24

Water

24

Water

List of Contents

Water

<u>Need</u>

Water is essential to life and health. It is often not available in adequate quantity or quality in refugee emergencies, thus creating a major health hazard.

<u>Aim</u>

To provide enough safe water for the refugees and to meet communal needs.

<u>Principles of response</u>

- ☐ Seek expert advice, co-ordinate closely with the appropriate national services and involve the refugees.
- ☐ Ensure consideration of the water supply at the site selection and planning stage and co-ordinate response closely with public health and environmental sanitation measures.
- ☐ Avoid the need to treat water if at all possible.
- ☐ Provide a reserve supply and spare capacity, to meet temporary difficulties and the needs of new arrivals.

  Take account of seasonal variations.

<u>Action</u>

- ☐ Organize an immediate, competent assessment of water supply possibilities in relation to needs.
- ☐ Protect existing sources of water from pollution and store a reserve.
- ☐ Develop sources and a storage and distribution system that supplies a sufficient amount of safe water.
- ☐ Ensure regular testing of water quality.

24

24.1 Introduction

1. Safe water is essential to life and health. In an emergency, refugees can generally survive for a longer time without food than without water. Thus the provision of water demands immediate attention from the start of a refugee emergency. The aim is to assure availability of enough water to allow unrestricted distribution, and to ensure that it is safe to drink. Adequate storage capacity and back-up systems for all aspects of water supply must be assured, since interruptions in the supply may be fatal. To avoid contamination, all sources of water used by refugees must be separated from sanitation facilities and other sources of contamination. As a rule, the simplest possible technologies are the most appropriate in refugee emergencies.

2. Availability will generally be the determining factor in organizing the supply of water in sufficient quantity and of a safe quality. It may be necessary to make special arrangements for extraction of the water, storage and distribution. Measures will be required to protect the water from contamination and in some circumstances treatment will be needed to make the water safe to drink. The safety of the water must be assured right through to consumption in the home. The dangers in drinking contaminated water are discussed in 24.7.1.

3. Improvements in the existing water supply may take time, particularly where it is necessary to drill or dig wells. In many refugee emergencies only contaminated surface water (standing water, streams or rivers) is initially available and immediate action must be taken to reduce contamination. If it is evident that available sources are inadequate, arrangements must be made to bring in water by truck. Where even the most basic need for water cannot safely be met from existing sources in the immediate area and where time is needed for further exploration and development of new sources, the refugees should be moved to a more suitable location.

4. Water and sanitation are the subject of separate chapters. The considerations are, however, largely interdependent and this chapter should be read in conjunction with chapter 25 on sanitation.

24.2 Assessment and organization

- ☐ An immediate, competent assessment of local water supply possibilities, involving the government authorities, is essential.
- ☐ Expertise is required, and local knowledge is most important.
- ☐ Involve the refugees, use their special skills and train them to operate and maintain the system.
- ☐ Technology and equipment should be simple, reliable, appropriate and familiar to the country.

General

1. An immediate on-the-spot assessment of local sources of water in relation to needs is essential. The government's competent central and local authorities and experts should be involved in this assessment, and expertise from outside the country should be brought in only when clearly necessary. Knowledge of the local terrain and conditions is indispensable. An influx of refugees may over-strain water resources used by the national population in the area.

2. Available sources must be protected from pollution at once. Rationing of available scarce water may need to be introduced at once to ensure survival of the weak and equity in distribution to the rest of the refugee population. The design, establishment and continuing functioning of a water supply and distribution system must be closely co-ordinated with the site planning and layout and with health and environmental measures, and in particular sanitation.

Assessment

3. While an assessment of the need for water does not require special expertise, assessment of supply possibilities does. A distinction may be useful between the identification of sources on the one hand, and their assessment leading to decisions about a water supply and distribution system on the other. Depending on the situation, sources of water and their characteristics may be identified by: the local population (water diviners may be useful); the refugees themselves; the lay of the land (ground water near the surface in vicinity of rivers and in low places generally, or indicated by richer vegetation); maps and surveys of water resources; and national and expatriate experts (hydrologists). The assessment of water sources which must be the basis for decisions on a water supply and distribution system generally, requires expertise in water engineering, sanitation (testing, purification) and in some cases logistics.

4. Seasonal factors must be carefully considered. Supplies that are adequate in the rainy season may dry up at other times. Local knowledge will be essential.

Personnel and material

5. Local sources of information and expertise may include: central and local government departments (e.g. interior, public works, agriculture, water resources), UNDP, UNICEF, World Bank, bilateral aid programmes and NGOs. If it is clear that locally available expertise will not meet the needs, Headquarters assistance should be requested without delay. If outside assistance is necessary, this should be provided whenever possible in support of local experts. Where a water supply and distribution system has been established with the help of expatriates and mechanized technology, running and maintenance by refugees and other local personnel must be assured before the departure of the expatriates. If this is not done, even the best system will break down.

6. As the provision of safe water is essential to the health of the community, and impossible without the understanding and co-operation of the community, the system must be developed with the refugees and operated by them to the extent possible. The refugees, particularly if from rural backgrounds, may themselves have relevant skills. For example, some nomadic communities contain individuals who are expert at digging and maintaining wells. Others may be familiar with common pump motors. Such skills must be fully utilized in planning, developing and operating the water system. Refugees without prior experience should be trained as necessary. Basic public health education, for example on the importance of avoiding pollution of the water by excreta and the use of clean containers in the home, will be essential.

7. While special equipment may be required in the exploration for new ground water sources or for purification of surface water, the need for material and equipment to establish a water supply and distribution system should be met locally to the maximum possible extent. As a general rule, technology should be kept simple. It should be appropriate to the country and draw on local experience. Where pumps and other mechanical equipment are necessary, supplies should be standardized as far as possible, with local familiarity, availability of spares and fuel and ease of servicing the criteria.

24.3 The need

- ☐ Calculate on at least 15 litres per person per day plus communal needs and a spare capacity for new arrivals.
- ☐ To preserve public health, a large amount of reasonably pure water is preferable to a smaller amount of very pure water.
- ☐ The water must nevertheless be safe: test new sources before use and periodically thereafter, and immediately there is an outbreak of a potentially water-borne disease.

Quantity

1. The following amounts of water are desirable:

> Individuals: 15-20 litres per person/day;
> Health centres, hospitals: 40-60 litres per person/day;
> Feeding centres: 20-30 litres per person/day.

Further needs may include livestock, sanitation facilities, other community services, including fire fighting, and irrigation.

2. Reduction in the quantity of water available to individuals directly affects their health. As supplies are reduced, clothes cannot be washed, personal hygiene suffers, cooking utensils cannot be properly cleaned, food cannot be adequately prepared and finally the direct intake becomes insufficient to replace the water and moisture lost from the body. The reduction is reflected in increased incidence of parasitic, fungal and other skin diseases, eye infections, diarrhoeal diseases and the often fatal dehydration associated with them. Even those individuals who may have traditionally lived on less than the recommended amount of water, for example nomads, will require more in a refugee community because of crowding and other environmental factors.

3. The needs of community services vary widely, for example from sufficient water to swallow a pill and wash hands in a health centre to the large quantities required in a hospital. Proper supplementary and therapeutic feeding programmes will be impossible unless sufficient water is available for preparation of food and for basic hygiene.

4. The availability of water will be a major factor in deciding on a sanitation system. For example, the Oxfam Sanitation Unit requires up to 3,000 litres per day to serve 1,000 persons; aquaprivies serving single families must have a minimum water tank volume of 1,000 litres, to which at least five litres per user must be added daily.

5. Water will be needed for livestock brought along with the refugees. Where circumstances permit, measures to help ensure the survival of livestock must be taken. Conversely, care should be taken to avoid pollution or depletion of scarce water sources by livestock. As a rule of thumb, cattle need about 30 litres of water daily and small stock about five. Cattle and most small stock need daily watering, camels can go for long periods without water.

6. Water for irrigation will be essential to the cultivation of food by the refugees.

7. While water will probably be of limited use in controlling major fires on refugee sites owing to a lack of sufficient quantity and pressure, fire control should nevertheless be a consideration in the design of any water supply and distribution system, as prompt fighting of small fires can prevent them spreading and causing major damage.

8. As more refugees are likely to arrive, calculations on the desired and available quantities of water must allow for a substantial spare capacity over present needs.

Quality

9. The water must be both acceptable to the refugees and safe to drink. If it tastes and looks acceptable, it will be drunk, with the main dangers being from micro-biological organisms. However these "water-borne" diseases may not be as serious as the "water-washed" diseases, such as skin and eye infections and diarrhoea, which result from insufficient water for personal hygiene. Thus a large quantity of reasonably safe water is preferable to a smaller amount of very pure water. The most serious threat to the safety of a water supply is contamination by excreta: once the water has been contaminated it is extremely hard to purify it quickly under emergency conditions. Possible treatment measures are considered in section 24.7.

10. New water supplies should be tested before use, and existing ones periodically, and immediately there is an outbreak of a typically water-borne disease. The test should cover at least the presence of faecal coliform bacteria (which indicate contamination by human excreta) and alkalinity. The water must be safe at the time of consumption or use in the home, not just at the distribution point. Domestic hygiene and environmental health measures to protect the water between collection and use will be important.

24.4 Immediate response

- ☐ If even the minimum amount of water cannot be made available in time from local sources, the refugees should be moved.
- ☐ Whatever the water source, take immediate action to prevent it from pollution by excreta.
- ☐ Organize a distribution system that prevents pollution of the source and ensures equity if there is insufficient water.

1. Short-term emergency measures may be necessary while the longer term supply system is being developed or pending the move of the refugees to a more suitable site. If the locally available water supply is insufficient to meet the minimum needs of the refugees, arrangements must be made to bring in water by truck. If this is not possible, the refugees must be moved without delay. Often, however, the quantity of water available will meet initial minimum needs and the immediate problem is its quality: it is likely to be dangerously contaminated.

2. The refugees will be using surface water or sometimes an existing source of ground water (well or spring). This is most often whatever water is closest, regardless of quality. The best immediate response is likely to be organizational and should be arranged with the refugee community leaders. Whatever the water source, take immediate steps to prevent pollution by excreta. If the source is flowing, supplies must be drawn off upstream and a special area set aside for this. Then allocate an area for washing and finally, downstream of the settlement, allow any livestock to water. Fence off parts of the river bank as necessary, and beware of any dangers in the water, such as crocodiles. Where the source is a point (well or spring or pump outlet), fence off, cover and control the source. Prevent refugees drawing water with individual containers which may contaminate the source. If possible make immediate arrangements to store water from the source and distribute from the storage. Not only does this help avoid direct contamination but storage can make water safer.

3. If the immediately available supplies of water are insufficient, action to ration supplies and ensure equitable distribution will be a priority. Rationing is difficult to organize. The first step is to control access to the sources, using full-time watchmen if necessary. Uncontrolled distributions are open to abuse and some form of registration with individual or family distribution cards should be undertaken if possible. Distribution at fixed times for different sections of the site should be organized. Vulnerable groups may need special arrangements. Every effort must be made to increase the quantity of water available so that strict rationing is unnecessary.

24.5 Water sources and their protection

- ☐ Rain water, ground water from springs and wells, and water from municipal and private systems is usually of better quality than surface water from sources such as rivers, lakes or dams, and should be used if available.
- ☐ Avoid sources that require treatment if at all possible.
- ☐ Physical protection of the source from pollution will be essential.
- ☐ Expert advice and local knowledge is necessary before sinking wells.
- ☐ New or repaired sources and equipment should be disinfected.

General

1. There are three main natural types of fresh water: surface water (streams, rivers, lakes), ground water (underground or emerging at springs) and rain water. Table 24-1 indicates comparative advantages. particularly in remote areas, can be difficult and requires trained supervision to be reliable. The following paragraphs provide general information on different sources of water and indicate the likely need for treatment. Treatment methods are covered in 24.7.

Table 24-1

Source	Quality	Quantity	Abstraction/Collection
Surface	3	1-3(s)	2-3
Ground	1 (unless shallow)	1-2	3
Rain	1	3(s)	1 (needs roof/gutter)

Key 1 : good/easy 3 : bad/difficult s : seasonal

2. Considerations in choosing between alternative sources of water in an emergency include:

(1) speed with which source can be made operational;

(2) volume of supply;

(3) reliability of supply (taking into account seasonal variations and, if necessary, logistics);

(4) water purity, risk of contamination and ease of treatment if necessary;

(5) rights and welfare of local population;

(6) simplicity of technology and ease of maintenance;

(7) cost.

3. In practice the main criterion determining what existing sources are being used is availability. This generally means surface water, with the consequent high risks of contamination. In addition to organizational measures to protect the water supply, some form of treatment may be necessary. However, sources which would require treatment should be avoided if at all possible. The purification of unsafe water,

Surface water

4. Water from streams, rivers, ponds, lakes, dams and reservoirs is rarely pure, and its direct use is likely to require treatment measures; it may also cause difficulties with the local population. However, where such a source holds water year-round, the ground water table in the vicinity can be expected to be very near the surface. It is generally preferable to use such ground water, as it will have passed through the natural filter of the soil, rather than use surface water directly. One or more suitable types of well may be used. If the ground is not sufficiently porous to allow extraction of enough water from wells, surface water may be the only option. In such circumstances, emergency treatment measures such as storage and sand filtration will probably be necessary. If surface water must be used, the controls described in 24.4.2 are essential.

Springs

5. Springs are the ideal sources of ground water. Water from a spring is usually pure at the source and can be piped to storage and distribution points. It should be taken off above the site if possible. However, care should nevertheless be taken to check

the true sources of spring water, as some apparent springs may really be one or another form of surface water which has seeped or flowed into the ground a short distance away. It is essential that spring water be protected against pollution by means of a simple structure built of bricks, masonry or concrete at the source from which the water flows directly through a pipe to a tank or collection point. Care must also be taken to prevent contamination above the take-off point. The supply of water from a spring may vary widely with the seasons and will be at its minimum at the end of the dry season; seek local advice.

Other ground water

6. If the need for water cannot be met by springs, the next best option is to raise ground water by means of tube wells, dug wells or boreholes. Ground water, being naturally filtered as it flows underground, is usually quite pure. The choice of method will depend on circumstances in each case, including the depth of the ground water table, yield, soil conditions and availability of expertise and equipment. Table 24-2 gives some basic characteristics of the different types of wells.

7. The yield of a well depends on the geological formation in which it is sunk, the well construction, pump and development: any new well or borehole must first be "developed" to full yield by an initial period of pumping at a fast rate. This has the effect of pumping out finer soil particles and thus allowing water to pass more easily into the well. A very approximate indication of general yield from a typical well in different geological formations is given in Table 24-3.

Table 24-3

Geological formation	Approximate general yield in litres/minute
Sand, gravel and clay (intermixed or interbedded)	2000 - 4000
Sand and gravel	1000
Sand and clay	2000
Fractured sandstone	2000
Limestone	40-200, sometimes much more near caverns or streams
Granite and/ or hard rock	40
Shale	Less than 40

8. Without good water resource surveys, preliminary tests or clear local evidence from nearby existing wells, there is no assurance that wells will yield the necessary amount of water, and salinity may be a problem in some areas. They can also be expensive. It is often better to try and improve an existing well that is polluted or has an inadequate yield than dig a new one. Wells, boreholes and pumps should be disinfected immediately after construction, repair or installation, as they may have been polluted during the work. Two or three buckets of a 0.2% chlorine solution in water would be a suitable disinfectant and the techniques are described in the technical guides.

9. Like springs, wells must be protected from pollution. They should be located where surface water, and in particular any seasonal rain or flood water, will drain away from the well head. They should be above and at least 30 (preferably 50) metres away from any sanitation facilities and their discharge. A well head, consisting of a headwall and drainage apron, running off to a soakway, are essential to avoid direct contamination down the well. Whenever possible a cover should seal the top of the well and the water should be raised by a pump. If a bucket must be used, rollers, pulleys or a windlass should be provided to avoid people leaning over the well. Individual buckets must never be allowed down the well, and close supervision and control will be essential.

Table 24-2

Type of well	Approximate Maximum depth	Technique	Comments
Driven Tube Well	10-15 metres	Simple: special pipe hammered into ground; can be sunk in 1 or 2 days	Small; cannot be sunk in heavy clay soil or rock; needs special filter "well point" at tip of pipe
Bored Tube Well	25 metres	Simple: Hand-bored hole using an auger; can be sunk in 2-3 days	Larger than driven tube well; augers may need to be imported, but locally available boring tools can also be used
Jetted Tube Well	80 metres	More difficult: water pumped down a hole and overflowing to carry out and loosen soil, enabling pipe to be pushed down	Requires considerable amount of water to sink, as well as special equipment
Hand Dug Well	30-40 metres	Requires skilled workers otherwise dangerous. Speed depends on soil conditions. For team of 4 men perhaps between 1 day and 1 week per 10 metres depth	Only advisable if water expected within 40 metres; larger capacity than tube wells
Borehole	Over 100 metres	Large drilling rig	If more than 60 metres deep, cannot use hand pumps

Rain water

10. Reasonably pure rain water can be collected from the roofs of buildings or tents if these are clean and suitable. This method can only be the major source of water in areas with adequate and reliable year-round rainfall, and it requires suitable shelter as well as individual household storage facilities. It is, therefore, not generally the solution in refugee emergencies. However, every effort should be made to collect rainwater and small collection systems, for example using local earthenware pots under individual roofs and gutters, should be encouraged. The supply of water which it is possible to collect by this method is estimated as follows:

> One millimetre of yearly rainfall on one square metre of roof will give 0.8 litres per year, after allowing for evaporation. Thus, if the roof measures 5 x 8 metres and the average annual rainfall is 750 mm. the amount of rain water which can be collected in a year equals: 5 x 8 x 750 x 0.8 = 24,000 litres per year or an average of 66 litres per day.

11. Rain water may be a useful supplement to general needs. for example through special collection off the roofs of community service buildings such as health and feeding centres, where the safety of the water is most important. It should also be noted that surface water is particularly likely to be contaminated in the rainy season. Thus rain water may be a useful source of safe water for individual use at a time when other water is plentiful but unsafe.

Sea water

12. In locations where no adequate sources of fresh water exist but where sea water is near, desalination is one possible but very costly option. However, neither of the two basic methods - distillation using the sun's heat or the use of modern desalination plants - is likely to meet immediate needs in a major emergency. In such circumstances, relocation of the refugees must be considered as a matter of urgency.

Municipal and private system

13. Existing municipal and private water systems in the vicinity of the refugees, for example those belonging to industrial or agricultural establishments, may be able to meet part or all of the need during the emergency phase, and should obviously be utilized where possible before unnecessary measures to create other sources are taken.

24.6 Pumps, storage and distribution

- ☐ Mechanical pumps will almost certainly be needed. Seek expert local advice on what is suitable and remember the fuel.
- ☐ Water storage facilities will be essential.
- ☐ Distribution points should be within 100 metres of the user's dwelling.
- ☐ Site the distribution points carefully and protect the ground around them.
- ☐ Standpipes and taps are usually best: 1 tap per 200-250 refugees.

1. Once an adequate source of water exists, arrangements are necessary to store and distribute the water in a way that guarantees minimum needs are met on a continuing and equitable basis.

Pumps

2. Water can be raised in two basic ways: by hand using some kind of bucket or by using pumps. In a major refugee emergency, pumps will almost certainly be required, either to raise water for direct distribution at the well or to move it to storage tanks or other distribution points. Unless proper precautions are taken, buckets are likely to increase the risk of pollution, and alone they are in any case unlikely to be a practical means of raising and moving enough water in refugee emergencies. All pumps have

moving parts and require regular maintenance. While hand pumps are easier to install and generally more reliable than motorized pumps, the latter have a far greater output and are therefore usually indispensable in large refugee emergencies. If motors are required, local advice should be sought and local familiarity, fuel supplies, spares, ease of maintenance and above all reliability will be major considerations in their selection. Self-priming centrifugal pumps are usually recommended. Always have a standby pump. Where possible, arrangements should be such that motorized pumps do not have to operate at night.

Storage

3. In nearly all systems it will be necessary to store water in covered tanks between the source and distribution points. This will provide an essential reserve, can greatly facilitate distribution, particularly when water is pumped up to elevated tanks, and helps purify water (see 24.7.4). All refugee sites must be provided as soon as possible with facilities to store an adequate reserve supply of water. The size of the reserve will depend, beyond the number of people, on the nature of the water supply system in each case and particularly on its logistical aspects. Tank capacities are calculated as follows:

(a) Rectangular tanks: length x breadth x height (in metres) x 1,000 = capacity in litres

(b) Cylindrical tanks: length x radius ^{2} (in metres) x 3140 = capacity in litres.

4. In certain circumstances, notably in areas with pronounced dry and rainy seasons and where alternative sources of water are limited, the construction of a reservoir to collect water to be used during the dry season may be an option, despite the dangers of pollution and of mosquitoes breeding. Catchment tanks for collection of surface water can also be considered for the drier parts of the world. Pits are dug in the ground to catch and hold the water which runs off hard ground surfaces during heavy storms. They need special lining in order to hold the water, and should be covered if possible.

Distribution

5. The refugees must have easy but controlled access to water. Ideally, no dwelling should be further than 100 metres from a distribution point. Experience has shown that where persons have to fetch water from considerable distances, they tend not to fetch enough to limit water-washed diseases. Hence the importance of availability and the relative advantage of quantity over quality. Water distribution will be an important consideration in the layout of the site, and the distribution points should not be in hollows. The area round the point should be paved with stones or gravel, or protected by duckboards, with a run-off to allow proper drainage.

6. Water can be distributed to individual users in a number of ways, depending on local conditions. Uncontrolled access by individual consumers to primary water sources must be avoided. A distribution system should have a sufficient number of sources and/or outlets in relation to the size of the population to ensure that people do not need to wait for long periods to have access. Equity in the distribution of scarce water is an extremely important consideration. While vulnerable groups (the sick, wounded, most severely malnourished, children, pregnant and lactating women and the disabled) should have adequate and assured allocations, scarce water must be evenly shared among the rest of the population. Refugees should be encouraged to assume responsibility for equitable distribution, and arrangements carefully monitored in order to detect and prevent abuses.

7. The most appropriate method of distributing water to large populations will depend on a number of variables in each specific situation, such as the kinds, numbers and locations of primary sources and the availability of materials, equipment and expertise.

Where possible, standpipes and taps are recommended. There should be one tap per 200-250 refugees. The larger the number of people using a single source or outlet of water, the greater the risk of pollution. If it is necessary to draw water manually out of the storage tank or even a well, this must be carefully controlled and supervised; watchmen are often needed on such distribution points. Individual containers must not be allowed directly into the water.

8. A certain amount of waste water will be generated in the community, both at the individual and communal service level. While this must not become a danger to public health, it may be usefully recycled, for example to water livestock, irrigate vegetable gardens or in water-flushed latrines.

24.7 Treatment

- ☐ All methods of water treatment require some expertise, regular attention, and maintenance.
- ☐ The most serious threat to the safety of a water supply is contamination by excreta.
- ☐ Covered storage is the simplest method of improving water quality.
- ☐ Sand filtration is an effective method of water treatment.
- ☐ Chemical disinfection for large-scale water treatment is generally only recommended if storage and/or sand filtration cannot meet the need.
- ☐ Water purification tablets and boiling are not generally appropriate for large-scale water treatment; they may be used in health centres, supplementary feeding centres or hospitals.

The dangers

1. The water may contain pathogens, particularly certain viruses, bacteria, protozoal cysts and worm eggs which are transmitted by the faecal-oral route: from faeces to mouth. Water contamination by human faeces is the major concern, although animal faeces in water may also cause disease transmission. Water contamination by urine is only a significant threat in areas where urinary schistosomiasis (schistosoma haematobium) is endemic. By far the greatest risk associated with polluted drinking water is the spread of diarrhoeas, dysentries and infectious hepatitis (hepatitis A). The diarrhoeas and dysenteries are caused by a variety of viruses (especially rotavirus), bacteria (especially toxigenic escherichia coli, shigella, salmonella and vibrio cholerae) and protozoa (especially amobae and giardia). The numbers of viruses and protozoa in water will always decrease with time and will decrease most rapidly at warm temperatures. Bacteria behave similarly, but in exceptional circumstances may multiply in polluted water. The infectious dose of the viruses and protozoa is typically very low (10 organisms), whereas the dose of bacteria needed to establish an infection in the intestine may be large (from 10^3 to 10^{10}).

Treatment

2. The importance of trying to find a source that does not require treatment has been stressed. If treatment is necessary, it should be the minimum required to ensure acceptably safe water, using appropriate technology and a method that is reliable. Determining how to treat water on a large scale is a matter for experts, and professional engineering advice must be taken. Full explanations of types of treatment are given in technical publications; the main systems are summarized below. All methods require regular attention amd maintenance.

3. In addition to the physical measures to protect water at its source and the initial disinfection of wells and boreholes (usually by chlorine), there are four basic methods of

treatment: storage, filtration, chemical disinfection, and boiling. These can be used singly or in combination.

4. Leaving water undisturbed in containers, tanks or reservoirs improves its quality. Storage causes some pathogens to die off and any heavy matter in suspension to settle (sedimentation). In an emergency where water supplies cannot be assumed to be safe, immediate action to provide maximum water storage capacity is a logical first step. Storage of untreated surface water for 12 to 24 hours will already bring about a considerable improvement in its quality: the longer the period of storage and the higher the temperature, the greater the improvement. The clarification of cloudy water can be speeded up by the addition of aluminium sulphate. Great care should be taken to prevent pollution of stored water. Storage tanks must always be covered: the dangers of contamination of open tanks more than offset the advantages of direct sunlight.

5. Longer-term storage can help control schistosomiasis (bilharzia), as the parasites die if they do not reach the fresh water snail within 24 hours of excretion by an infected person, or a human or animal host within 48 hours of leaving infected snails. Thus two days' storage would provide an effective barrier to transmission of the disease, provided infected snails do not enter the tank. Complementary measures will be required to prevent direct contact with infected surface water.

6. Sand filtration can be an effective method of treatment. A proper slow sand filter works in two ways. Passage of the water through the sand physically filters out solids and, more importantly, a thin and very active layer of algae, plankton, bacteria and other forms of life develops on the surface of the sand bed. This is called the "schmutzdecke", where micro-organisms break down organic matter. The rate of filtration depends on the surface area, depth and type of sand through which the water is passed, and the head of water. The usual size range of the sand is 0.3-1 mm. Provided the rate of filtration is slow enough, the quality of the treated water is very good.

7. Three types of sand filter may be mentioned

(1) Packed drum filters are suitable for small communities and can be made from clean, 200 litre (45 gal.) steel drums, provided the drums have not previously held toxic materials. Sand is placed on a layer of gravel and the flow regulated to yield 50-60 litres of water per hour. Thus, operating 24 hours a day, 11-12 drums would be needed to provide 1000 refugees with 15 litres of water per day.

(2) Horizontal sand filters can be used to treat larger amounts of water. These should be arranged above ground level, for a gravity outlet, if possible. A raised trough is built and lined with plastic sheeting on which sand is placed. Alternatively, a large diameter polythene tube can be laid flat in the channel or trench and filled with sand. Untreated water is fed in uniformly across one end of the filter and the filtered water is collected at the other end. The longer the filter, the more effective the water treatment. An estimated one cubic metre of sand is needed for each 10 litres of water per hour to be filtered. Thus, a 6.25 cubic metre filter would produce about 15 litres of water a day for 100 people. Larger filters can be built. This type of filter serves simultaneously as a water storage facility: sand can hold up to 40% of its volume in water.

(3) River bed filters are devices which draw treated water directly from sources such as rivers, ponds and lakes. A screen shaped like an inverted box, open at the bottom, is buried in the river bed. A suction pipe leading to a pump is connected to the top of the box and the box itself is partially filled with sand to which gravel may be added. The river bed itself and the filtering material in the box will filter the water before it is pumped out. Commercially produced filters of this type are available.

8. Diatomite filtration, though mechanically somewhat sophisticated, can give a high degree of purification of surface water. It is much quicker to install than sand filtration. It requires some care to operate, but with basic technical supervision has proved reliable under field conditions.

9. Chemical disinfection as a method of water treatment on a large scale is, as a rule, only recommended in situations where storage and/or filtration cannot meet the need. It will, however, be required initially to purify wells, sand filters, pumps and piped water systems. Both iodine and various forms of chlorine can be used; chlorine is more widely used, cheaper and often more readily available. The most generally suitable form of chlorine for refugee emergencies is calcium hypochlorite powder. Care must be taken to ensure strict control of any chemical disinfection process and particularly to test the water for chemical residual levels after each disinfection and before distribution. Persons unaccustomed to the taste of chlorine may not be prepared to drink water treated at the recommended concentration. Chlorine and iodine water purification tablets are also available, but are rarely used as a method of water treatment for large populations. They may be used in health centres, supplementary feeding centres or hospitals.

10. Boiling is the surest method of water sterilization, and simply bringing water to the boil will destroy all pathogens that may be transmitted by drinking water. Vigorous boiling is often recommended but is not necessary to destroy the faecal-orally transmitted pathogens. Vigorous boiling is wasteful of fuel and will increase the concentration of nitrates in the water. If artificial feeds are reconstituted using water with a high concentration of nitrates this will be dangerous for very young babies. Domestic fuel supplies may be the determining factor; boiling requires about one kilogram of wood per litre of water. This method is not often practicable for large quantities of drinking water, but may be used where limited quantities of safe water are essential, for example in health and feeding centres.

11. While clear water may only require chlorination, turbid surface water will usually require sedimentation and/or filtration before chemical disinfection.

FURTHER REFERENCES

For both Water and Sanitation (Chapter 25)

Assar, M. (1971)	Guide to Sanitation in Natural Disasters Also relevant to man-made disasters	WHO
Cairncross S. et al (1980)	Evaluation for Village Water Supply Planning A simple and comprehensive guide, published in association with the WHO International Reference Centre for Community Water Supply	Wiley
Cairncross S. (1978) and Feachem R.	Small Water Supplies A clear presentation with simple diagrams and practical advice.	Ross Bulletin No. 10
Feachem R. (1978) Cairncross S.	Small Excreta Disposal Systems Likewise	Ross Bulletin No. 8
Feachem R. (1977) McCarry M. Mara D. (Eds)	Water, Wastes and Health in Hot Climates Comprehensive (416 pages)	Wiley
Howard J. (1979)	Safe Drinking Water Information on treatment methods	Oxfam Technical Guide
Jones D. (Ed) (1980)	Water Supply and Waste Disposal Booklet in Poverty and Basic Needs Service	World Bank
Pacey A. (Ed) (1978)	Sanitation in Developing Countries Comprehensive (252 pages)	Wiley
Rajagopalan S. (1974) Shiffman M.	Guide to Simple Sanitary Measures for for the Control of Enteric Diseases Clear and comprehensive, covering water supply and all aspects of sanitation including food sanitation	WHO