WATER PURIFICATION

The purification of unsafe water requires some trained supervision if it is to be
done effectively. Such supervision is rarely available in the villages and the procedure tends to be neglected sooner or later. Under these circumstances every effort must be made to obtain a source that provides naturally wholesome water and then to collect that water and protect it against pollution by the methods already described. Thus, the necessity for treatment of the water may be avoided,
and the practical importance of managing this can hardly be overemphasized.

Water treatment under rural conditions should be restricted by the responsible control agency to cases where such treatment is necessary and where proper plant operation and maintenance is assured.

If the water needs treatment, this should, if at all possible, be done for the whole community and certainly before, or on entry to the dwelling so that the water from all the taps in the house is safe. The practice, common in the Tropics, of sterilizing (by filtration and boiling) only the water to be used for
drinking, teeth cleaning, etc., though efficient in itself (when carefully done)

is frequently nullified by carelessness. Furthermore, children are likely to use water from any tap. Contrary to an all too common opinion, ordinary freezing of water, though it may retard the multiplication of bacteria, does not kill them, and ice from a household refrigerator is no safer than the water from which it was made.

The principal methods of purifying water on a small scale are boiling, chemical disinfection, and filtration. These methods may be used singly or in combination, but if more than filtration is needed the boiling or chemical disinfection should be done last. Each method is discussed briefly below. Following this general introduction are descriptions of a variety of water purification technologies: boiler for drinking water, chlorination of polluted water, water purification plant, and sand filter.

Boiling is the most satisfactory way of destroying disease-producing organisms in water. It is equally effective whether the water is clear or cloudy, whether it is relatively pure or heavily contaminated with organic matter. Boiling destroys all forms of disease-producing organisms usually encountered in water, whether they be bacteria, viruses, spores, cysts, or ova. To be safe the water must be brought to a good "rolling" boil (not just simmering) and kept there for 15-20 minutes.

Boiling drives out the gases dissolved in the water and gives it a flat taste, but if the water is left for a few hours in a partly filled container, even though the mouth of the container is covered, it will absorb air and lose its flat, boiled taste. It is wise to store the water in the vessel in which it was boiled. Avoid pouring the water from one receptacle to another with the object of aerating or cooling it as that introduces a risk of re-contamination.

Chlorine is a good disinfectant for drinking water as it is effective against the bacteria associated with water-borne disease. In its usual doses, however, it is ineffective against the cysts of amoebic dysentery, ova of worms, cercariae which cause schistosomiasis, and organisms embedded in solid particles.

Chlorine is easiest to apply in the form of a solution and a useful solution in one which contains 1 percent available chlorine, for example, Milton Antiseptic. Dakin's solution contains 0.5 percent available chlorine, and bleaching powder holds 25 percent to 30 percent available chlorine. About 37cc (2 1/2 tablespoons) of bleaching powder dissolved in 0.95 liter (1 quart) of water will give a 1 percent chlorine solution. To chlorinate the water, add 3 drops of 1 percent solution to each 0.95 liter (1 quart) of water to be treated (2 tablespoonfuls to 38 gallons), mix thoroughly and allow it to stand for 20 minutes or longer before using the water.

Chlorine may be obtained in table form as "Sterotabs" formerly known as "Halazone"), "Chlor-dechlor" and "Hydrochlorazone," which are obtainable on the market. Directions for use are on the packages.

Iodine is also a good disinfecting agent. Two drops of ordinary tincture of iodine are sufficient to treat 0.95 liter (1 quart) of water. Water that is cloudy or muddy, or water that has a noticeable color even when clear, is not suitable for disinfection by iodine. Filtering may render the water fit for treatment with iodine. If the water is heavily polluted, the dose should be doubled. Though the higher dosage is harmless it will give the water a medicinal taste. To remove any medicinal taste add 7 percent solution of sodium thiosulphate in a quantity equal to the amount of iodine added.

Iodine compounds for the disinfection of water have been put into table form, for example, "Potable Aqua Tablets," "Globaline" and "Individual Water Purification Tablets"; full directions for use are given on the packages. These tablets are among the most useful disinfection devices developed to date and they are effective against amoeba cysts, cercariae, leptospira, and some of the viruses.

Source:

Small Water Supplies, Bulletin No. 10 London: The Ross Institute, 1967.

Other Useful References:

**Mann, H.T. and Williamson, P. Water Treatment and Sanitation. London: Intermediate
Technology Publications, 1976.**

Iornech Disinfection System, Iornech Ltd., 2063 Lakeshore Blvd. West Toronto, Ontario, Canada, (undated).

Manual of Individual Water Supply Systems. Public Health Service Publication No. 24, Washington, D.C. U.S. Department of Health amd Human Services, 1962.

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International Reference Center for Community Water Supply and Sanitation, newsletter. P.O. Box 93190, 2509 AD, The Hague, Netherlands.

Boiler for Drinking Water

The boiler described here (Figure 1) will provide safe preparation and storage of

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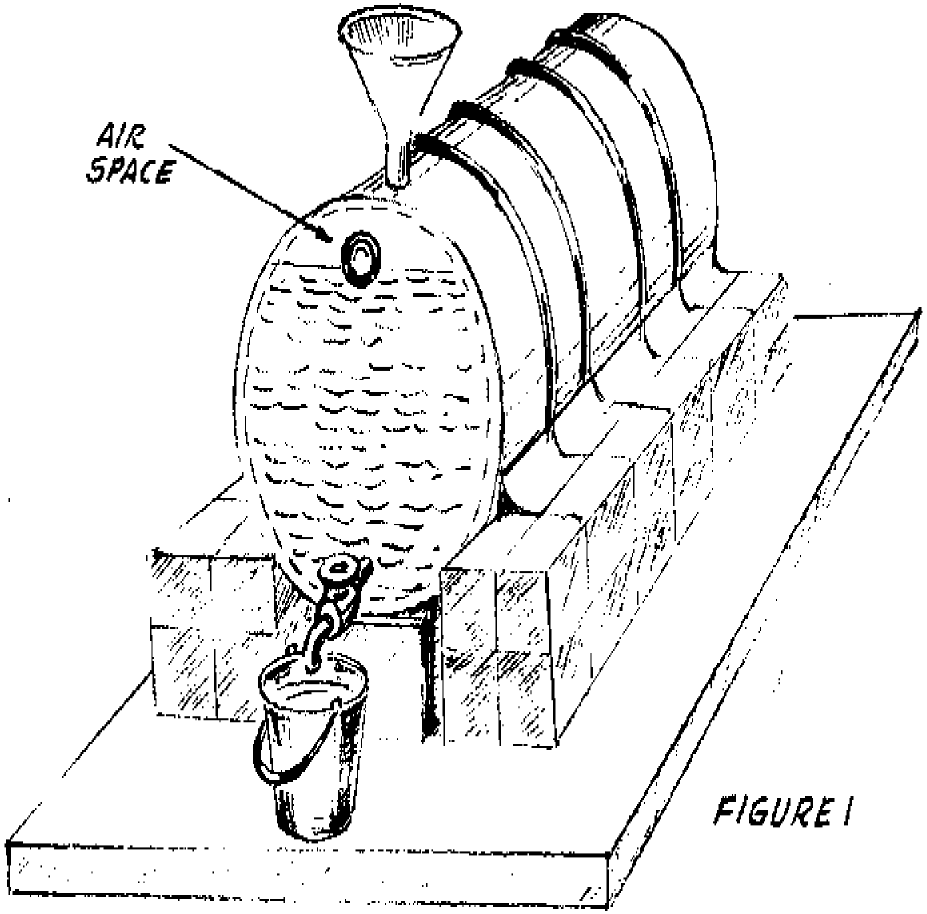

FIGURE 1

drinking water in areas where pure water is not available and boiling is practical.
When the unit was used in work camps in Mexico, a 208-liter (55-gallon) drum supplied 20 persons with water for a week.

Tools and Materials

208-liter (55-gallon) drum
10mm (3/4") pipe nipple, 5cm (2") long
Bricks for two 30cm (1') layers to support drum

Sand and 1 sack of cement for mortar and base of fireplace
Large funnel and filter medium for filling drum
Metal plate to control draft in front of fireplace
19mm (3/4") valve, preferably all metal, such as a gate valve, that can withstand heat.

The fireplace for this unit (see Figure 2) is simple. It should be oriented so that

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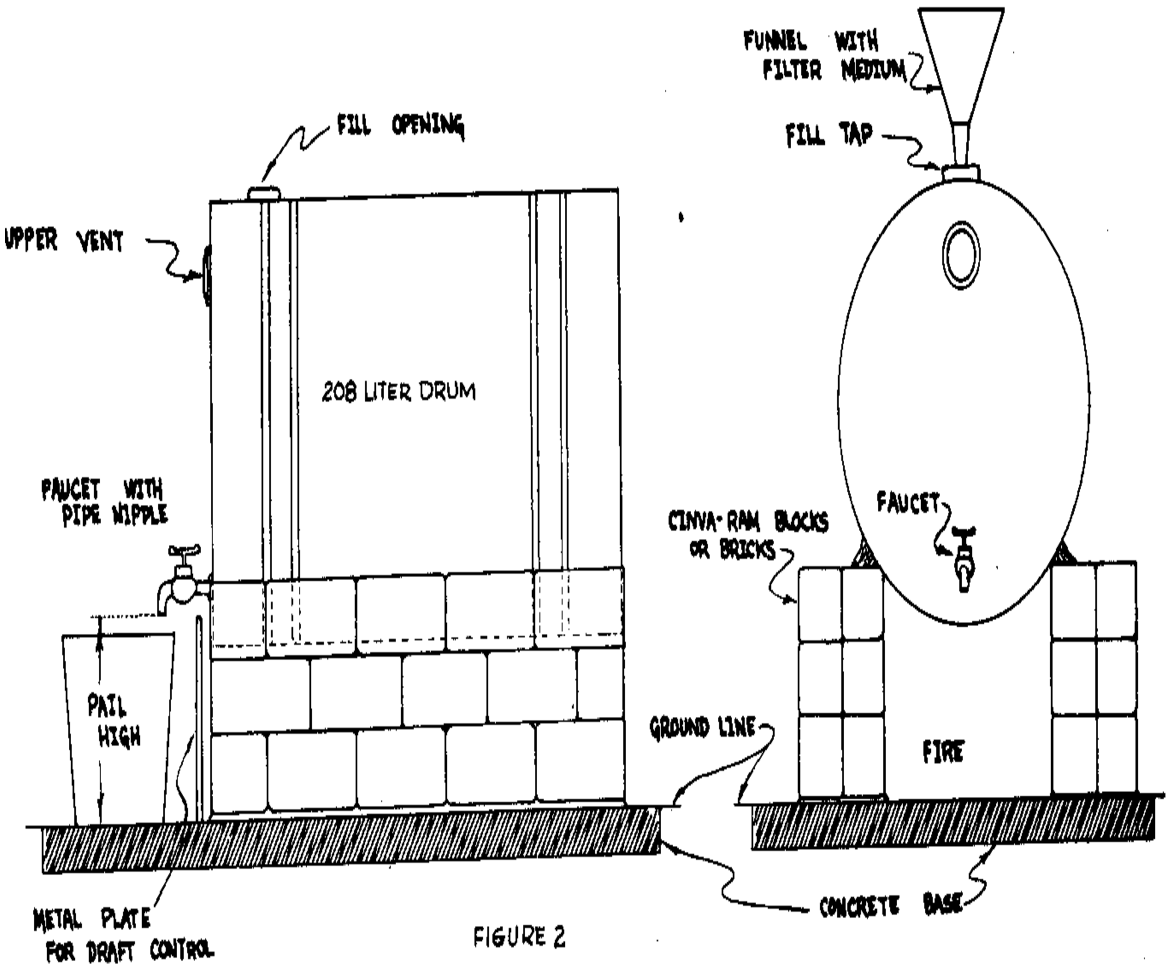

FIGURE 2

the prevailing wind or draft goes between the bricks from the front to the back of the drum. A chimney can be provided, but it is not necessary.

When filling the drum, do not fill it completely, but leave an air space at the top
as shown in Figure 1. Replace the funnel with a filler plug, but leave the plug completely loose.

Water must boil at least 15 minutes with steam escaping around the loose filler plug. Make sure that the water in the pipe nipple and valve reach boiling temperature by letting about 2 liters (2 quarts) of water out through the valve while the drum is at full boil.

Source:

Chris Ahrens, VITA Volunteer, Swannanoa, North Carolina

Chlorinating Wells, Springs, and Cisterns

Chlorination, when properly applied, is a simple way to ensure and protect the purity of water. Guidelines given here include tables to give a rough indication of
the amounts of chlorine-bearing chemical needed. Instructions are also given for super-chlorination for disinfecting newly built or repaired wells, spring encasements,
or cisterns. Chlorine-bearing compounds, such as ordinary laundry bleach
made with chlorine are used because pure chlorine is difficult and dangerous to use.

Determining the Proper Amount of Chlorine

The amounts of chlorine suggested here will normally make water reasonably safe.

A water-treatment system should be checked by an expert. In fact, the water should be tested periodically to make sure that it remains safe. Otherwise, the system itself could become a source of disease.

Tools and Materials

Container to mix chlorine
Chlorine in some form
Scale to weigh additive

The safest way to treat water for drinking is to boil it (see "Boiler for Drinking Water"). However, under controlled conditions, chlorination is a safe method; it is often more convenient and practical than boiling. Proper treatment of water with chlorine requires some knowledge of the process and its effects.

When chlorine is added to water, it attacks and combines with any suspended organic matter as well as some minerals such as iron. There is always a certain amount of dead organic matter in water, as well as live bacteria, viruses, and perhaps other types of life. Enough chlorine must be added to oxidize all of the organic matter, dead or alive, and to leave some excess uncombined or "free" chlorine. This residual free chlorine prevents recontamination. Too much residual chlorine, however, is harmful and extremely distasteful.

Some organisms are more resistant to chlorine than others. Two particularly resistant varieties are amoebic cysts (which cause amoebic dysentery) and the cercariae of schistosomes (which cause bilharziasis or schistosomiasis). These, among others, require much higher levels of residual free chlorine and longer contact periods than usual to be safe. Often special techniques are used to combat these and other specific diseases.

It always takes time for chlorine to work. Be sure that water is thoroughly mixed with an adequate dose of the dissolved chemical, and that it stands for at least 30 minutes before consumption.

Polluted water that contains large quantities of organic matter, or cloudy water, is not suitable for chlorination. It is best, and safest, to choose the clearest water available. A settling tank and simple filtration can help reduce the amount of suspended matter, especially particles large enough to see. Filtration that can be depended upon to remove all of the amoebic cysts, schistosomes, and other parthogens normally requires professionals to set up and operate.

NEVER depend on home-made filters alone to provide drinking water. However, a home-made slow sand filter is an excellent way to prepare water for chlorination.

Depending on the water to be treated, varying amounts of chlorine are needed for adequate protection. The best way to control the process is to measure the amount of free chlorine in the water after the 30 minute holding period. A simple chemical test, which uses a special organic indicator called orthotolidine, can

be used. Orthotolidine testing kits available on the market come with instructions on their use.

When these kits are not available, the chart in Table 1 can be used as a rough

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TABLE 1

INITIAL CHLORINE DOSE TO SAFEGUARD DRINKING WATER SUPPLY*

Water Condition	Initial Chlorine Dose in Parts Per Million (ppm)	
	No hard-to-kill organism suspected	Hard-to-kill organisms present or suspected
Very Clear, few minerals	5 ppm	Get expert advice; in an emergency boil and cool water first, then use 5 ppm to help prevent recontamination. If boiling is impossible, use 10 ppm.
A coin in the bottom of 1/4 liter (8 ounce) glass of the water looks hazy.	10 ppm	Get expert advice; in an emergency boil and cool first. If boiling is impossible use15 ppm.

* Parts per million (ppm) is the number of parts by weight of chlorine to a million parts by weight of water. It is equivalent to milligrams of per liter.

guide to how strong a chlorine solution is necessary. The strength of the solution
is measured in parts by weight of active chlorine per million parts by weight of

water, or "parts per million" (ppm).

The chart in Table 2 gives the amount of chlorine-compound to add to 1,000 liters

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TABLE 2

AMOUNTS OF CHLORINE COMPOUND TO ADD TO DRINKING WATER

Chlorine Compound	Percent by Weight Active Chlorine	Quantity to add to 1000 U.S. gallons of water required strength			Quantity to add to 1000 liters to get required strength		
		5 PPM	10 PPM	15 PPM	5 PPM	10 PPM	15 PPM
High test Calcium Hypochlorite $Ca(OCl)_2$	70%	1 oz	2 oz	3 oz	8 gms	15 gms	23 gms
Chlorinated Lime	25%	2 1/2 oz	5 oz	7 1/2 oz	20 gms	40 gms	60 gms
Sodium hypochlorite NaOCl	14%	5 oz	10 oz	15 oz	38 gms	75 gms	113 gms
Sodium hypochlorite	10%	7oz	13 oz	20 oz	48 gms	95 gms	143 gms
Bleach—A Solution of Chlorine in water	usually 5.25%	13 oz	26 oz	39 oz	95 gms	190 gms	285 gms

or to 1,000 gallons of water to get the solutions recommended in Table 1.

Usually it is convenient to make up a solution of 500 ppm strength that can then

be further diluted to give the chlorine concentration needed. The 500 ppm solution must be stored in a sealed container in a cool dark place, and should be
used as quickly as possible since it does lose strength. Modern chlorination plants
use bottled chlorine gas, but this can only be used with expensive machinery by trained experts.

Super-Chlorination

Super-chlorination means applying a dose of chlorine that is much stronger than the dosage needed to disinfect water. It is used to disinfect new or repaired wells, spring encasements, and cisterns. Table 3 gives recommended doses.

TABLE 3

RECOMMENDED DOSES FOR SUPER-CHLORINATION*

Application Recommended Dose Procedure

New or repaired well 50 ppm 1. Wash casing, pump exterior
and drip pipe with solution.
2. Add dosage to water in well.
3. Pump until water coming from
pump has strong chlorine
odor for deep wells, repeat
this a few times at 1
hour intervals.)

4. Leave solution in well
at least 24 hours.
5. Flush all chlorine from well.

Spring encasements 50 ppm Same as above.

Cisterns 100 ppm 1. Flush with water to remove
any sediment.
2. Fill with dosage.
3. Let stand for 24 hours.
4. Test for residual chlorine.
If there is none, repeat
dosage.
5. Flush system with treated
water.
*** To find the correct amounts of chlorine compound needed for the required dosage, multiply the amounts given under 10ppm in Tables 2 or 3 to get 50ppm and by 10 to get 100ppm.**

Example 1:

A water-holding tank contains 8,000 U.S. gallons. The water comes from a rapidly moving mountain stream and is passed through a sand filter before storage. How much bleach should be added to make this water drinkable? How long should the water be mixed after adding?

Solution:

In this case 5 ppm are probably sufficient to safeguard the water. To do this with bleach requires 13 ounces per 1,000 gallons. Therefore the weight of bleach to be added is 13 x 8 or 104 ounces.

Always mix thoroughly, for at least a half hour. A good rule of thumb is to mix until you are certain that the chemical is completely dissolved and distributed and then ten minutes longer. In this case, with an 8,000-gallon tank, try to add the bleach to several different locations in the tank to make the mixing easier. After mixing, test the water by sampling different locations, if possible. Check the corners of tank especially.

Example 2:

A new cistern has been built to hold water between rainstorms. On its initial filling it is to be super-chlorinated. How much chlorinated lime should be added? The cistern is 2 meters in diameter and 3 meters high.

Solution:

First calculate the volume of water. For a cylinder, Volume is [D.sup.2 = H (D is diameter, H is height and is 3.14.) --------
4

Here D = 2 meters H = 3 meters.

V = 3.14 x (2 meters) x (2 meters) x (3 meters)

4

V = 9.42 cubic meters = 9,420 liters (Each cubic meter contains 1,000 liters.)

From Table 3 we learn that a cistern should be super-chlorinated with 100 ppm of chlorine. From Table 2, we learn that it takes 40 grams of chlorinated lime to bring 1,000 liters of water to 10 ppm C1. To bring it to 100 ppm, then, will require ten times this amount, or 400 grams.

400 grams x 9.42 thousand liters = 3,768 grams.
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thousand liters

Source:

Salvato, J.S. Environmental Sanitation. New York: John Wiley & Sons, Inc., 1958

Field Water Supply, TM 5-700.

Water Purification Plant

The water purification plant described here uses laundry bleach as a source of chlorine. Although this manually-operated plant is not as reliable as a modern water system, it will provide safe drinking water if it is operated according to instructions.

Many factors in this system require operating experience. When starting to use the system, it is safest to have the assistance of an engineer experienced in water supplies.

Tools and Materials

3 barrels, concrete tanks, or 208 liter (55-gallon) drums
20cm (8") funnel, or sheet metal to make a funnel
2 tanks, about 20 liters (5 gallons) in size
4 shut-off valves
Throttle or needle valve (clamps can be used instead of valves if hose is used)
Pipe or hose with fittings
Hypochlorite of lime or sodium hypo-chlorite (laundry bleach)

The water purification plant is made as in Figure 3. The two tanks at the top of

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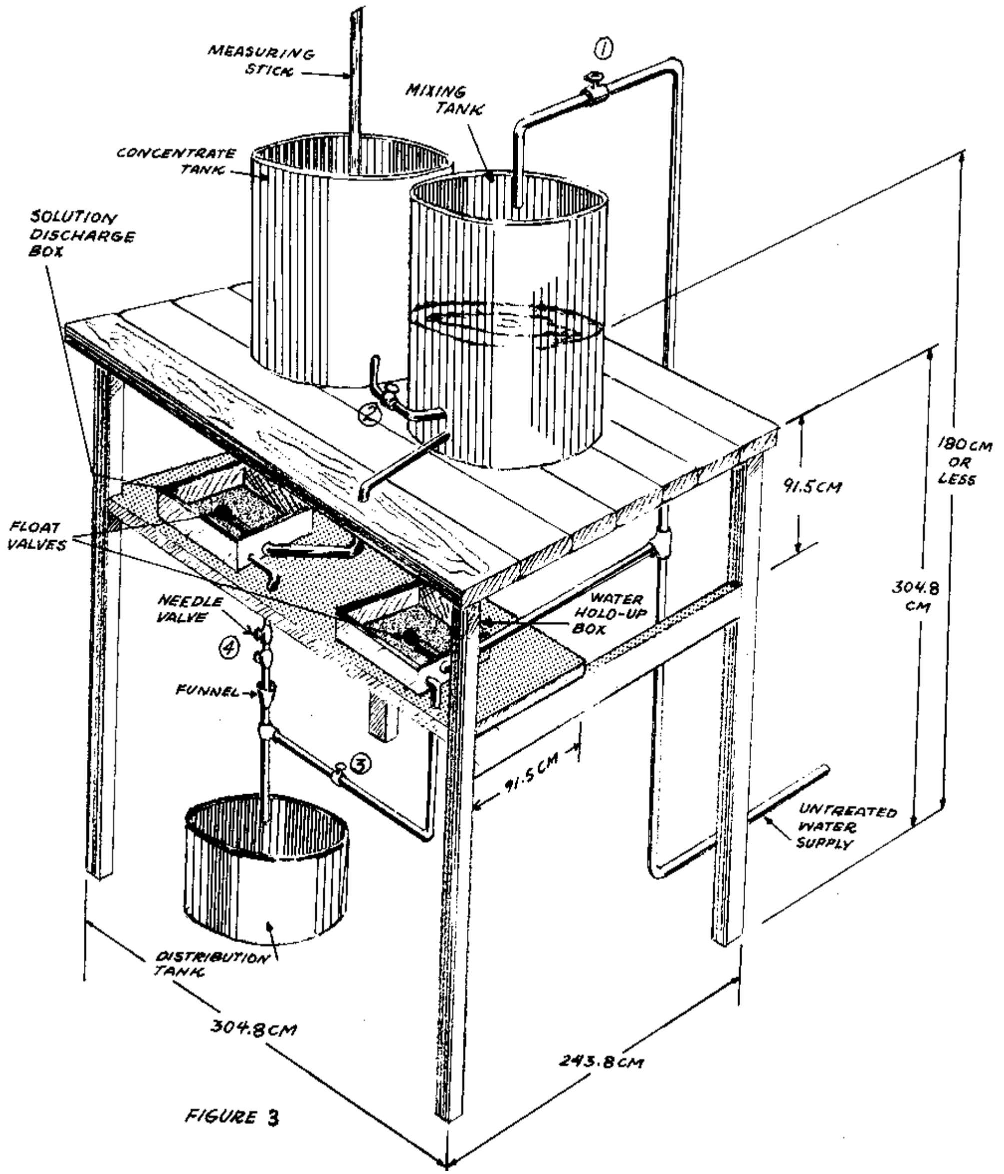

FIGURE 3

the structure are for diluting the bleach. (The system can be simplified by eliminating the concentrate tank; the bleach is then added directly to the mixing tank.)

The two smaller tanks on the shelf below are for holding equal amounts of diluted bleach solution and water at a constant pressure; this makes the solution and the water flow at the same speed into the hoses that lead to the mixing point. The mix, which can be seen through the open funnel, is further controlled by the valves. If a needle or throttle valve is not available a throttle action can be obtained by installing another shut-off valve in series with Valve #4.

Placing the two barrels at a height of less than 1.8 meters (6') above the float valve causes a pressure of less than 0.35kg per square centimeter (5 pounds per square inch). Thus, the plumbing does not have to be of high quality except for Valve #1 and the float valve of the water hold-up tank, if the water supply is under higher pressure.

A trial and error process is necessary to learn how much concentrate should be put in the concentrate tank, how much concentrate should flow into the mixing tank, and how much solution should be allowed past the funnel. A suggested starting mixture is 1/4 liter (1/2 pint) of concentrated bleach for a mix tank capacity of 190 liters (50 gallons) to treat 1,900 liters (500 gallons) of water.

The water in the distribution tank should have a noticeable chlorine taste. The amount of bleach solution required depends on how dirty the water is.

1. Mix concentrated bleach with water in the concentrate tank with all valves closed. The mixing tank should be empty.

2. Fill the pipe from the mixing tank to the solution tank with water after having propped the float valve in a closed position.

3. Let a trial amount of concentrate flow into the mixing tank by opening Valve #2.

4. Use a measuring stick to see how much concentrate was used.

5. Close Valve #2 and open Valve #1 so that untreated water enters the mixing tank.

6. Close Valve #1 and mix solution in the mixing tank with a stick.

7. Remove the prop from the float valve of the solution tank so that it will operate properly.

8. Open wide the needle valve and Value #4 to clean the system. Let 4 liters (1 gallon) drain through the system, if the pipe mentioned in the second step is not permitted to empty before recharging the mixing tank.)

9. Close down to needle valve until only a stream of drops enter the funnel.

10. Open valve #3.

The flow into the funnel and the taste of the water in the distribution tank should be checked regularly to ensure proper treatment.

Source:

Chris Ahrens, VITA Volunteer, Swannanoa, North Carolina

Sand Filter

Surface water from streams, ponds, or open wells is very likely to be contaminated
with leaves and other organic matter. A gravity sand filter can remove most of this suspended organic material, but it will always let rivus and some bacteria pass through. For this reason, it is necessary to boil or chlorinate water
after it has been filtered.

By removing most of the organic matter, the filter:

o Removes large worm eggs, cysts, and cercariae, which are difficult to kill with chlorine.

o Allows the use of smaller and fixed doses of chlorine for disinfection, which results in drinkable water with less taste of chlorine.

o Makes the water look cleaner.

o Reduces the amount of organic matter, including living organisms and their food, and the possibility of recontamination of the water.

Although sand filtration does not make polluted water safe for drinking, a properly built and maintained filter will make chlorination more effective. Sand filters must be cleaned periodically.

The household sand filter described here should deliver 1 liter (1 quart) per minute of clear water, ready for boiling or chlorinating.

Tools and Materials

Steel drum: at least 60cm wide by 75cm (2'x 29 1/2")
Sheet metal, for cover: 75cm (29 1/2") square
Wood: 5cm x 10cm (2" x 4"), 3 meters (9.8') long
Sand: 0.2 cubic meter (7 cubic feet)
Gravel
Blocks and nails
Pipe, to attach to water supply
Optional: valve and asphalt roofing compound to treat drum

The gravity sand filter is the easiest type of sand filter to understand and set up.
It uses sand to strain suspended matter from the water, although this does not always stop small particles or bacteria.

Over a period of time, a biological growth forms in the top 7.5cm (3") of sand. This film increases the filtering action. It slows the flow of water through the sand, but it traps more particles and up to 95 percent of the bacteria. The water level must always be kept above the sand to protect this film.

Sand filters can get partially clogged with organic matter; under some conditions this can cause bacterial growth in the filter. If the sand filter is not

operated and maintained correctly, it can actually add bacteria to the water.

The drum for the sand filter shown in Figure 4 should be of heavy steel. It can

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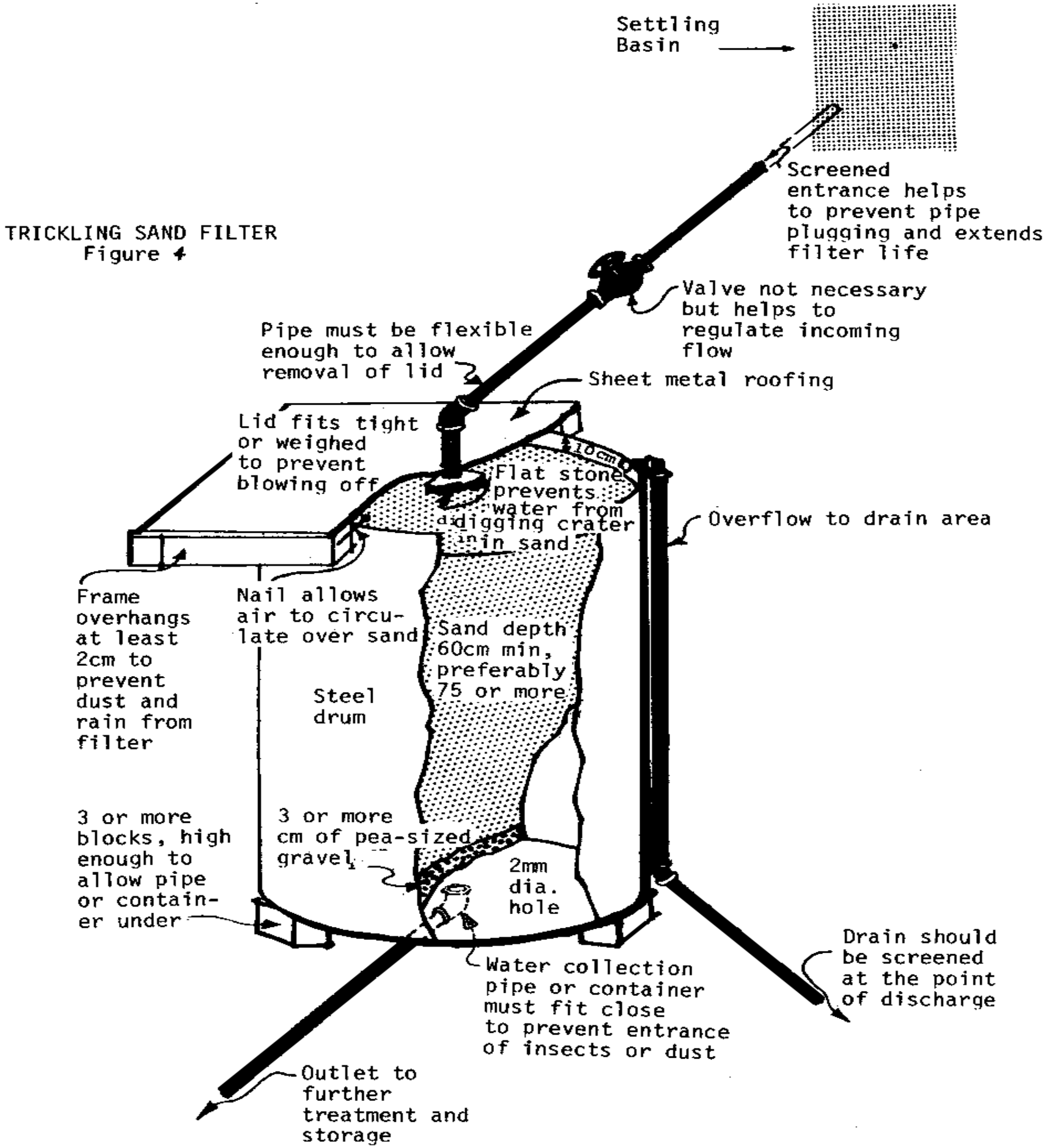

be coated with asphalt material to make it last longer.

The 2mm (3/32") hole at the bottom regulates the flow: it must not be made larger.

The sand used should be fine enough to pass through a window screen. It should also be clean; it is best to wash it.

The following points are very important in making sure that a sand filter operates
properly.

o Keep a continuous flow of water passing through the filter. Do not let the sand dry out, because this will destroy the film of microorganisms that forms on the surface layer of sand. The best way to ensure a continuing flow is to set the intake so that there is always a small overflow.

o Screen the intake and provide a settling basin to remove as many particles as possible before the water goes into the filter. This will keep the pipes from becoming plugged and stopping the flow of water. It will also help the filter to operate for longer periods between cleanings.

o Never let the filter run faster than 3.6 liters per square meter per minute (4 gallons per square foot per hour) because a faster flow will make the filter less efficient by keeping the biological film from building up at the top of the sand.

o Keep the filter covered so that it is perfectly dark to prevent the growth of green algae on the surface of the sand. But let air circulate above the sand to help the growth of the biological film.

o When the flow becomes too slow to fill daily needs, clean the filter: Scrape

off and discard the top 1/2cm (1/4") of sand and rake or scratch the surface lightly.

After several cleanings, the sand layer should be returned to its original thickness by adding clean sand. Before doing this, scrape the sand in the filter down to a clean level. The filter should not be cleaned more often than once every several weeks or even months, because the biological growth at the top of the sand makes the filter more efficient.

Source:

Hubbs, S.A. Understanding Water Supply and Treatment for Individual and Small Community Systems. Arlington, Virginia: VITA Publications, 1985.

Wagner, E.G. and Lanoix, J.N. Water Supply for Rural Areas and Small Communities. World Health Organization, 1959.