6 Water treatment

6.1 Introduction

Unfortunately, there is no such thing as a simple and reliable water treatment process suitable for small community water supplies. It is always preferable to choose and collect water from a source that provides naturally pure water, and then to protect it from pollution, than to treat contaminated water. Where there are no pure sources, then efforts should be made to reduce the amount of contamination that can reach a source so that subsequent treatment processes have to deal with a reduced amount of pollution. This short book can not give sufficient information for the design of a treatment system. Additional advice should therefore be obtained from one of the sources mentioned in the appendices and references, or from a water engineer.

As mentioned in Section 1.4, treated drinking water must be handled hygienically to minimize the risk of it becoming contaminated again. However, providing a good quantity of water which is not of a very high quality may result in greater health benefits than providing only a small amount of potable quality water. If a community is willing to distinguish between water for different uses, it may be feasible to treat only water which will be drunk or used for food preparation. This is particularly useful when treatment is taking place at household level, but can also apply in other situations such as a community choosing to continue to use a surface water source for laundry and cattle watering, etc.

Table 4 shows the main treatment stages for surface water used in conventional treatment systems. Some of these processes are inappropriate for small rural supplies because of the high level of operational skill required or the need for powered pumps, complicated equipment and chemicals. Treatment should only be considered if it can be afforded and be reliably operated. Both these requirements seriously limit the number of feasible treatment options for small rural communities. Suitable options are discussed below and the treatment of water for individual households is also mentioned where appropriate.

6.2 Screening

Screening of surface water has already been discussed in Section 3.4.4 and of rainwater in Section 3.2.

Table 4 Main treatment stages for surface water

Stage	Name of process	What takes place	Basis for process
1	Screening	Removes large solids (e.g. leaves, pieces of wood).	Physical
2	Aeration	Increases the oxygen content of the water; oxidation of some chemical compounds to an insoluble form; removes some sources of odour and taste.	Chemical
3	Sedimentation	Removes small suspended solids (e.g. sand, silt and insoluble chemicals).	Physical
4	Chemically assisted sedimentation (includes coagulators and flocculators)	Adds suitable chemicals (coagulants) to remove very fine suspended colloidal particles (e.g. clay particles).	Chemical and physical
5	Filtration (various forms, particularly rapid filtration and slow filtration, with one or two stages)	Removes remaining suspended particles; reduces or eliminates bacteria and other pathogens.	Mainly physical. Some biological (particularly for slow filtration)
6	Disinfection	Disinfects the water to kill any remaining bacteria or other pathogenic organisms, and to protect the water before it is consumed.	Chemical

Note:
This table is a simplification of the processes. Large particles are removed first, then smaller and smaller organic and inorganic particles.
Depending on the quality of the raw water, it may not be necessary to use all of the treatment stages shown, or it may be necessary to use some alternative forms of treatment.

At a domestic level straining surface water through a fine cloth will remove the very small water creatures that carry the guineaworm larvae. However the cloth needs to be kept clean, and should always be used the same way round. Sewing a thread onto one side to mark it enables that side to be identified.

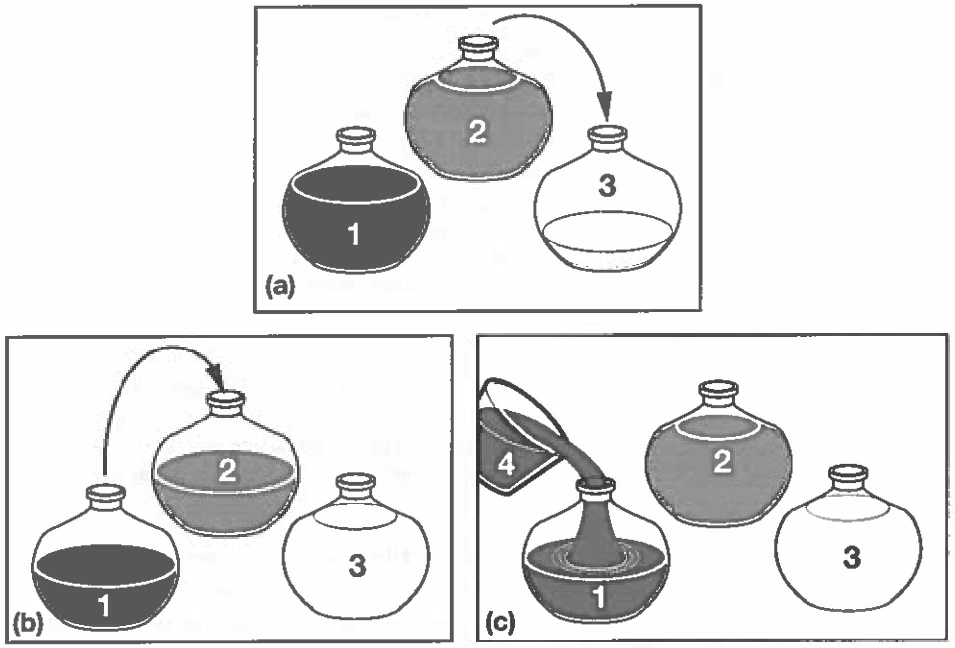
6.3 Storage and sedimentation

The simplest method of treatment is storage in a covered tank. If the water can be stored for at least two days, schistosomes (small larvae which cause bilharzia) will die. It will also contain considerably fewer bacteria because these slowly die off because the conditions in the tank are not normally suitable for their survival and multiplication. Pathogens (i.e. disease causing organisms including some types of bacteria) attached to suspended solids will settle to the bottom of the tank together with the solids, further purifying the stored water.

At domestic scale the simple three pot system (Figure 55) can be used to promote settlement during storage.

In a normal storage tank, such as one used to meet peak daily demands, most of the water will not be held in the tank for very long so the degree of improvement in the quality of the water will be limited. If the water level becomes shallow there is always a danger that settled solids will be stirred up by the incoming water and be carried into the distribution system.

Sedimentation tanks can be used to provide conditions suitable for silt and other solid material to settle out of the raw water. Although this removes some of the pathogens it is particularly useful before slow sand filtration to



Drinking water: Always take from pot 3. This water has been stored for at least two days, and the quality has improved. Periodically this pot will be washed out and may be sterilized by scalding with boiling water.

Each day when new water is brought to the house:

(a) Slowly pour water stored in Pot 2 into Pot 3, wash out Pot 2.
(b) Slowly pour water stored in Pot 1 into Pot 2, wash out Pot 1.
(c) Pour water collected from the source (Bucket 4) into Pot 1. You may wish to strain it through a clean cloth.

Using a flexible pipe to siphon water from one pot to another disturbs the sediment less than pouring.

Figure 55 The three-pot treatment system.
Source: Shaw (1999)

remove materials that may quickly block such a filter. Sedimentation will not be very effective unless the tank is designed to ensure that the incoming water cannot flow in a narrow stream directly from the inlet to the outlet. Sedimentation tanks therefore often have baffles to spread the flow at inlet and use weirs to collect the flow from a wide area at outlet (Figure 56). If a long rectangular tank is not used, a similar result can be obtained by using a series of vertical walls, to create a long narrow channel which zigzags across the tank from one end to the other. The width to length ratio of a sedimentation tank, or the channel, should be between 1:3 and 1:8. An average horizontal velocity of between 4 and 36 m/hr is necessary to promote settlement, depending on the nature of the sediment and the design of the tank. The

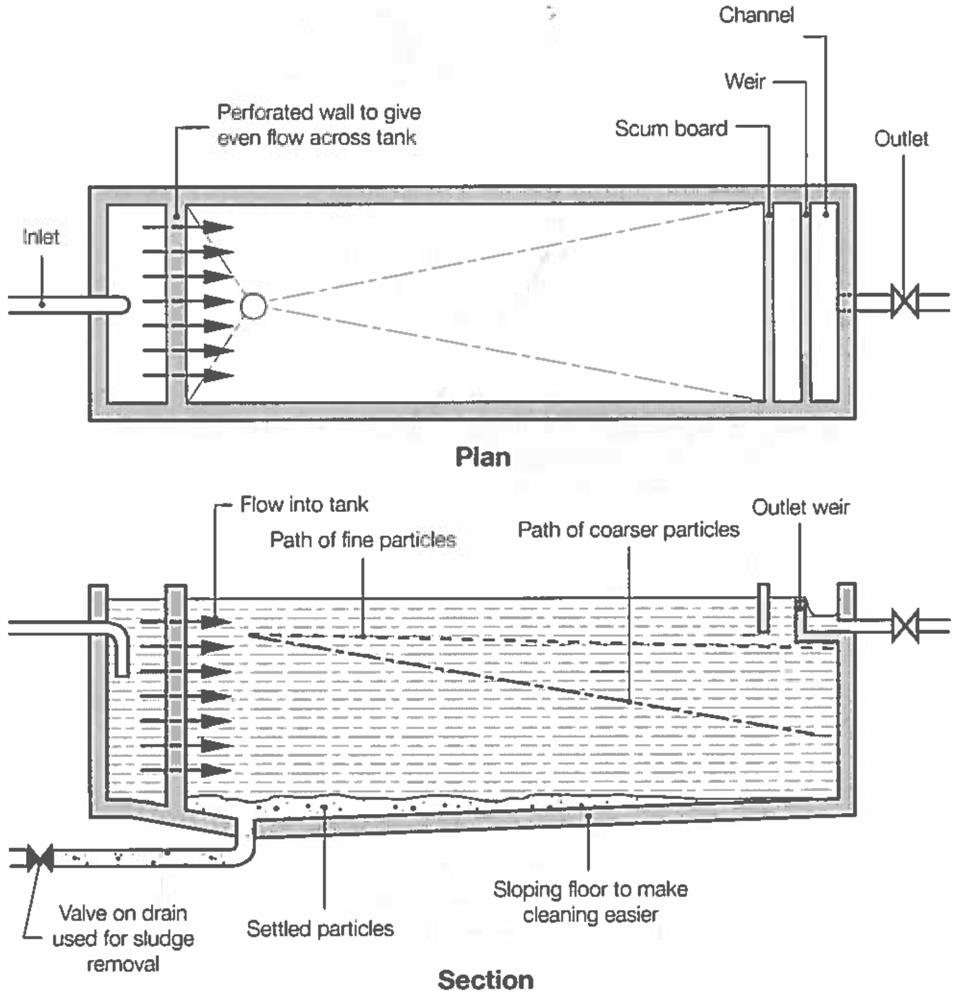


Figure 56 Plain sedimentation tank.
Source: WEDC

ratio of the flow rate through the tank to the surface area of the tank usually lies between 0.1 and 1 $m^3/m^2/hr$.

Usually at least two sedimentation tanks will be needed so that one can be in use while the other is being cleaned. Since the tank is designed for silty surface water which has already been exposed to pollution no cover is required unless there is a risk that the tank becomes a breeding place for mosquitoes.

If the suspended solids in the water are very fine, they may not settle quickly enough for simple sedimentation to work. This may be checked by leaving a sample to settle in a bottle for an hour. If the water is still dirty after this time, it is likely to require the addition of special chemicals, called coagulants, to get the fine suspended solids to settle effectively. A frequently used chemical is alum (aluminium sulphate), but a coagulant can also be produced from the seeds of the *Moringa Oleifera* tree that is found in many tropical countries. After coagulation a flocculator may be needed to gently agitate the chemically dosed water before the sedimentation stage.

Large-scale processes of coagulation and flocculation are usually far too complicated to be appropriate for a small rural community and are not covered further in this short book. Alum and ground-up seeds of the *Moringa Oleifera* tree are sometimes used at household level where they are added to buckets of water which are then stirred very slowly for at least five minutes and then left undisturbed for an hour or more for the settlement to take place.

Roughing filters can be a more effective way of removing suspended solids than simple sedimentation tanks (i.e. those that do not use chemicals). The particles removed by a roughing filter are smaller than the spaces between the stones so, despite the name 'filter' the suspended solids are not filtered out. These are rather a type of settlement system in which the water passes through the pores between the stones in a number of chambers. Each chamber is filled with a different size of stones, with the first chamber holding the largest size. The particles that are removed settle on the stones, or are attracted to their surfaces.

There are two main designs of roughing filter, vertical flow and horizontal flow. An upflow system (Figure 57) using three chambers which operate in series is usually considered to be the best type of system. Each needs to be cleaned periodically by quickly opening very large outlets to cause the tank to drain to waste very fast. As a result, most of the deposits are washed off by a high velocity of flow through the pores. In recent years research has taken place to investigate the performance of roughing filters. Helpful guidance on their design and operation is available (see appendices and references).

Roughing filters

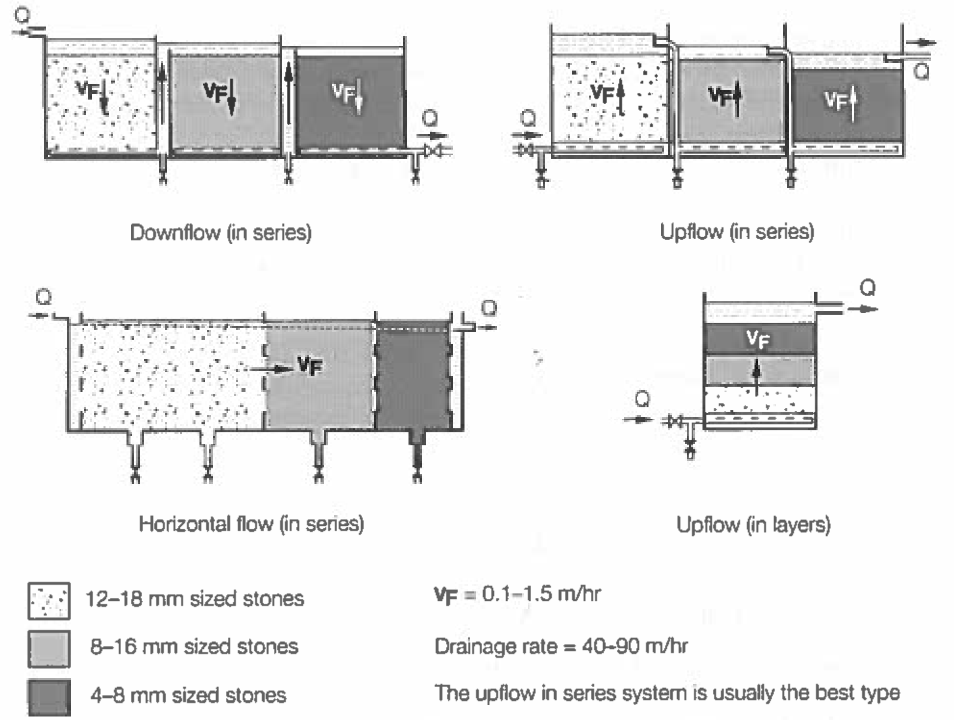


Figure 57 Roughing filters.
Source: Wegelin (1996)

6.4 Filtration

6.4.1 Introduction

Some kinds of water filter can remove more than 99% of the bacteria and viruses in water if they are correctly operated, as well as other sources of disease such as cysts, ova and schistosomes. Loose granular materials such as sand are often used in these filters. They can treat water on a large or small scale.

At a household scale, instead of using granular materials, a solid porous filter (e.g. ceramic 'candle') can be used to filter the small amounts of water needed for drinking. These filters are rarely used on a wide scale in low-income areas. The ceramic material needs to be regularly scrubbed clean and disinfected using boiling water. It should be replaced if any crack develops or when, as a result of the frequent scrubbing, it wears too thin to filter the water effectively. Some manufacturers include silver compounds in the ceramic which kill micro-organisms that come into contact with them.

In granular filters the medium is usually sand, but other materials such as burnt rice husks may be used. Charcoal is sometimes used to remove tastes and odours but it can become a breeding ground for bacteria and is not recommended for small treatment systems. Whatever granular material is used, the particles should be clean and fairly uniform in size. Different types of filter need different sizes of sand. Rapid filtration operates at a fairly high filtration rate (e.g. 5–7 $m^3/m^2/hr$) and needs fairly coarse sand (e.g. 0.7–1.0 mm particle sizes). Slow filtration, which can remove virtually all bacteria, uses a slower filtration rate (e.g. 0.1–0.2 $m^3/m^2/hr$) and uses much finer sand (e.g. 0.15–0.35 mm). Both use the depth of water above a bed of sand to push water through it into a collection system that covers the whole floor of the tank.

6.4.2 Rapid sand filters

Most rapid sand filters are contained in an open reinforced concrete tank. Usually the depth of water above the sand provides the pressure to push the water through the sand. A pressure filter is a special type of rapid sand filter in which the sand is instead held inside a closed prefabricated, pressure-resistant unit. This means that a pump (or sometimes gravity flow) can be used to increase the pressure of the water contained above sand, resulting in a faster rate of filtration.

Both types of rapid filter can remove most of the suspended solids from water, particularly if coagulation, flocculation and sedimentation precede them, but many bacteria and viruses will still remain in the water. This means that to produce potable water they must be followed by disinfection, or by a slow sand filter.

Rapid sand filters usually need a pumps, and ideally an air compressor too, to regularly backwash and fluidize the sand bed, to wash out the material removed from the raw water. Hence such filters are generally too complicated for operation in small communities. They will therefore not be considered further.

6.4.3 Slow sand filters

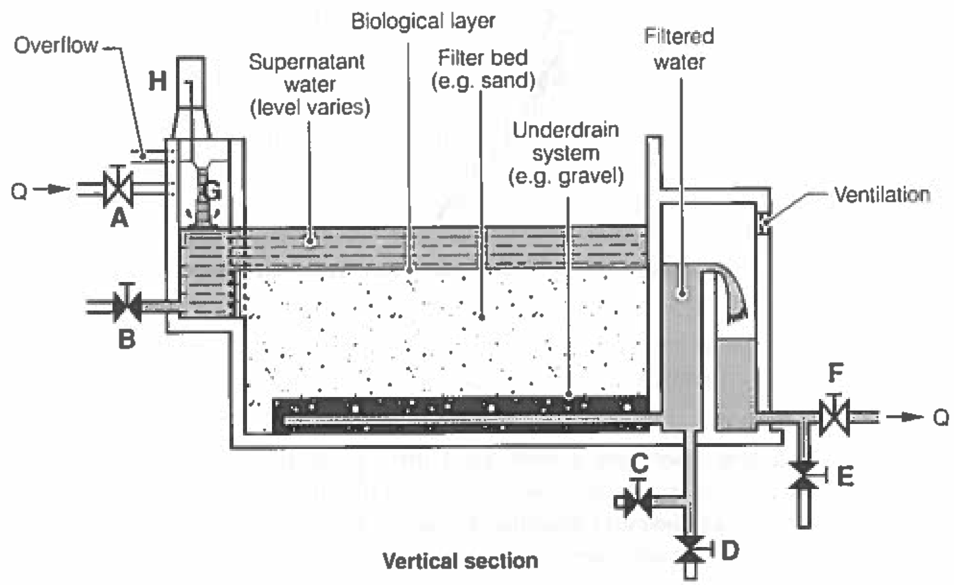
Slow sand filters are simpler to operate and maintain than rapid sand filters and are usually very effective in removing bacteria and other water-borne pathogens. Although operation requires little skill, a slow sand filter needs regular attention from a committed caretaker who understands the process if it is to perform well. The filter also needs to be carefully designed. Advice on this can be obtained from some of the sources mentioned in the appendices and references.

A slow sand filter consists basically of a large tank containing a bed of fine sand which is initially 0.9–1.2 m thick. Water flows through this bed to reach a set of drains that take it to an outlet weir (Figure 58). The filter works by a combination of biological action, adsorption (like a roughing filter) and

straining. Its most important feature is the sticky deposit (called the *schmutzdecke*) which forms on the very top of the sand. In this layer bacteria and microscopic plants multiply to form a very fine straining mat in the topmost few millimetres. Useful micro-organisms in the mat and deeper in the sand feed on any pathogens in the water. This greatly improves its quality.

If the water going into the filter is reasonably clear, a slow sand filter may run for weeks or even months without cleaning. If the water is not reasonably clear the slow sand filter will need very frequent cleaning. If the water is very dirty, it is advisable to try to improve it before it enters the filter. This is best done using a sedimentation tank or a roughing filter. Where appropriate a rapid sand filter can be used.

To produce good quality treated water the flow rate through the filter needs to be carefully controlled. Control can be by manually adjusted valves at inlet (Figure 58) or at outlet (not shown). A 'V' notch (Section 3.6.2) on the inlet or outlet weir, used together with a depth of flow indicator, allows



A Valve for raw-water inlet and regulation of filtration rate (discharges behind weir)
B Valve for drainage of supernatant water layer
C Valve for back-filling the filter bed with clean water
D Valve for drainage of filter bed and outlet chamber
E Valve for delivery of treated water to waste when filter is maturing
F Valve for delivery of treated water to the clear-water reservoir
G Inlet weir
H Calibrated flow indicator

Figure 58 Basic components of an inlet controlled slow sand filter.
Source: IRC (1987)

the operator to check the flow rate. Automatic systems can also be used. However, they need to be simple and reliable.

A slow sand filter requires cleaning before the flow rate becomes insufficient for the community's needs, even when the water level above the filter has risen to its maximum depth (e.g. 1.5 m). Cleaning comprises draining the water to about 50 mm below the top of the sand and then scraping off the top 10–20 mm. This material is discarded, or is washed clean and stockpiled for reuse.

When, after successive cleaning, the sand bed is only 600 mm thick, 300 mm or more of clean sand has to be added to the bed, bringing the bed back to its original thickness. First the surface must be scraped clean in the usual way. It is then best to remove a 400 mm layer of the remaining sand, or to move this to one side of the tank, to enable the new sand to be placed low in the bed. The removed sand is then replaced to form the top layer. This is advantageous because useful organisms in the existing sand can then quickly regenerate the *schmutzdecke*.

The quality of the water flowing from a well-operated sand filter is usually very good. However, after cleaning, the filtered water will not be of potable quality until a few days later, during which time the *schmutzdecke* is being re-formed. During this 'ripening' period water should be recycled or run to waste, although it could be used for drinking water if it were disinfected (see Section 6.5). If only one filter is being used, and disinfection is not feasible, then several days of storage of treated water would be necessary. A better idea is to use more than one filter, so the other filter(s) can provide the full daily demand for treated water during cleaning and for a few days afterwards.

Water that is to pass through a slow sand filter should never be chlorinated because the residual chlorine will kill off the useful micro-organisms living in the sand (Section 6.5.2).

Building and operating a slow sand filter properly is not straightforward so before choosing to use one it is best to obtain advice from a water engineer. Useful guidance is available in some of the material mentioned in the appendices and references.

Small sand filters for use by individual families, often based on partly filling oil drums with sand, have been used in some places. These are not able to produce as good a quality of water as conventional slow sand filters. This is partly because of three main reasons:

- the depth of sand is often less than 600 mm
- there is often no flow rate control system
- the maximum depth of water above the sand is usually not very deep (e.g. only 0.3 m instead of 1.5 m) leading to short periods of operation before cleaning is necessary. This period can be extended by using sedimentation, such as provided by the three-pot system (Figure 55), before filtration.

Despite the fact that not all pathogens may be removed, the water quality from a household filter will be much better than the raw water. Hence they are still worthwhile, provided the owner is committed to following the correct operating procedure involved in regularly scraping off the top layer of sand and periodically replacing the sand which has been removed. As mentioned above, proper provision also needs to be made for supplying potable water when the filter is being cleaned and for several days afterwards.

6.5 Disinfection

6.5.1 Introduction

Disinfection reduces the numbers of organisms in water to such a low level that no infection or disease results when the water is drunk. It is a term usually used for the addition of chemicals to water, but ultraviolet (UV) light (which can be from the sun or an electrically powered lamp) also kills some harmful micro-organisms, as does boiling water.

The need to disinfect water to kill all pathogens in drinking water should be considered carefully. Despite consuming clean water users can still ingest similar pathogens, sometimes at much greater concentrations, from other sources, such as with food. Where this is the case the health of the community may improve more if, instead of implementing chemical disinfection, the money is spent on funding a programme which leads to changes in hygiene practices (See Section 1.4).

Disinfection on a regular basis is rarely practicable in rural areas. It should be viewed as a last resort. As mentioned earlier, it is far better to find, protect and use an unpolluted source.

6.5.2 Chemical disinfection

Water supplies are usually disinfected by adding chlorine, although other substances like ozone gas may also be used. Other chemicals, such as iodine and potassium permanganate, may also be used for small-scale disinfection. Sources of chlorine and ways of preparing solutions with certain concentrations of chlorine have already been discussed in Section 3.5.

Chlorine can kill bacteria, schistosomes, some viruses and, in higher doses (>2 mg/l), amoebic cysts. There is little danger to health from excessive dosing, but if too much chlorine is added, the unpleasant taste may drive people to use more heavily polluted water instead.

Chlorination is often an unreliable process when used in small communities. This is because of one or more of the following problems.

- A reliable source of chlorine may not be available in outlying districts. (However, a recent development is the availability of simple electrically powered devices that can produce dilute sodium hypochlorite from the electrolysis of a solution of common salt. Such devices make regional supply of an easily applied source of chlorine more feasible.)

- The strength of the chlorine compound can vary with age and storage conditions. It needs to be frequently measured.
- The rate at which the compound is applied needs to be reliably regulated to supply the correct dose. Sometimes this rate will need to vary because of changes in the flow rate.
- Chlorine needs to be in contact with the water for sufficient time (the contact time), before the water will be safe to drink. This period is typically 30 minutes.
- The amount of chlorine required for effective disinfection will vary with the quality of the raw water. However, the quality of surface water will depend on the recent pattern of rainfall.
- A reliable method of testing the free residual chlorine is needed. Free residual chlorine is the amount of chlorine still available after disinfection, to kill any pathogens that may subsequently come in contact with the treated water.

Any organic contaminants in the water quickly absorb chlorine; it is therefore important to check that sufficient free residual chlorine is present after the required contact period. A residual amount of 0.3 mg/l (0.3 parts per million) at the point at which the water is collected is usually considered sufficient to indicate that the water has been successfully disinfected. To achieve this residual value of 0.3 mg/l a much higher concentration (e.g. 3 mg/l) is initially needed. Simple kits for measuring chlorine are available. They require a regular supply of chemical tablets.

Chlorination is sometimes applied after slow sand filtration, not necessarily because of remaining pathogens, but to create free residual chlorine in the water to protect it from minor contamination while it is in a piped distribution system. Measuring the free residual value in the water collected at ends of the distribution system can then be used to monitor the state of the pipework. One risk of contamination is from polluted water that may seep into leaking joints or at illegal connections. This can occur if the water pressure in the pipe becomes lower than the groundwater pressure outside the pipe.

Chlorine should never be applied before slow sand filtration because the residual chlorine in the water is likely to kill the useful micro-organisms on and in the sand bed. Dirty or cloudy water should not be chlorinated either, because the dirt in the water will absorb the chlorine. Sedimentation and/or filtration before chlorination will prevent chlorine being wasted. Note that there is very little value in chlorinating if insufficient chlorine is added to produce the required free residual amount.

It is wise to seek expert advice about chlorination. Regular attention and careful adjustment is necessary to ensure systems run reliably. **There is no point in using a chlorinator that is not reliable.** Simple chlorinators, which dispense a chlorine solution at a constant rate, can be bought or made with

materials available in most developing countries. One simple system that is rarely mentioned in the literature is the constant head aspirator shown in Figure 59.

Some practitioners use a perforated pot, filled with a mixture of bleach and coarse sand to apply chlorine to wells. The pot is meant to slowly release chlorine into the well. There is considerable doubt about the reliability of such systems, even if the contents of the pot are replaced every two weeks.

Water sterilising tablets are sometimes available for household-scale disinfection but are rarely affordable for regular use in rural areas. A cheaper alternative is to use Javel water, or to use a prepared 1% solution of chlorine in water (See Section 3.5) but correct preparation and/or dosing by householders is likely to be problematic. Three drops of 1% solution should be

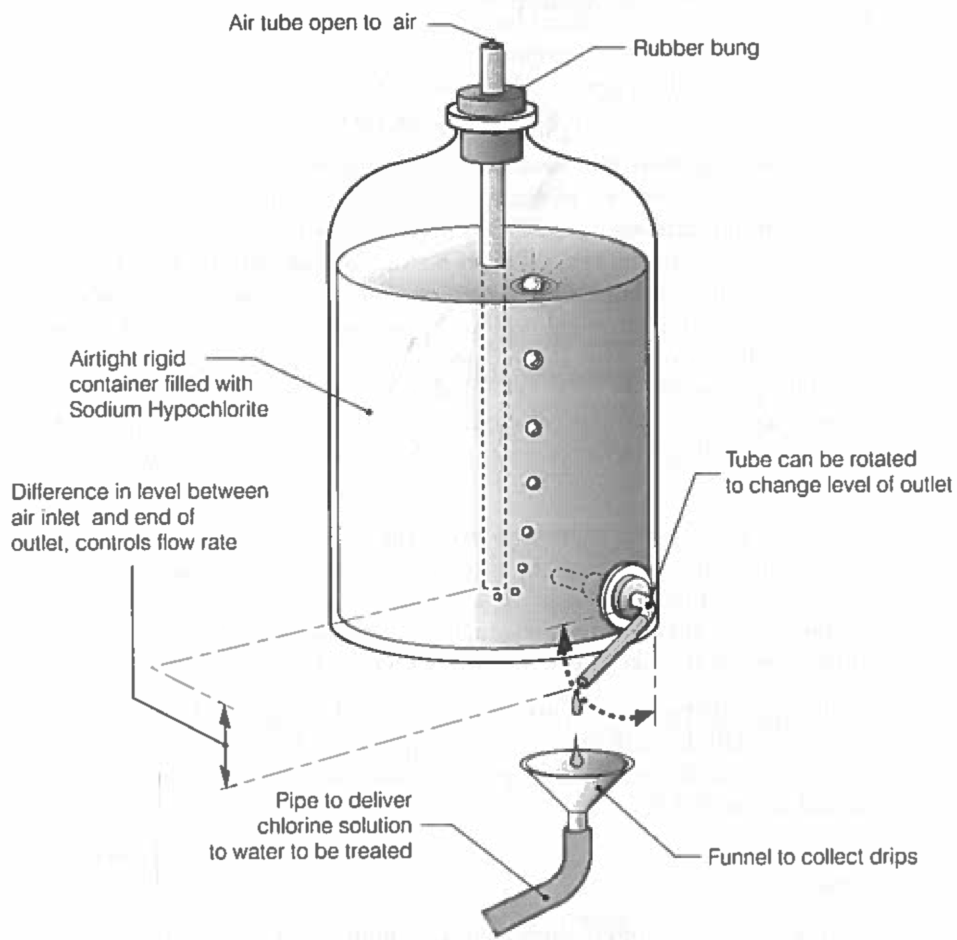


Figure 59 Constant head aspirator.
Source: WEDC

mixed thoroughly into to each litre of clean water to be treated and the water should then be allowed to stand for 30 minutes or longer before it is drunk. If the strength of the chlorine compound is unknown, add enough of it until it can still be tasted in the treated water after the contact period.

Iodine works in a similar way to chlorine. It can be bought as a tincture (solution) about 2% strong from chemists, and should be added at a rate of two drops per litre and left for 30 minutes or longer before using the water. It is suitable for occasional use, but should not be used continuously for a long time lest it cause any unpleasant side effects.

6.5.3 Solar disinfection

If clear water is exposed to strong sunlight for a sufficient period of time the light kills any bacterial pathogens. This is because the UV radiation in sunlight will destroy most faecal bacteria. The water can be contained in clear glass, or plastic bottles or even plastic bags can be used. Increasing the oxygen content in the water (e.g. by shaking the partly filled bottle before and during exposure) has been found to speed up the die-off rate of the bacteria.

The effectiveness of the disinfection process increases with temperature, although it does not have to rise above 50°C to be effective. To ensure a beneficial temperature rise the SODIS system uses half-blackened bottles that are laid clear side up, typically on a sloping roof. Plastic bottles made of polythylene terephthatate (PET) are recommended but durable plastic bags can also be used. In tropical regions, it has been found that a safe exposure period is about five hours, centred about midday under bright or 50% cloudy sky. This period needs to be extended to two consecutive days under 100% cloudy sky. More information about this method can be found on the SODIS web site, which can be accessed through the GARNET web site mentioned in Appendix 3.

As people are unlikely to want to drink the warm water it should be hygienically stored after treatment to allow it to cool. It is preferable to store it in the same container until it is used, since this avoids the risk of it becoming contaminated again. One advantage of this method of treatment is that, unlike boiling, it makes little difference to the taste of the water.

Some solar treatment systems do not use the UV light but only a temperature rise to kill the pathogens. These systems are often called solar water pasteurizers. Strictly speaking, for pasteurization to take place the temperature should reach 79.4 °C.

6.5.4 Boiling

Boiling of water is often suggested as a method of disinfection of limited amounts of drinking water. A typical recommendation for disinfecting water by boiling is to bring the water to a rolling boil for at least five minutes. It is now thought that boiling for such a long period is unnecessary. Reaching a

temperature of 100 °C for a few moments is more than sufficient to kill virtually all pathogens and most are killed before the temperature reaches 70°C.

The main disadvantage of boiling water is the high cost of the additional fuel required. Already many rural areas are becoming deforested and increased use of firewood for boiling water will contribute to the degradation of the environment. Boiling water adversely affects its taste but after cooling the taste can be improved by vigorously stirring the water, or shaking it in a bottle to aerate it. Some users like to add a small amount of salt.

Like the water disinfected by solar methods, boiled water needs to be stored hygienically, while it cools and until it is used.

6.6 Aeration and removal of iron, manganese, tastes and odours

In a few areas, high concentrations of iron and manganese in the groundwater can give it an unpleasant taste, and a brownish colour to clothes washed in it or to rice cooked in it. While they are not harmful, these chemicals may also give the water an unpleasant taste that may discourage people from using it. The concentration of iron and manganese and some other unpleasant tastes and odours can sometimes be reduced by aeration. Aeration usually changes the iron and manganese so that they are no longer soluble in water, and they form sediment that is easily removed by storage or filtration.

On a community scale, aeration can usually be achieved by allowing the water to trickle through a well-drained layer of gravel in a perforated and ventilated container, but it is best to ask a water engineer for advice. On a domestic scale, aeration can be achieved by vigorously shaking water in a partly full container such as a jerrycan. It can then be stored to allow sedimentation to take place.

Iron and manganese removal plants which use aeration followed by filtration are available for attachment to handpumps, but communities rarely maintain them properly and they fall into disuse. Iron can also be removed organically in a slow sand filter.

Oxygen is needed to sustain the useful micro-organisms in slow sand filters. Surface water usually contains sufficient oxygen but groundwater is likely to need aeration before it is filtered.

6.7 Removal of salt

Salty water can be purified by various methods. Small solar stills that are based on the evaporation and condensation of water can be suitable for household use. Other methods of desalination are needed for the volumes of water required by a community but simple methods are not available. The methods used for desalination in developed countries are too complex and costly for use in developing countries.

When ground water is salty as in some flat areas near the sea, there is sometimes fresh water lower down. If so, sometimes a deep tube well or borehole may be sunk to reach the fresh water below.

6.8 Removal of fluoride

Where fluoride is found in concentrations over 4 parts per million, those who drink it risk long term damage to their teeth and bones. The local medical authorities usually can advise if the ground water in an area contains a dangerous amount of fluoride. Fluoride can be removed by the addition of lime and alum, followed by sedimentation. This is known as the Nalgonda technique. Other methods pass the water through granular activated alumina or through bone char. All these methods need specialist advice and long-term support to ensure sustainability.

6.9 Removal of arsenic

Harmful concentrations of arsenic have recently been identified as a major problem in groundwater in Bangladesh, Nepal, Vietnam and West Bengal in India. High concentrations are also found in some other parts of the world. There is no simple test available to accurately measure low, yet dangerous, concentrations of arsenic in water. Work is presently taking place to find such a method. Investigation is also focused on simple ways to reduce the concentration of arsenic in water to a safe level.

Most of the existing methods of removal are hard to sustain without a ready supply of chemicals such as chlorine and alum. One promising method is similar to the SODIS method of disinfection. This SORAS method also uses bottles that are exposed to sunlight. Exposure is followed by a period for settlement of newly formed arsenic compounds. The water above the sediments has a much reduced arsenic content.

Fortunately iron removal also removes much of the arsenic, which precipitates out combined with the insoluble iron compounds after aeration. Some methods therefore add iron compounds to the water as part of the treatment process.

Where arsenic removal is not feasible the water can still be used for purposes other than for cooking and drinking.

7 Piped water distribution

7.1 Introduction

It is not possible in this short book to offer much guidance about the choice of appropriate pipe materials, pipe diameters and pipework layouts for the supply of water. Help can be found in some of the sources mentioned in the appendices and references. A better option is to contact a water engineer for advice.

7.2 House and yard connections

As mentioned in Chapter 2, there are great advantages in piping water into individual households, rather than providing it for collection from widely spaced public water points (standposts). This is because the convenience of having water at the home usually leads to increased usage, which results in an improved level of hygiene and better health. In fact in some situations it may be essential to provide water at homes (either to a yard tap just outside the house, or to one or more internal taps) to obtain any health benefits from the water supply. However, water should not be provided at homes without providing an appropriate way of disposing of the used water too. If the used water is not disposed of properly it can create a severe nuisance and health risks such as increased breeding of malaria-carrying mosquitoes.

House connections are of course more expensive than scattered standposts. However, there is often a high demand for this level of service, which means that people are willing to pay more for it, although it may be necessary to collect the connection charge in instalments. Payment by consumption, registered on domestic water meters, can reduce wastage of water but the use of meters may introduce unwarranted additional costs and increase the complexity of managing the scheme to a point where it becomes unsustainable.

Even if house connections are not provided initially, it will be prudent to design the main pipes to allow houses to be connected to them during the design life of the system. However, this will only be appropriate where there is a source that will be able to meet the increased future demand.

Small-scale Water Supply

A Review of Technologies

Brian Skinner

PRACTICAL ACTION
Publishing