorite is the main ingredient in liquid laundry bleaches. It comes in domestic and commercial strengths. The domestic strength is the most common and usually can be bought in local stores. This strength contains about five percent available chlorine but can be purchased with concentrations up to 12-15 percent. Sodium hypochlorite loses its strength gradually in two or three months after containers are opened. Calcium hypochlorite is available in powdered or tablet form and comes in strengths ranging between 30-75 percent available chlorine. A solution of 70 percent is most common. Like sodium hypochlorite, it slowly loses its strength with exposure to air. Calcium hypochlorite dissolves easily in solutions for water treatment.

To treat water prepare a one percent chlorine solution. Remember all chlorine must be stored in sealed containers in a cool dark place to retain its strength. Table 1 shows the availability of chlorine in different compounds of various strengths and the amount of each that must be mixed with one liter of water to make a one percent solution.

Table 1. Chlorine Strengths and Mixtures for a One Percent Solution

Material and Strength (percent available chlorine)	Amount of Material to Dissolve in One Liter of Water to Make a 1% Solution	
	Grams	Tablespoons (level full)
Calcium Hypochlorites		
High-Test Hypochlorite or Perchloron Powder (70%)	15	1.0
B - K Powder (50%)	18.6	1.5
Chlorinated Lime (35%)	37.5	2.5
Sodium Hypochlorites		
Liquid (12%)	78.2	5.5 = (½ cup or 120ml)
Chlorox (5%)	188.6	12.5 = (1 cup or 240ml)
Purex (3%)	307	20.5 = (2¼ cups or 540 ml)

To chlorinate water using a one percent solution, add three drops of the solution per liter of water or 30ml (2 tablespoons) per 145 liters of water. For example, to determine the amount of one percent chlorine solution to add to a cistern with a capacity of 500 liters, follow the steps outlined in Worksheet A.

After adding the correct chlorine dosage, wait 20 minutes or longer for the chlorine to take effect before using the water. If the water is not turbid but is colored or has a noticeable sulfur odor, the dosage should be doubled.

Chlorine is available in tablet form. When using the tablets, carefully follow all directions printed on the package to determine the correct chlorine dosage. When in doubt about the appropriate dosage, add enough chlorine to get a noticeable chlorine taste or odor.

Boiling

Water should be brought to a rolling boil rapidly for two to five minutes to destroy the disease-causing organisms in it. The amount of fuel needed to boil water depends on the type of fire, stove, and container used. An acceptable assumption is that 1kg of wood is needed to boil 1 liter of water. Water should be cooled and stored in the same container in which it is boiled. The boiled water should not be stirred or poured from one container to another in an attempt to add air and regain the taste lost by boiling. Stirring the water or changing containers may recontaminate the water.

Storage

If water is stored for several days, the level of disease causing bacteria in it is reduced. Usually, five or six days' water storage is enough to reduce the level of bacteria enough so

Worksheet A. Amount of One Percent Solution Needed for Disinfection of a Cistern

Example: Assume the cistern is 1m long, 0.8m wide, and 0.6m high.

1. Determine the volume of water that must be treated.

   Volume of a rectangular cistern: V = Length x Width x Height

   V = *1* m x *0.8* m x *0.6* m

   V = *0.48* m^3 ($1m^3$ = 1000 liters)

   V = *480* liters

2. Determine the amount of solution to add, using 30ml of 1% solution per 145 liters of water.

   Volume of water - 145 liters = Times must add 30ml of solution

   480 liters - 145 liters = *3.3*
   Multiply this figure by 30ml
   3.3 x 30ml = *100* ml (*0.1* liters)

3. Divide ml by 15 to get the number of tablespoons

   100 ml - 15 = *7* tablespoons or
   Multiply ml by .0042 to get the number of cups
   100 ml x 0.0042 = *0.42* cups, (about one half cup or 120ml)

that people can safely drink the water. However, water quality should be checked. If water quality is poor, the length of storage should be much greater. Furthermore, certain bacteria are not affected by storage (i.e., giardia) and no length of storage will be sufficient to make water quality acceptable.

For basic four or five day storage, use two 200-liter steel barrels with spigots as shown in Figure 1. These two barrels should provide enough storage if the "treated" water is used only for drinking, cooking and minor bathing purposes. These barrels must be cleaned carefully. They may have contained oils, pesticides, chemical liquids or chemical powders. Such remains can be poisonous.

Fill both barrels and empty one completely before using water from the second. When use of water from the second barrel begins, refill the first barrel. Water from one barrel should not be used until the other barrel is empty.

To determine the amount of storage needed, multiply the number of people who will use the stored water by the average daily consumption rate. Assume that the water is used only for drinking, cooking and minor bathing purposes so that each person uses 10 liters per day. A family of six would then use 60 liters per day (6 people x 10 liters per person per day). Each 200-liter barrel would store enough water for just over three days. If less water is used, storage time will increase. Water from the second barrel will only be used on the fourth or fifth day which should be sufficient if water quality is not very bad.

If storage time in the barrels is insufficient, another form of storage must be found. For information on storage, refer to "Methods of Storing Water," RWS.5.M and "Designing a Household Cistern," RWS.5.D.1. If an alternative storage method is not available, chlorinate the water stored in the barrels. All storage containers must be covered to protect the stored water from contamination. Buckets or utensils should never be dipped into

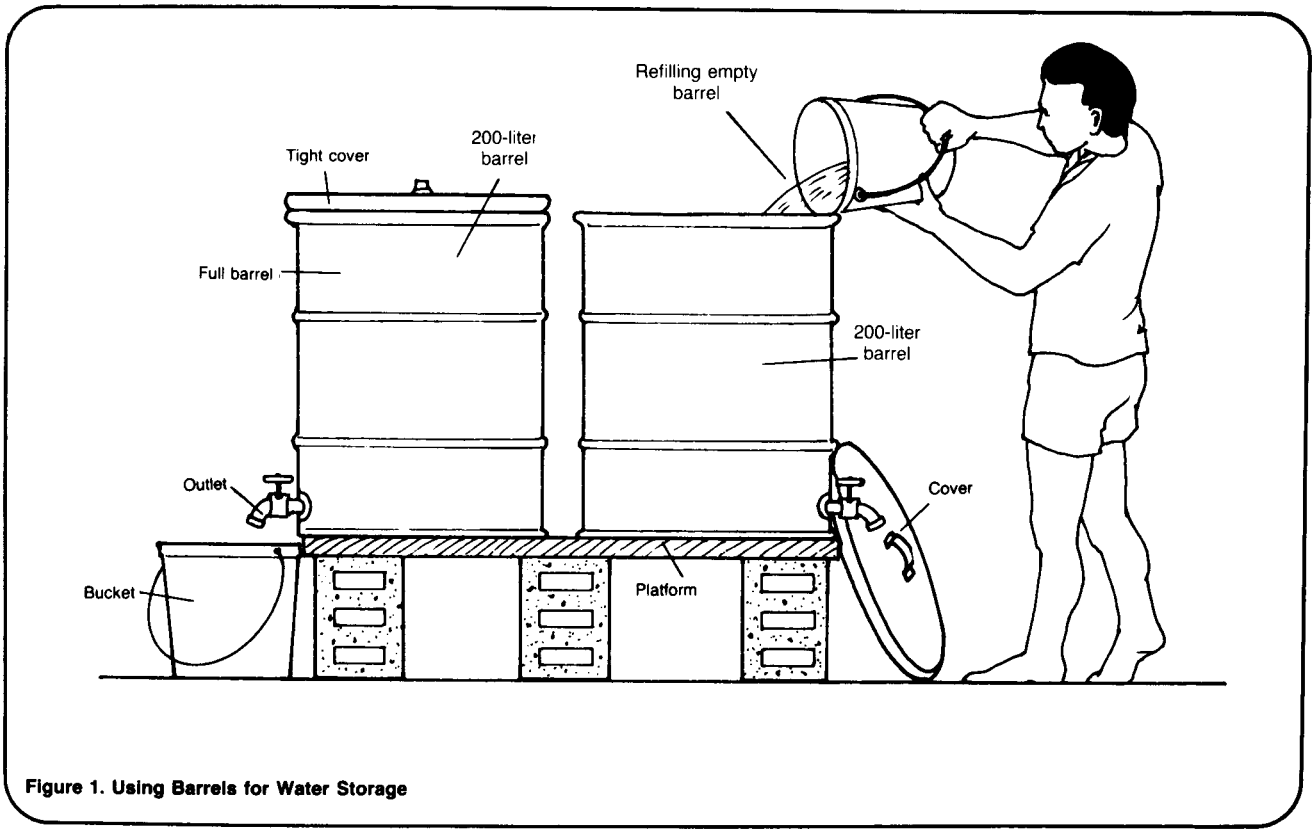


Figure 1. Using Barrels for Water Storage

storage containers. Remember, to be safe, water quality should be checked or water should be boiled or chlorinated.

Filtration

Household sand filters are very useful and popular devices for filtering water and providing basic treatment. They can be built with locally available materials. Household sand filters are relatively effective in removing most bacteria from water if a constant flow of water covers the sand at all times. Otherwise, the household filter will only remove turbidity and the water will need further treatment.

The design of a sand filter can fit local needs. Follow the design steps outlined below and refer to Figure 2. Table 2 is a list of materials needed.

A household sand filter requires a 200-liter steel barrel approximately 600mm in diameter and 750mm tall and enough clean sand to make a layer 600mm deep in the barrel. The sand layer should be about 750mm deep if a taller barrel is used. Sand size between 0.1-1.0mm is acceptable, but sand size from 0.2-0.5mm is preferred.

Determine the volume of sand needed for the filter by using the following formula:

$$V = \frac{\pi}{4} (d^2) (h)$$

where V = volume

$\pi = 3.1$

d = diameter of the barrel = (0.6m)

h = the height of the sand layer = (0.6m)

$$V = \frac{3.14}{4} (0.6m^2) (0.6m)$$

$$V = 0.785 (.36m^2) (0.6m)$$

$$V = 0.17m^3 \text{ or } 0.2m^3$$

For the filter, choose a fine grain sand. Generally, the finer the sand, the better the quality of water. Do not use coarse sands in the filter. Coarse sands allow organic matter and bacteria to pass through the filter.

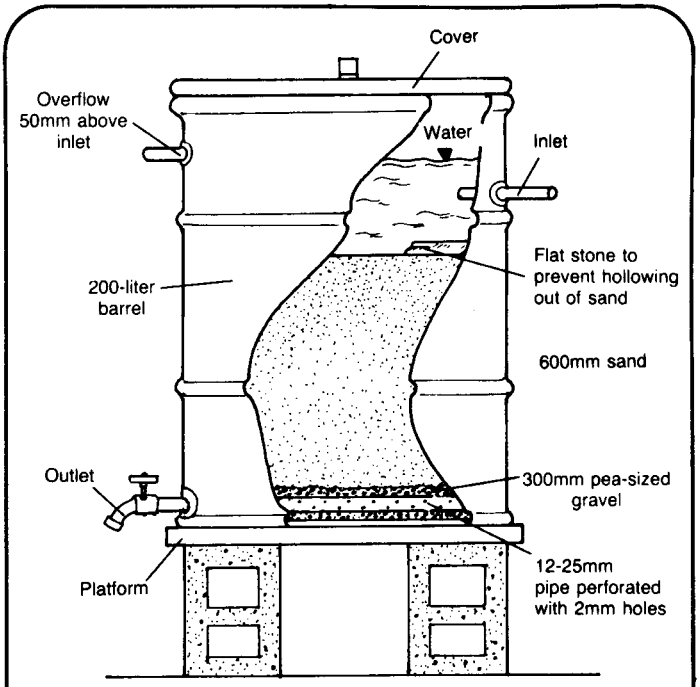


Figure 2. Household Sand Filter

Table 2. Materials List for Slow Sand Filter

Item	Quantity
Steel drum for filter (0.6m x 0.75m)	_____
Pre-and post-filtration storage drums (200-liter capacity)	_____
Clean sand, sized 0.1-1.0mm	_____
Pea gravel	_____
Sheet metal and wood, for cover	_____
Polyethylene flexible pipe for inlets and outlet pipes	_____
Valve to regulate water flow	_____

Pea-sized stones should be used to line the bottom of the barrel where the outlet for the filter is located. The gravel layer should be 30-50mm thick. The filter outlet hole should be no more than 2mm in diameter.

If the sand filter is designed to receive a continuous flow of water, there should be an inlet hole and an overflow at the top of the barrel. The overflow should be about 50mm higher than the inlet.

Provide for a continuous flow of water through the filter sufficient to keep the filter full with a slight overflow. The maximum rate of flow through the filter should not be more than about 1 liter/minute. Water should flow from storage into the sand filter by gravity flow through flexible plastic pipe. A valve should be installed to regulate the flow. See Figure 3.

The sand in the filter should never be allowed to dry out. If the sand layer dries, the sand should be wasted or replaced. Dried sand may add bacteria to the water. Flow should be checked occasionally to ensure that the sand layer is always covered. An outlet pipe should be connected to the filter so that the water flows to a storage container.

It is much easier to use the sand filter only as a means of clarifying water rather than removing bacteria. The design of the sand filter is simpler when disinfection is not included. Operation and maintenance requirements are also less demanding.

For simple filtration, design the sand filter in the same way as described except do not include either an inlet or an outlet hole on the upper side of the steel barrel. To filter the water, the cover is removed and the desired quantity of water poured into the filter. Then the cover should be replaced. There is no need to keep the sand layer always submerged. Filtered water is collected in a storage vessel. Water filtered in this manner probably needs further treatment to disinfect it.

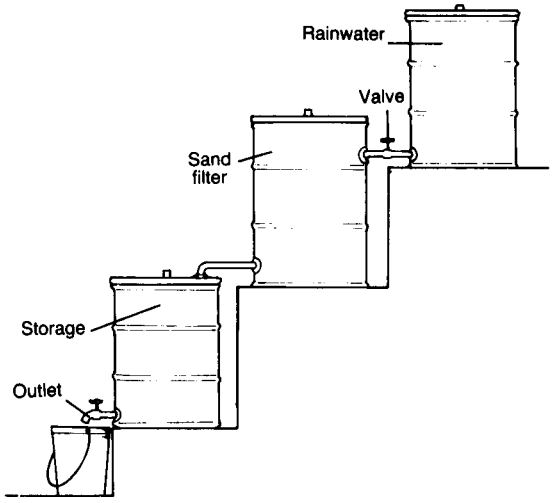


Figure 3. Household Sand Filter System with Gravity Flow and Storage

Summary

The design of most household treatment systems is simple and inexpensive. The choice of treatment method depends on available materials for construction, the users' access to chemicals, and the quality of the water supply. Proper design and proper use of chemicals are very important in ensuring that water quality is suitable. If questions or doubts about the use of a treatment process arise, an expert should be consulted to assist in the development of the most appropriate treatment method. If this is not possible, water should be boiled to disinfect it until a more permanent solution to the problem is found.