SAFE DRINKING WATER

Information and practice when treatment of drinking water supplies is necessary
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1. Introduction.

A safe water is one that cannot harm the consumer when drunk under normal conditions. This technical guide is intended for field staff and gives a number of recommendations to provide a safe water supply in difficult field conditions.

Polluted drinking water is a major cause of enteric diseases in man. In India the annual death rate from these diseases is stated to be in the order of 360 per 100,000 population due mainly to the consumption of polluted supplies. In disaster situations such deaths and disease rates are likely to increase rapidly.

Floods and refugees are the most common situations we have to deal with. In these conditions normal drinking water supplies are often seriously disrupted or polluted Refugee populations have to move to safer areas – but this may increase water demand from sources of water that might well be considered unsatisfactory in normal circumstances.

It is essential therefore that simple methods of disinfecting water are explained, understood, and utilised when needed. The objective of this booklet is to explain the methods as simply as possible.

2. Disinfection Techniques

A first requirement is for a rapid survey of possible water supplies as water for drinking should be obtained from a source as far removed as practicable from any sewage disposal area. Directly linked with this survey must be the consideration and provision of suitable sanitation facilities as part of the planned operation.

Contamination by human or animal sewage or rotting animal matter, is the greatest problem – and it is virtually impossible to speedily purify a water that is seriously contaminated with fresh sewage by methods which would be available in a disaster area. When deciding the best water source it can be said that clear water is easier to treat and likely to be less contaminated than turbid or clouded waters which indicate much suspended matter. It may be that the proposed water source is safe for drinking purposes without treatment – but do not be deceived by crystal clear waters as they may contain millions of bacteria per litre.

If therefore it is evident from local conditions that there is the need for treatment of any water to be supplied, there are four general methods which can be used (a) boiling (b) storage/sedimentation (c) filtration and (d) chemical disinfection. These can be used singly or in combination.

2 1 Boiling

Boiling is undoubtedly the surest method of sterilisation in that it will destroy all forms disease organisms, bacteria, spores, cercariae, cysts or ova. It is more reliable than chemical disinfection because it will destroy germs embedded in suspended matter. The process does, however, require about 1kg. of wood to boil a litre of water and it is essential to boil thoroughly for 5-10 minutes. The final product has a somewhat 'flat' taste but it is not advisable to aerate because of the risk of re-introducing pollution. Although boiling is a satisfactory method it is only of limited use and is not practicable for large volumes of drinking water.

2.2 Storage and Sedimentation

The simple holding of water in a reservoir or tank is highly desirable. Such storage will reduce the number of pathogenic bacteria (disease causing bacteria) present because they die off and do not usually find in water a suitable environment for multiplication. Additionally the storage of water allows the heavy matter in suspension to settle out (sedimentation). As these sediments may contain pathogens and eggs of human parasites, these sediments should therefore be as undisturbed as possible and not be drawn off with the drinking water.

Closed tanks – or any other vessel – and particularly flexible pillow tanks (see page 16) are suitable for water storage purposes.

The holding period for the water should be a minimum of 7 days and longer if possible. Tank sizes should be based on a minimum requirement of two gallons of drinking water per day per person multiplied by a minimum of seven days of storage.

Every care should be taken to prevent people polluting these holding tanks while drawing off water for consumption.

In addition to this technique it is also possible to greatly speed up clarification of turbid or cloudy water by the adding of Aluminium Sulphate.

It is recommended that the following procedure be adopted

(a) Erect two tanks in such a manner that the bottom of one is level with the top of the other.

(b) Fill the top tank with the water to be treated.

(c) Crush and weigh out the required amount of aluminium sulphate (alumino-ferric or alum cake). The maximum useful alum dose is about 500 mg/l which is equivalent to 500 g per 1000 litres or 0.05% w/v or ½lb per 100 gal. Dissolve this in 1-2 gallons of water.

(d) Add this alum solution to the water to be treated, mix by stirring and allow to settle for 2-6 hours.

(e) Syphon off the clarified water for drinking use into tank No. 2 and run the sludge to waste.

2.3 Slow Sand Filtration

Before chlorination was introduced slow sand filtration alone was shown to have significantly reduced the incidence of water-borne diseases in the U.K. Probably no other single treatment process can simultaneously improve to such an extent the microbiological, chemical and physical quality of water It is simple, inexpensive and reliable and is still the most appropriate and favoured choice of treatment available.

Properly operated, a sand filter can remove 99% or more of the E.coli population (bacteria indicating the presence of human sewage) and even where water temperatures fall to 3°C a mean reduction of 97% E.coli and microbial pathogens can be maintained. (Lloyd 1974).

The slow sand filter is suitable for treating water of fairly reasonable quality, possibly contaminated but which is low in turbidity (if not, some preliminary sedimentation is recommended).

The slow sand gravity filter is essentially an open-topped box drained at the bottom and partly filled with a filtering medium (normally clean sand and a layer of stones or gravel)

Raw water is admitted to the space above the sand under the action of gravity Purification takes place during this downward passage and the treated water is discharged through the under-drains.

The sand filter is not just a water-screening technique but the filter will develop a very active and desirable microbiological treatment of the water. The filter will run for weeks or months without cleaning.

The slow sand filter comprises a bed of clean, medium-coarse sand with a particle size of 0.3 – 0.4 mm about 1.2 metres in depth, supported on a bed of gravel or broken stone 10 cm – 30 cm thick with a drainage point at the bottom for collecting the treated water

It is important that the flow through the filter should be controlled at a flow rate of 100 litres per sq. metre of filter surface per hour (about 2 gallons per sq. ft. per hour). To function it is important the sand filter has at all times a layer of water 10cm (4") or more deep on top of the sand and the filter must not be allowed to run dry, as it is necessary to maintain and protect the layer of silt and film of slime that will build up on the sand surface. This layer is an essential part of the water treatment process. When the depth of this silt and slime layer thickens to the point where obviously the time the filter will have to be cleaned. Cleaning is carried out by carefully draining off top water first then scraping off the top 5 – 8 cm (2 – 3 inches) of sand off the filter. This done the filter can be put back into action. The dirty sand removed from the filter can be washed and re-used or discarded, and the filter topped up with fresh sand at the next cleaning cycle.

The finer the filter sand the more efficient will be its filtering action but the quicker it will clog and need servicing. The lower the rate of filtration the more effective the water treatment.

2.4 Packed Drum Filters

For small scale use a simple type of sand filter can be made from a 180 litre (40 gallon) steel drum or similar. This drum shown in Fig. 1 has holes cut into it for overflow and outlet points, and is packed with a layer of gravel and then sand.

A continuous flow of water should be fed to the filter in sufficient quantity to ensure a slight overflow at all times. A filter of this type should be controlled to deliver approximately 40-60 litres per hour. It could well be that following satisfactory sand filtration the water would need no further treatment. The rate of flow will, obviously, drop with time but the filter should only be cleaned when absolutely necessary, as its efficiency depends to a large extent, as stated before, on the formation of a biological growth on the surface (and in the sand bed). When cleaning is essential, the top layer of sand, about ¾ inch (1-2 cm), should be scraped off and discarded. The exposed sand surface should then be lightly raked to leave it loose and filtration recommenced. After several such cleanings the sand should be restored to its initial level with clean sand.

The filter should be fitted with a lid which does much to prevent algae growths which shorten the filter life. A lid also minimises the risk of additional pollution of the water from the immediate environment.

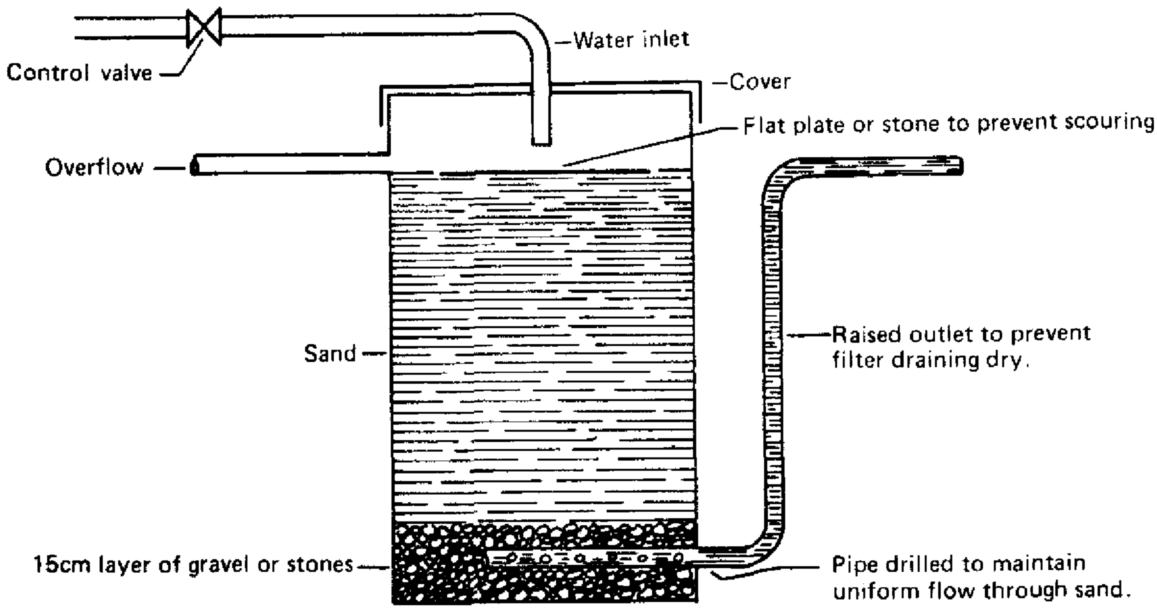

FIG. 1 *Gravity Sand Filter using 200 litre (40 gallon) drum or similar container. Drawing shows position of sand-gravel and pipe connections.*

2.5 Horizontal Sand Filters

This method of filtration is particularly suitable if large quantities of water need cleaning up on a continuous flow basis before chlorination. The filter consists of a channel or trench cut into or arranged on the ground which is then lined with polythene film to make the container water-tight, and the sand is placed on this plastic lining. A polythene lay-flat tube filled with sand would be equally suitable (see Figure 2).

It is estimated that one cubic metre of sand for each 10 litres of water per hour to be filtered should be provided and the filter length should be as long as possible to provide the maximum filtration. As an example a 10 cubic metre filter on a continuous flow basis would provide 10 litres x 10 cubic metres x 24 hours = 2400 litres per day. This would provide 10 litres per person per day for 240 people. Certainly larger filters can be built, and this type of filter should if possible have the capacity to hold 3 or 4 days' water supply for the community it serves. The water-holding capacity is 40% of sand's volume and a 10 cubic metre filter of this type would have a water bearing capacity of 4 cubic metres (4000 litres). Remember usually the longer the retention time the safer any water becomes, providing no toxic materials are involved.

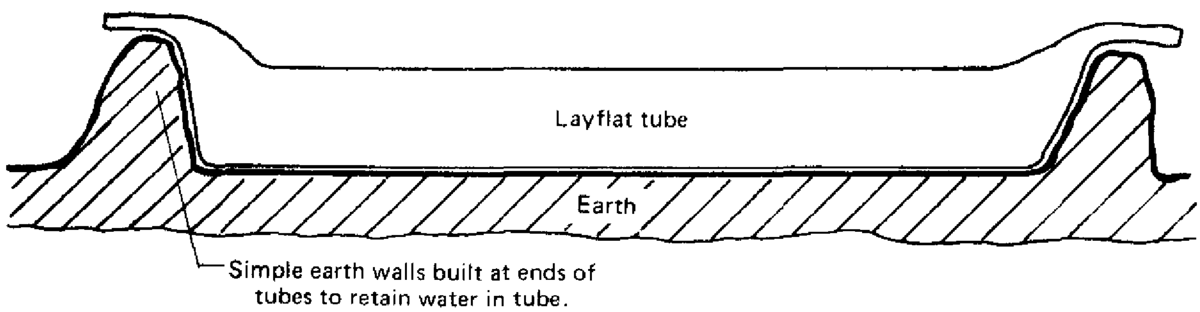

FIG. 2 *Lay-flat Polythene tube used for water storage or adapted as sand filter. Tube available in 1000 gauge thickness, in 30cm to 3 metre diameter in lengths up to 50 metres.*

2.6 River Bed Filters

A modified slow sand filtration technique for the treatment of fresh water from ponds or rivers has also been successfully used. See Figure 3.

The concept is to use a screen placed actually in a hole in the river bed and then the screen is covered with clean sand or gravel from the river. The screen is connected to the suction pipe of a hand or power operated pump.

As water is drawn by the pump through the screen, dirt and sand gather and are held on the river bed above the screen thereby increasing the filtering mass. The surrounding river bed itself becomes a biological filter that destroys bacteria and reduces the level of ammonia and iron that may be present. Water moving over this bed helps to clean it, helped by any fish present which will feed on these sediments.

This concept of filtration has been researched by G. Cansdale and B. Lloyd – and a special filter (SWS Unit) has been developed for this purpose (see manufacturers list).

However other locally available items such as baskets are often used as screens for this particular purpose.

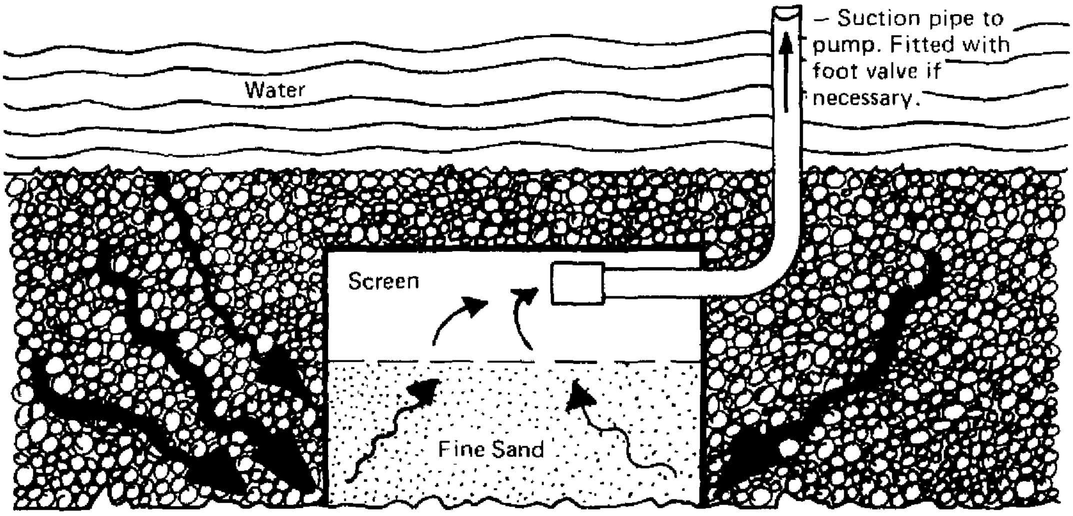

FIG.3 *Pond or River Bed being used as filter showing position of screen and suction pipe. Arrows show direction of water flow.*

3.1 Chemical Disinfectants – Iodine

Iodine can also be used for disinfecting water and is excellent providing the water is not turbid or highly coloured. WHO recommend two drops of 2 per cent tincture of iodine per litre of water.

Water which is cloudy, muddy or having noticeable colour is not well suited for disinfection with Iodine. Turbid water can be filtered and then treated. If the water is thought to be highly polluted then the dose should be doubled – such amounts are not harmful but will have a medicinal taste. Iodine compounds, such as tetraglycine potassium tri-iodide are supplied as tablets which are claimed to be effective against amoeba cysts, cercariae, leptospira and some viruses.

Some commercial names are "Globaline" "Potable Aqua" and "Individual Water Purification Tablets". These tablets are highly recommended for sterilising purposes.

3.2 Chlorination

For chemical disinfection chlorine in one form or another is the most common chemical used. It is normally effective against bacteria commonly associated with water borne diseases although there is some evidence that it is less efficient in the case of certain cysts, ova and viruses.

As it is the most widely used and often readily available chemical for the purpose we shall deal with its use in some detail.

The first essential is that it is necessary to add sufficient chlorine to satisfy the chlorine demand of the water, and to have a little spare chlorine left which is termed "free active chlorine". Chlorine when used in water readily combines with any organic matter present and in such a combined form plays little part in disinfection. Also chlorine will not necessarily rapidly or efficiently penetrate particulate matter in the water and therefore storage, sedimentation and clarification of very turbid waters is required if chlorination on a larger scale is to be effective.

Chlorine and chlorine compounds are supplied as a gas, a solution or as a solid. In emergency conditions it is unlikely that the gaseous form will be either available or practicable to transport to the site. Probably the easiest form of sterilisation of emergency water supplies is by the use of either calcium or sodium hypochlorite. Calcium hypochlorite is supplied in powder form in drums which can be fairly roughly handled should transport conditions be difficult. Sodium hypochlorite is normally supplied in liquid form and thus one is largely transporting water which is usually uneconomical.

3.3 Calcium Hypochlorite

Ordinary bleaching powder CA $(OC1)_2$ is a cheap chlorine compound which is available in most countries. When fresh it should contain approximately 33 per cent available chlorine. Once the can is opened it fairly rapidly loses its initial chlorine (about 5% in 40 days if the can is opened for 10 minutes each day or approximately 19% if left open all the time in the same period). The bleaching powder has to be made into a solution before use. The recommended method is to place the requisite amount of powder in a suitable vessel and add just sufficient water to make a uniform cream breaking up the lumps with a wooden stirrer.When a smooth cream is obtained add more water and mix thoroughly, dilute to the volume required, allow the sediment to settle, decant and use the clarified liquid as the sterilising agent in the water to be treated. See tables 1 and 2.

In making up these solutions of bleaching powder the strength should not exceed 5 per cent available chlorine otherwise considerable loss of chlorine will result by retention of the chemical in the sediment. The most satisfactory working solution is of the order of 1 per cent available chlorine which is the most stable concentration and if prepared to this strength there will be only a loss of approximately 10 per cent of the chlorine in the settled sludge.

Solutions of bleaching powder are even more prone to deterioration than is the solid and it is necessary to store both powder and solution in a dry place at the lowest temperature possible. The powder is normally supplied and stored in cans but the solution should be transferred to brown or dark green bottles and securely closed.

Bleaching powder is corrosive, and has a low density. Corrosion resistant containers should be used for solutions (glass, wood, ceramic, plastic) and protective clothes, particularly goggles and gloves, worn. Cans containing these compounds have been known to burst in hot climates and they should be kept if possible in a cool dry store.

Stabilised bleaches are available (e.g. I.C.I. Trophical Bleach – 34% available chlorine and Stabochlor – 25% available chlorine) and can be used with advantage. They are, of course, more expensive than ordinary bleaching powder in the first place but because of the longer shelf life are more economical in the long run. Knowledge of bleaching powder stocks should be kept up to date to avoid delay in obtaining supplies for immediate use in disaster areas. Other types of powder marketed (HTH – High Test Hypochlorite) contain approximately 70% available chlorine.

Certain proprietary chemical compounds are available in tablet form speciticially manufactured for the purification of water and are of use for the chlorination of small volumes on a temporary basis, usually for individual or family use.

This category would include many trade names such as Sterotab, Puritab and Halazone, all of which should be used according to the manufacturer's instructions. One American production (Chlor-dechlor) has a double action. The tablet first disinfects the water with a special chlorine compound and then, after the outer portion is dissolved, the inner core neutralises the remaining chlorine to reduce the taste.

3.4 Sodium Hypochlorite (Na OC1)

This can be obtained as a solution in varying strengths, viz: (a) alkaline hypochlorite solutions such as Chloros and Voxsan with an available chlorine content of between 10 and 18 per cent; (b) Laundry bleaches, sold under a variety of trade names, usually contain approximately 3 to 5 per cent available chlorine, and (c) antiseptic solutions or electrolytic hypochlorite solutions such as Milton, Zonite and Javel water, with an available chlorine content of about 1 per cent.

The stability of the solution decreases with rising chlorine content. The 1 per cent solutions are comparatively stable but the purchase and use of such is an uneconomical proposition. It is better to procure the stronger solutions and dilute to an approximate value of 1 per cent available chlorine.

3.5 **Making Chlorine Solutions**

Table 1 gives a guide for producing 1 per cent solutions from the various chemical compounds. It must only be taken as a rough guide due to the dependence of the initial chlorine content and the age of the chemicals used.

TABLE 1

To make one litre of 1% Chlorine solution

Mix the following quantities of chlorine with one litre of water.

SOURCE OF CHLORINE	AVAILABLE CHLORINE %	QUANTITY REQUIRED
Bleaching Powder	34	30-40 gms
Stabilised Bleach (Stabochlor)	25	40 gms
Tropical Bleach	34	30 gms
Electrolytic hypochlorite solution (e.g. Milton)	1	1 litre
Alkaline hypochlorite solution (e.g. Chloros Voxsan, etc.)	18 14 10	56 ml 71 ml 100 ml
Laundry Bleach	7 5	145 ml 200 ml
HTH (High test hypochlorite)	70	14 gms

This 1 per cent solution is the means of sterilising larger quantities of water for drinking purposes. The amount of 1 per cent solution which is required to treat stated volumes of water with the doses of chlorine specified is shown in Table 2. The recommended doses are approximate and have been adjusted to convenient measures. Other amounts can be calculated easily – Table 3 gives some comparative measurements.

3.6 **Using Cholorine Solutions**

TABLE 2

Volume of 1% solution required to treat water.

CHLORINE DOSE REQUIRED PART PER MILLION	VOLUME OF 1% SOLUTION TO BE ADDED TO: 1 GALLON (4.5 LITRES)	10 GALLS (45 LITRES)	100 GALLS (450 LITRES)
1 ppm	8 drops	1½ teasp.	3 tbs.
5 ppm	38 drops	1½ tbs.	15 tbs.
10 ppm	1½ teasp.	3 tbs.	30 tbs.
100 ppm	3 tbs.	30 tbs.	1 gall. (4.5 litres)

NOTE: 1 ppm = 1 milligram per litre.

3.7 TABLE 3

Comparative Measurements

50 drops	=	1 teaspoon	=	4 millilitre
2 teaspoons	=	1 desertspoon	=	8 "
4 teaspoons	=	1 tablespoon	=	15 "
10 tablespoons	=	¼ pint	=	150 "
1 pint	=		=	568 "
1¾ pint	=		=	1 litre
1 gallon (Imperial)	=		=	4.5 litres

3.8 Using and Measuring Chlorine in Water n Water

The chlorine dose required for any particular water will of course vary depending on the quality of the water and the amount of matter in suspension.

Chlorine is a very active material and will react very quickly with organic and inorganic matter present in the water. The time required to sterilise water is not less than 30 minutes. Enough chlorine solution must be added to the water to have some unused (free active) chlorine in the drinking water after the other chlorine demands within the water have been met.

As a general rule the initial dose of solution to the water supply is usually about 5 ppm, and following a 30 minute contact period tests should be carried out to be ascertain the remaining free active chlorine which should be in the order of 0.3 – 0.5 ppm but can be variable.

If the free active chlorine content is above 0.5 ppm the initial chlorine input can be reduced. If the free active chlorine content is below 0.3 then more chlorine should be added.

There is little danger in over-chlorinating a water supply, but it will tend to make it unpalatable. Usually a large demand for chlorine by a water supply will indicate much pollution.

To enable the tests for free active chlorine to be as simple and as easily carried out as possible we recommend the use of chlorine testing kit available from B.D.H. Ltd. called the Aquamerck Reagent Kit. The Aquamerck Kit is available from the OXFAM Supplies Dept.

The directions for using the kits are supplied with each pack, but the usual procedure is that six drops of No 1 Reagent are placed in the testing vessel, followed by one drop of No 2 Reagent. Then the testing vessel is filled with the treated water and the resulting colouring of the water is compared to a colour scale provided with the kit. This colour comparison will indicate the free active chlorine available. In addition it is possible to determine the total chlorine needs of the water by the addition of the No 3 Reagent.

The Kit can also be used to determine the pH value of the water. The pH is the intensity of acidity or alkalinity of a water which if severe can affect the chemical (chlorine) treatment of water. Neutral waters are said to have a pH of 7.0. Acid waters are less and alkaline waters are greater than 7.0. The desirable limits of pH for water supplies are between 6.5 and 8.0.

If the pH values are outside these limits it is recommended that specialised advice be obtained, or if possible another water source be sought.

3.9 Disinfection at Source

A decision will have to be made on whether a potential drinking water supply will need to be treated or not. In normal circumstances a bacteriological and clinical analysis would be made but we are assuming this is not possible in the disaster situation.

Likely sources will be (a) surface waters such as streams and rivers (b) open wells (c) or ground waters from tube wells or springs. Common sense and some practical observations of the actual location of the source, the visual appearance of the water, the quantities available and the means of transporting it from source to user will all need to be considered. Some guidelines and techniques are suggested.

3.10 Groundwater Supplies

Generally it can be reasonably assumed that groundwater obtainable from a tube-well or protected spring supply will be bacterially safe to use as drinking water without any treatment unless it is evident that pollution has recently taken place. There should be no pit privy or sewage discharge within 50 metres of intended water sources. Ground water sources are of the highest value provided the capacity is sufficient for the population to be served. If not the population by necessity will be forced to use other sources which may well be heavily polluted.

3.11 Surface Waters

Always select a surface water that is upstream of any pollution source. Usually it is difficult to provide a safe supply from surface water without the use of storage facilities unless a combined filtration and chlorination unit, such as the Army equipment, is available. See page13.When using surface waters, water may need to be clarified before chlorination either by filtration or sedimentation as described on page 4.

The clarified water is best fed to a storage tank and the requisite amount of chlorine solution (see Table 2) added as the water flows into the storage receptacle. In this way mixing and efficient sterilisation is more easily achieved.

Care should be taken to prevent the public having access to storage tanks or they are likely to dip buckets or pots in the tank and cause more pollution. If proper draw-off points cannot be arranged then a special dipper should be provided which will be used to fill the buckets and pots of the population. The dippers should be stored in a clean place when not in use.

3.12 Dug Wells – using Pot Chlorinators

Open wells are almost invariably contaminated and the periodic addition of chlorine compounds, either as a solid or a solution, is not satisfactory. There is, however, some advantage in adding a large dose of chlorine to the standing water in wells which have been dug recently or which have been out of use for sometime. In this way the initial chlorine demand of the water is satisfied.

Considerable development on simple satisfactory methods for the disinfection of open wells has been carried out by the National Environmental Engineering Research Institute at Nagpur in India. Some of the following information is taken from literature supplied by this institute.

Many attempts have been made to use bleaching powder contained in porous pots which could be lowered into the well. However, the pots normally become quickly sealed with calcium carbonate and, in addition, the bleaching powder cakes and liberation of chlorine is prevented. The N.E.E.R.I. recommendations are designed to overcome these difficulties.

Simple Pot with Holes in the Middle

The apparatus consists of an earthenware pot of 12 to 15 litres capacity with two 0.6 cm. diameter holes in the middle of the periphery. The pot is filled with a moistened mixture of 1.5 kg. of bleaching powder and 3 kg. of coarse sand (1.4 to 1.6mm). The mixture normally occupies the volume of the pot below the level of the holes. The mouth of the pot is covered with polyethylene or other foil and the unit lowered into the wall to one metre below the water level.

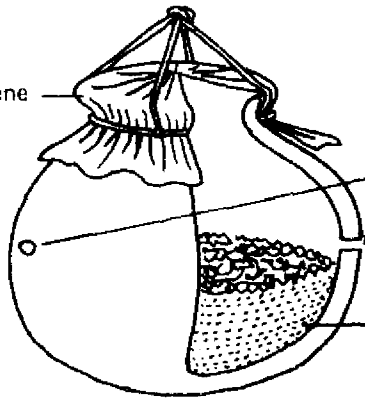

Fig 4

It is claimed that the unit can chlorinate wells of 9,000 to 13,000 litres water content with a withdrawal rate of 900 to 1,300 litres per day (estimated sufficient for 40 to 60 people per day) for a period of at least one week giving a chlorine residual of between 0.2 and 0.8 ppm.

Pot with holes at Bottom

The Unit consists of an earthenware pot of .7 to 10 litres capacity. Six to eight holes (0.6 cm diameter) are made in the bottom and covered with stones approximately 2 to 4 cm in size; The stones are then covered with pea gravel. A dry mixture of 1.5 kg of bleaching powder of 3 kg. of sand is placed over the gravel and the pot filled with pebbles up to the neck.

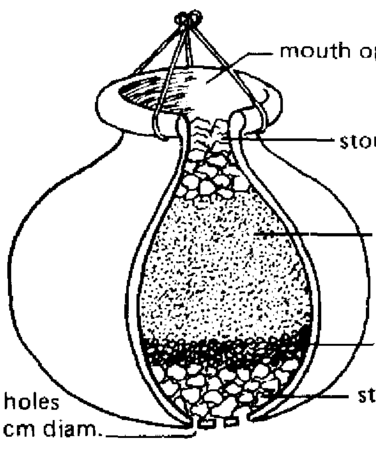

Fig. 5

With both the above type of pots a period of one or two days is necessary to reach the desired residual chlorine content in the water drawn off unless sufficient bleaching powder has been added to the well manually before the introduction of the pots, to satisfy the initial chlorine demand...

For small wells, containing 4,000 litres or less, having wirthdrawal rates of about 360 to 450 litres per day, the use of the previously described chlorination pots will give rise to over-chlorination. If this is the case the use of a unit consisting of two cylindrical pots, one inside the other, will be more satisfactory.

The inner pot should be filled with a moistened mixture of 1 kg of bleaching powder and 2 kg of coarse sand to just below the level of the hole (see Fig 6).

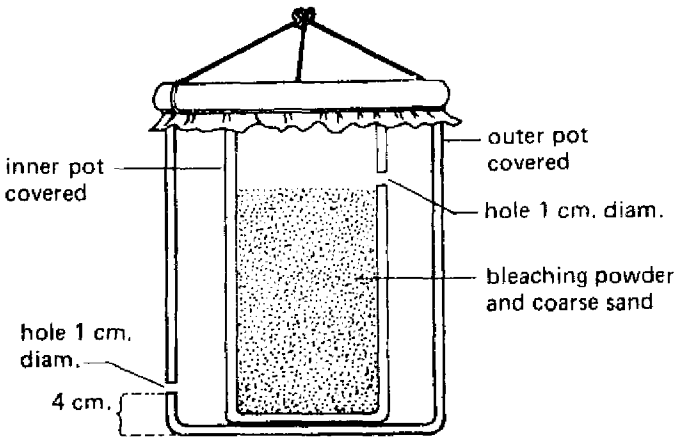

Fig. 6

The inner pot is placed inside the outer vessel which has a one centimetre diametre hole 4 cm from the bottom. The mouth of both containers is closed by a polyethylene sheet, or other foil, and the unit lowered into the well so that it is situated about 1 m. below the water level. Satisfactory chlorine residuals between 0.3 and 0.5 ppm should be obtained over a period of 2 to 3 weeks.

3.13 Drip Type Chlorinator for Small Supplies

A drip type device has been described by the World Health Organisation with reported satisfactory operation. The lay-out is shown in Figure 7.

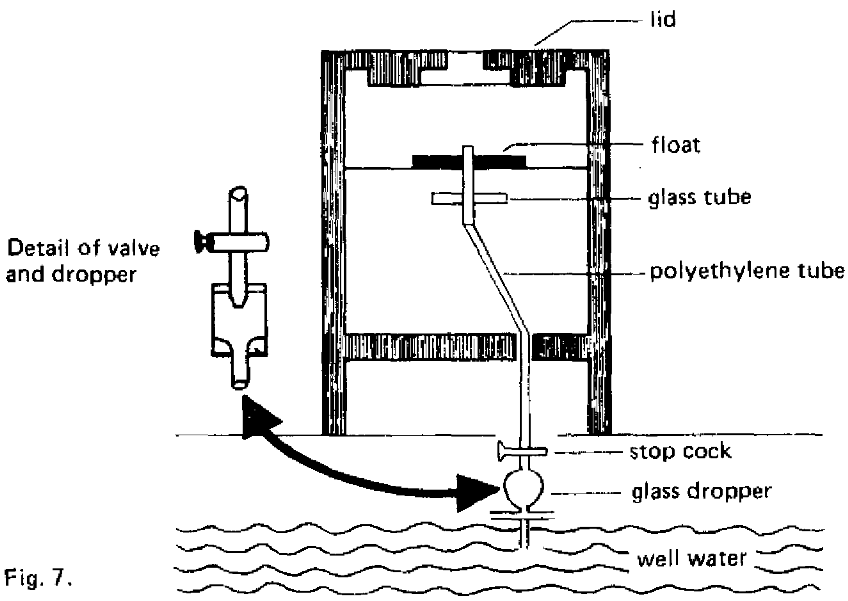

Fig. 7.

The outer container can be of any suitable material and plastic jerry cans have been used. The tendency for blockage of the outlet normally experienced with most drip-feed devices can be minimised by the use of the type of dropper shown which is similar to those used in blood transfusions.

It is advisable to add sufficient bleaching powder to the well water, before using the drip chlorinator, to satisfy the initial chlorine demand. A dose of 0.5 to 1.5 ppm will normally be adequate. The chlorine solution used for disinfection is usually a one per cent mixture, prepared overnight; allowed to settle and decanted. Alternatively, solutions of sodium hypochloride can be used.

It is claimed that such a unit should give satisfactory service for 6 to 8 days after which blockage of the stop-cock is likely and cleaning and readjustment will be necessary. It is also necessary that the outlet should be carried down and maintained below the water level if blockage is to be minimised.

The container should be large enough to hold enough chlorine solution for approximately one week for a well of about 20,000 to 60,000 litres content and a daily withdrawal of 2,000 to 6,000 litres.

3.14 Chlorination of a Pumped Supply

If the supply of water necessitates the use of a pump it is common practice to utilise the pump to dose the supply with the sterilising solution. A relatively simple proportioning device using bleaching powder solution as the disinfectant is shown in Fig. 8, and as will be seen there is a direct connection from the chlorine solution supply tank to the suction line of a centrifugal pump.

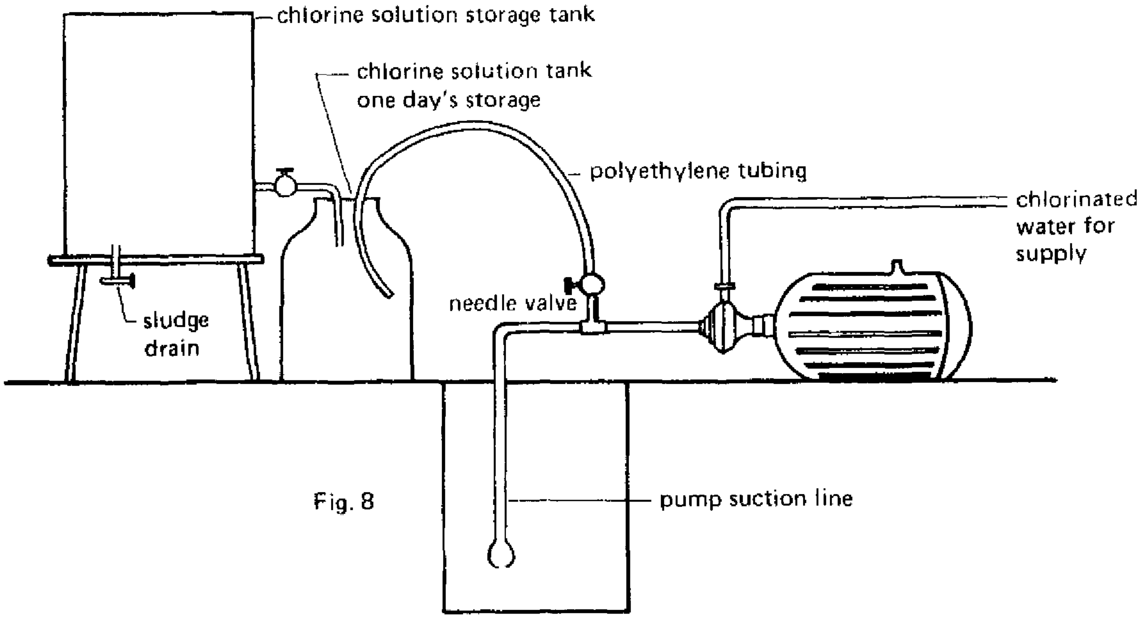

Fig. 8

Bleaching Powder solution of 1 per cent available chlorine is mixed with water in the storage tank and allowed to settle. The sludge is removed through the sludge drain. This chlorine solution is passed from the storage tank to the supply tank which should hold sufficient to last for one day. Care should be taken to shut off the solution feed line when the pump is stopped. The dosage rate required will depend on the quality of the water to be dosed, and can only be determined and adjusted by measurements of chlorine residuals in the treated water.

More sophisticated and permanent apparatus is available on the market produced by specialist firms in the water treatment field.

3.15 Dechlorination

It may be necessary to provide facilities for dechlorination particularly if there is a public resistance towards chlorinated water due to strong chlorinous tastes, in which case people will seek alternative and possibly highly polluted supplies.

Of all the chemicals used to dechlorinate water the most satisfactory and stable is sodium thiosulphate (hypo). 3 lb. (1.4 kg) should be sufficient to dechlorinate 20,000 gallons (91,000 litres) treated so as to contain 0.5 ppm of chlorine. The chemical is, however, harmless and there is no risk in adding more.

Water can be decholorinated, if necessary, at the household level, by adding one crystal of thiosulphate to 2 pints or 1 litre or less of water – 4 to 5 crystals to a bucketful.

4.1 Mobile Water Purification Equipment

Several types of mobile units are manufactured. These are usually built to military standards and specifications and are designed to be either easily transportable packs or are trailer mounted units.

The units produce potable supplies from fresh water sources otherwise unfit for drinking – and have capacities ranging from 2.7m^3 (600 galls.) to 13.5m^3 (3000 galls.) of drinking water per hour. The units use ceramic type filters for the removal of suspended solids, bacteria and organisms, and then additional disinfection is achieved by a chlorine dispenser within the unit.

The basic units comprise of the following items:

A primary and secondary filter – a chlorinator – a generator – a centrifugal pump – a diesel or petrol engine to drive pump and generator. It is claimed that all items of equipment are capable of being carried by four men.

These units can also be trailer mounted or each unit be individually mounted to a tubular frame for easy handling. One model is designed for air dropping by parachute.

These units, being motor powered, would require sound engineering and maintenance supervision.

This same company produce a mobile desalination unit for producing fresh water from brackish or saline sources. This equipment is unfortunately very costly to purchase and to run.

4.2 Drilling

It is not the intention to detail various tube well drilling methods in this paper. Nevertheless, as ground water is usually quite safe to drink without any treatment, it should be considered whether or not it is feasible to drill some tubewells and fit hand or motorised pumps to extract the water for drinking purposes.

Several drilling techniques are possible – three of them are particularly useful and well proven.

4.3 The Hand Operated Earth Boring Auger

These augers can be obtained in sizes 15-30 cm (6-12 inches) and can drill in suitable soils to a depth of 10-15 metres. The augers are easily handled, of low cost can be most effective. A small stock is held in the OXFAM Disaster Store in Oxford, but it is advisable to have a small stock of these augers at the field level or to have a known source or manufacturer in the country concerned.

4.4 The Auguered, Driven or Jetted Well Points

These systems are much used both for obtaining water or for dewatering in Civil Engineering construction works.

The principle is simple and inexpensive. A well point as shown in Fig. 9 is jetted down up to a depth of 7 metres into the earth. Where jetting is used a pump of 100 gallons per minute at 50 p.s.i. pressure is suitable for forcing water down through the well point, thereby escaping through the jetting shoe and washing away the surrounding soil and allowing the well-point to be forced further into the earth. In suitable soils the jetting time to a depth of 7 metres can be 15-30 minutes.

When the desired depth is reached the pump is reversed and the partial vacuum created draws the rubber ball against the seating and causes the water to be drawn through the screens of the well point up the rising pipe to the surface.

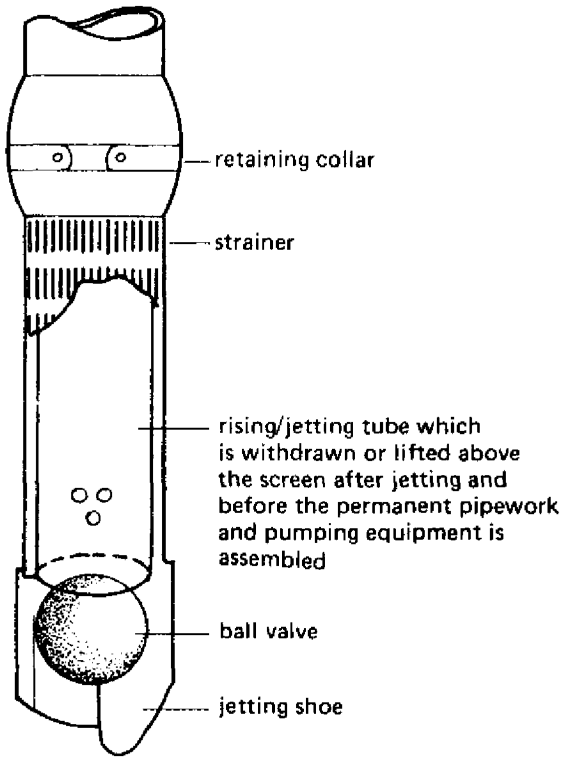

Fig. 9

The driven well point

The principle of the Driven tube well is that a specially perforated and pointed tube is driven down into the ground by means of a small weight or 'monkey' until water is reached. The water rises up the tube and is available for use by coupling it to a suitable pump, the tube itself acting as the suction pipe.

Tube wells of this type can be driven into all classes of strata provided the material is not too hard or dense or is hard rock. Figure 10 shows details.

Another advantage of this technique is, should no water be found it is possible to withdraw the tube and drive point and redrive at different points until success is achieved.

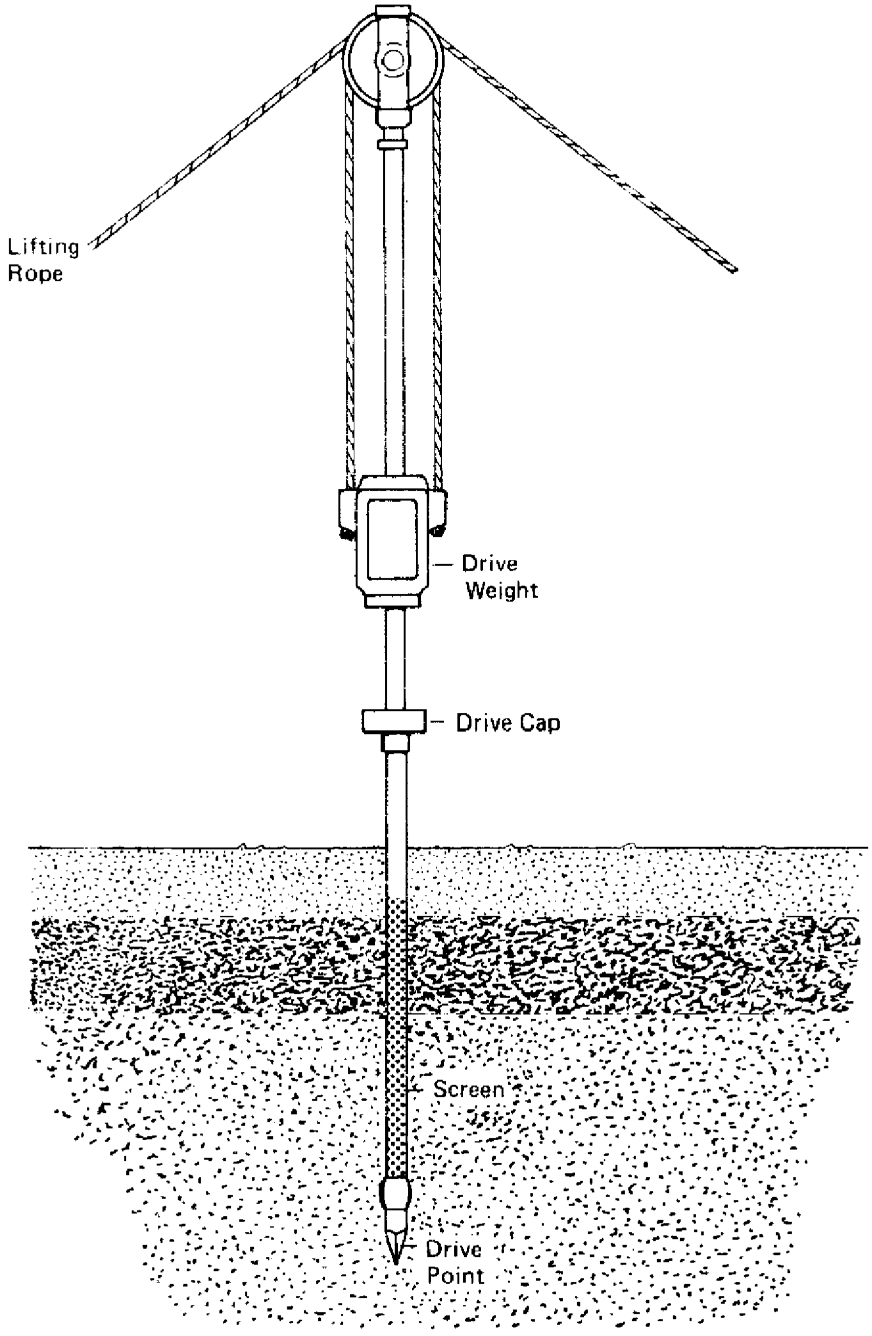

Fig. 10 *A tube well being driven with the driving tackle in position.*

It is possible to sink several well-points in one area to ensure an adequate water supply, and then to connect several points together at ground level with piping and to have a single pump set connected to this pipeline so that a very adequate and safe water supply is provided.

Recent tests carried out show that water drawn through the soil and well point screen by the pumping action in this type of installation was of excellent quality both chemically and bacteriologically even though the surface waters of the area were of poor quality.

It should be remembered that wells of this type can only be used when water is less than 25ft. from the surface, as for practical purposes this is the maximum suction possible with a standard hand operated piston or engine powered centrifugal pump.

4.5 Flexible Pillow Tanks for Water Storage

This type of tank has only been available for a few years but they are proving to be very suitable for situations where substantial quantities of water need to be stored or transported at short notice.

This type of tank needs no supporting structures and requires only a flat and reasonably level surface for installation.

The size of the tanks varies from 1000 litres (200 gallons) to 150,000 litres (30,000 gallons) depending on materials used.

The tanks are made in various flexible materials from low-cost polythene sheeting (tank sizes in this material have an upper limit of 350 gallons) to heavy grade nylon reinforced butyl, with a corresponding life span from a few months to several years. Costs are related to the quality used and the following prices are given as a guide.

For 200 gallon tanks:	Polythene	£20
	Unreinforced butyl	£120
	Heavy grade reinforced butyl	£250

These tanks are fitted with filling and vent points, and also can be supplied with valved outlets for dispensing the water to the public.

A particular use of these tanks up to 5000 litre sizes is that they can be used mounted on a flat truck for transporting water from a water source to the public etc. It follows that any suitable vehicle can be fitted with a flexible tank at short notice to serve this function. Equally the tank can be removed in a few minutes to allow the vehicle to be used for other purposes.

A few points on using these tanks:—

a) With some designs of these tanks where there is no bottom outlet but only a top filling point -- people have been baffled how a filled tank is discharged with only a pipe on the top. The method of discharge is simplicity itself, it merely requires a light pressure to be exerted on the tank by hand or foot pressure and water will be displaced at the required quantity and rate of discharge. If the complete contents need to be discharged a weighted object (an earth filled sack) can be placed on the tank and continuous discharge will take place.

b) Care should be taken with flexible tanks when they are located on unlevel ground. The tanks if tilted will have a tendency for the contents to move to one side or end and for the tanks to roll over. Apart from being possibly dangerous to bystanders, such rolling is not good for the structure of the tank, so check that possible sites are reasonably level, free of glass or sharp stones and preferably fenced from the public.

c) Tanks when being used on vehicles should be supplied with webbing or netting retaining devices which are used to hold the tank in position on the vehicle.

4.6 Lay flat Polythene Tube

Polythene sheet is manufactured in the first instance as a continuous tube and then it is split down one side for sheeting purposes.

If left in the tube form it is particularly suitable for short term static water storage, water treatment, or for sand filtration purposes as detailed on page 3.

This Polythene lay flat tube (recommended 1000 gauge) can be obtained in any diameter size from 30 cm (1 ft.) – 3 metres (10 ft.) and in lengths up to 50 metres.

The tube is supplied as a roll and the required amount is merely cut from the roll. A roll of 3 metre diameter tube at 50 metres length weighs 52 kg. A roll of 1 metre x 50 metres length weighs 23 kg.

4.7 Polythene Sheet

Polythene sheet has many advantages when used as waterproof membranes or linings for water tank purposes.

The chief advantages are its very low cost and weight per unit area. It is available in standard seamless sheetings of 10 metres in width and in any manageable length although for practical purposes 20-30 metres is preferred. The quality recommended is 1000 gauge black sheeting

Further details of polythene sheet can be obtained from OXFAM's Technical Guide, "Plastic Sheeting".

4.8 Calculating Tank Sizes

As water will also most certainly be stored during or after treatment, it will be valuable to determine to capacity of available tanks so that treatment or water content can be quickly caculated.

The following formulae are sufficiently accurate for the purpose.

(a) *Rectangular tanks*

Length x breadth x height (in feet) x 6.25 = capacity in gallons (4.5 litres)

(b) *Cylindrical tanks*

Length x (diameter)^2 (in feet) x 5 = capacity in gallons.

(c) *Elliptical-ended tanks*

Length x width of end x depth of end (in feet) x 5 = capacity in gallons.

Example

a cylindrical tank measures 10 ft. 4 inches long and is 3 ft. 7 inches in diameter.
Capacity in gallons = 10.3 x (3.6)^2 x 5 = 667 gallons.

5.1 Manufacturers Details

River bed filters (SWS type)

A detailed study of the SWS filter unit has been carried out at the Dept. of Microbiological Studies, University of Surrey, Guildford, Surrey, England under the supervision of Dr. Barry Lloyd.

Technical information about the unit can be obtained from Dr. Lloyd, or the manufacturers.

Sea Water Supplies Ltd., North Parade – The Promenade Skegness – Lincs. PE25 1DB

Chlorine Measuring Equipment.

B.D.H. Broom Road, Parkstone, Poole, Dorset.

Mobile Purification Equipment. (Military Type Units)

Stella-Meta Filters, Permutit – Boby, Laverstoke Mill, Whitchurch, Hampshire. RG28 7NR.

Well Drilling Hand Augers.

Lang-London Ltd., Central Way, Faggs Road, Feltham, Middlesex.

Well points – Augered or Jetted Type.

Millars Wellpoint International Ltd., Station Road, Barnham, Thetford. 1824 2PD.

Well points – driven type.

Duke and Ockenden Ltd., Ferry Wharf Works, Littlehampton, Sussex.

Flexible Pillow Tanks.

a) Polythene tanks

Drix Plastics, Portswood, Southampton.

b) Unreinforced Butyl tanks

Butyl Products Ltd., Radford Way, Billericay, Essex.

c) Heavy Reinforced Butyl tanks.

Marston Excelsior Ltd., Fordhouses, Wolverhampton, WV10 6QJ.

Lay flat tube and Polythene Sheet.

Ethylene Products Ltd.. Maerdy Industrial Estate, Rhymney, Gwent. NP2 5XQ.
Turner Whitehead Industries, 65-71 Bermondsey Street,
London, SG1 3HP.

Free-standing storage tanks in neoprene fabric which are collapsible with inflatable rims

Airborne Industries Ltd., Leigh-on-Sea, Essex.

5.2 Reference Books

Slow Sand Filtration	L. Huisman and W.E. Wood 1974 World Health Organisation publication – Geneva
Water Supply for Rural Areas and Small Communities	E.G. Wagner and J.M. Landoix 1959 World Health Organisation publication No. 42 Monograph series – Geneva.
Water Treatment and Sanitation	H.T. Mann and D. Williamson 1976 Intermediate Technology Publications 9, King Street, London, WC2E 8HN.
Disinfection for Small Community Water Supplies	National Environmental Engineering Research Institute (NEERI) Nagpur, India.
Small Water Supplies	S. Cairncross – R. Feachem 1978 The Ross Institute London School of Hygiene and Tropical Medicine, Gower Street, London. WC1 7HT.
Plastic Sheeting **An OXFAM Technical Guide**	J. Howard – R. Spicer 1977. OXFAM, Oxford.