technical brief **no. 58**

Household water treatment 1

This technical brief is the first of two examining the treatment of water at household level in the home. Here we introduce the subject, and cover treatment by straining, storage, settlement, solar disinfection, chemical disinfection, and boiling. The second brief (No. 59) considers treatment by coagulation, flocculation, filtration and solar distillation, and covers aspects of the reduction of some chemical concentrations.

Why treat water?

It is always better to protect and use a source of good quality water than to treat water from a contaminated source ...

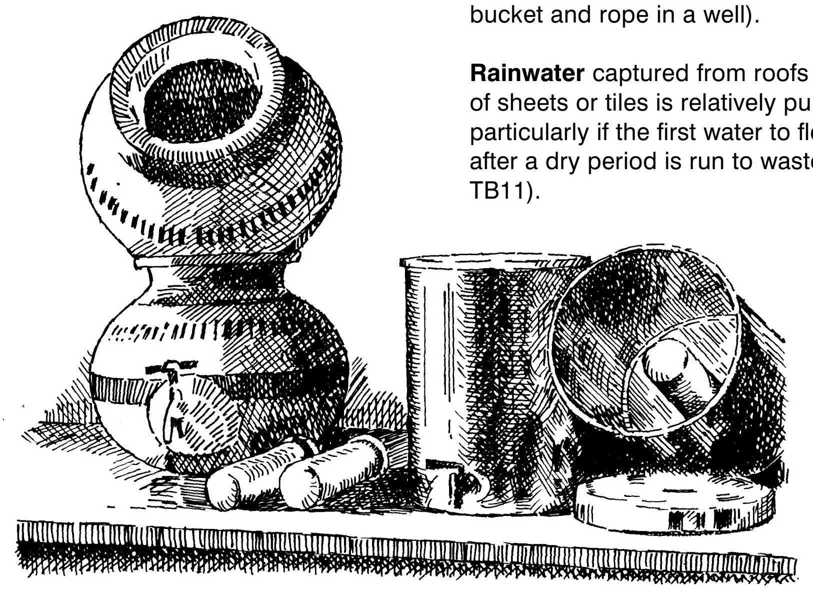
but water needs to be treated if:

- people refuse to use it because of its colour or taste; and / or
- chemicals or organisms in it pose a health risk to users.

Check if a single communal system which treats water for everyone would be more cost effective than a small system in every home. Remember that the community must be willing to co-operate in operating and maintaining a communal facility properly.

What contaminates water?

Pathogens (disease-causing organisms) including eggs or larvae of parasitic worms; bacteria; amoebas; and viruses.



Harmful chemicals from human activities (eg pesticides and fertilizers) or from natural sources (eg chemicals from rocks and soils).

Contaminants or physical properties which, although not harmful, cause people to reject the water because of its taste, smell, colour, or temperature.

What is the best source?

Where there is no good source the best option is to treat water from the source with the highest quality water. A change of source, or use of a treatment process, however, may give the water a different taste, uncceptable to the community.

Surface water is usually quite badly contaminated (see Technical Brief 37).

Groundwater is usually much purer than surface water, but may be contaminated by natural chemicals, or as a result of human activities (including the unhygienic use of a bucket and rope in a well).

Rainwater captured from roofs made of sheets or tiles is relatively pure, particularly if the first water to flow off after a dry period is run to waste (see TB11).

How much water needs to be treated?

Check first if it is feasible to only treat water used for drinking or preparing food which is eaten uncooked. Usually less than 5 litres/person/day are needed for these purposes. Providing only this amount of treated water will be much easier than treating all the water used in the house.

If the raw water looks reasonably clear it will not **usually** need to be treated before being used for other domestic purposes.

Water may sometimes need treatment:

- **bathing**, – if it contains pathogens which penetrate the skin (such as *Cercariae,* which transmit schistosomiasis);
- **cooking,** – if excessive iron or manganese cause problems with taste or colour, or if harmful chemicals are transferred from the water to the food;
- **laundry;** – if it contains so much iron or manganese that it stains the clothes.

Maintaining the quality

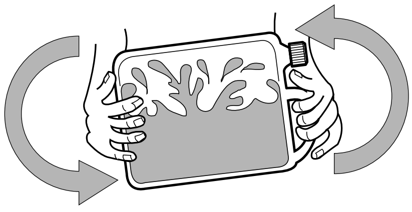
Removing pathogens will be pointless if the treated water is contaminated again before it is drunk (TB17 and TB19). The treated water should be carefully stored in, and hygienically collected from, covered containers.

Straining

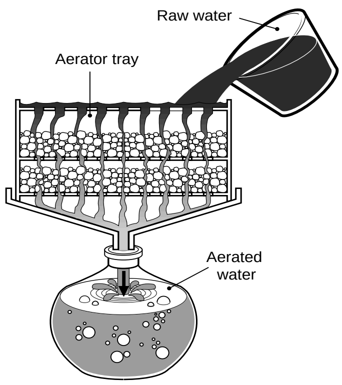
Pouring turbid (cloudy) water through a piece of fine, clean cotton cloth will often remove a certain amount of the suspended solids contained in the water. If the cloth is dirty, additional pollutants may be introduced! Purpose-made monofilament filter cloths specially produced for use in areas where Guinea-worm disease (dracunculiasis) is endemic. Such cloths are effective in straining out the copepods in the water. These tiny water creatures act as intermediate hosts for the larvae which transmit the disease. Some Guinea-worm eradication projects supply a large-diameter drinking-straw with a filter mesh on one end so that copepods are strained out when water is sucked up the straw.

Aeration

Aeration increases the air content of water; it reduces the concentration of volatile substances, such as hydrogen sulphide, which affect the odour or taste of water, and oxidises iron and manganese prior to settlement or filtration. Dissolved air is also important for the effective performance of slow sand filters but there may already be sufficient oxygen in surface waters. You can achieve aeration on a small scale by rapidly shaking a vessel part-full of water. Aerate larger volumes of water by allowing them to trickle through one or more well-ventilated, perforated trays containing small stones.



Vigorous shaking



Aerator trays

Storage and settlement

Storing water for just one day can result in the die-off of more than 50 per cent of most bacteria; conditions in storage vessels are usually not conducive to their survival! Longer periods of storage will lead to further reduction. The *cercariae,* which are an intermediate host in the lifecycle of schistosomiasis, can only live for 48 hours after leaving a snail if they do not reach a human or animal host. So storing water for more than two days effectively prevents the transmission of this disease.

The suspended solids and some of the pathogens in any water left in a container will begin to settle at the bottom. After several hours water collected from the top of the container will be relatively clear, unless the solids are very small (e.g. clay particles). Although this clear water will still contain some pathogens, many others will have settled to the bottom, often attached to the surface of particles. The three-pot treatment system exploits settlement and the death of pathogens during storage to improve the quality of raw water.

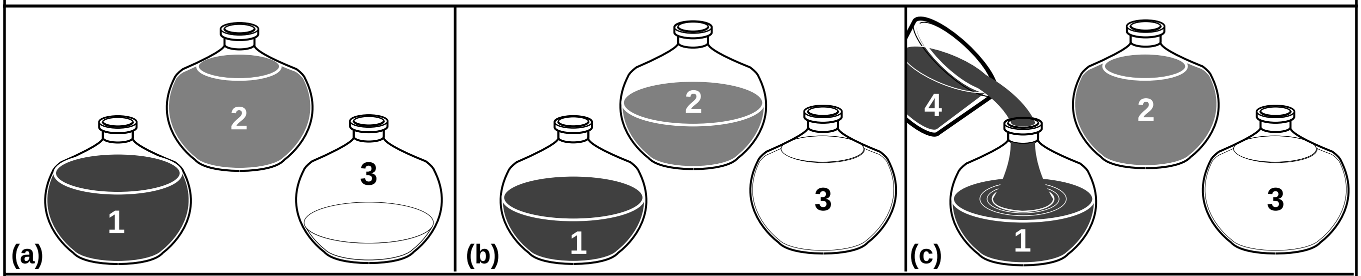
Disinfection

Disinfection is a way of ensuring that drinking-water is free from pathogens. For chemical and solar disinfection to be effective – and to a lesser extent for boiling – the water should be free of organic matter and suspended solids. Hence disinfection should be the **final** treatment stage, after any other treatment processes.

Disinfection by boiling

A typical recommendation for disinfecting water by boiling is to bring the water to a rolling boil for 10 minutes. As Miller (1986) points out, reaching 100°C for a few moments will kill most pathogens and most are killed at much lower temperatures (such as 70°C). The main disadvantage of boiling water is that it uses up fuel. It also affects the taste of the water, although increasing the air content by vigorously stirring the water, or shaking it in a bottle, after cooling, will improve the taste.

The Three Pot Treatment System



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.

Effectiveness of different household treatment systems

The effectiveness of some of the treatment systems shown in the table has been generalized. A treatment method should always be properly tested in a field situation before it is widely promoted. Some of the methods need to be combined to be effective.

Problem with raw water	Effectiveness of treatment method 0 = minimal if any effect. 1 - 4 = increasing effectiveness. - = unknown effect; + = helpful to another process mentioned											
	Straining through fine cloth	Aeration	Storage / pre-settlement	Coagulation,flocculation and settlement or filtration	Fine sand filtration (slow)	Course sand filtration (rapid)	Charcoal filter	Ceramic filter	Solar disinfection	Chemical disinfection	Boiling	Desalination / Evaporation
PATHOGENS Bacteria, (effectiveness also often also apply for amoebas, viruses and ova)	0	+	1 - 2	0 -1	4	2	-	3 - 4	4	4	4	4
Guinea-worm lavae (in cyclops)	4	0	0	-	4	2 - 3	-	4	2-4 b	-	4	4
Schistosomiasis cercaria	-	0	4	-	4	2 - 3	-	4	2-4 b	4	4	4
NATURAL CHEMICALS [a]												
iron and manganese	0	+	1	1	3	3	-	-	-	-	-	4
fluoride	0	-	0	4			-	-	-	-	-	4
arsenic	0	+	-	4	4	4	-	-	+	-	-	4
salts	0	0	0	-	0	0	0	0	0	0	0	4
OTHER PROBLEMS												
Odour and taste	0	2	1	1	2	2	3 - 4	2	0	1	-	3 - 4
Organic substances	1	1	2	1	3	3	-	3	-	4	-	4
Turbidity (cloudiness produced by suspended solids)	1	0	2	3	4	3	-	4	0	0	0	4

a. Technical Brief 64 touches on the removal of iron, flouride and arsenic.
b. Removal depends on sufficient temperature rise, Cercaria die at 38°.

Chemical disinfection

Chlorination (see TB 46) is the most widely used method for disinfecting drinking-water. There are several different sources of chlorine for home use including liquids (such as bleach), powders (such as bleaching powder) and purpose-made tablets. Iodine, another excellent chemical disinfectant, is also used sometimes. With both these chemicals you must add sufficient to the water to destroy all the pathogens; deciding on the right amount can be difficult since it will depend on substances in the water which will react with the disinfectant, and which may vary from season to season.

Another complication is that the strength of the chlorine compounds will vary with time; air-tightness, low temperature and absence of light are

Strength of various chlorine preparations

	Example calculation			
	% active chlorine when fresh	known concentration	amount in (gram) for preparation of 1 litre of1% solution, (i.e. 10g per litre)	ratio of volume of chlorine product to volume of additional pure water to produce 1% solution
Sodium hypochlorite				
commercial strength	up to 15%	14 g/l (14%)	71	1:13
household bleach	up to 5%	4 g/l (4%)	250	1:3
Javel water	about 1%	1 g/l (1%)	1000	undiluted
Chlorinated lime (Bleaching powder)	up to 35%	300 g/kg (30%)	33	-
High Test Hypochlorite (HTH) powder or tablets	up to 70%	660 g /kg (66%)	15	-

particularly important during storage. Make sure that the chemicals have sufficient contact time with the pathogens (about 30 minutes in the case of chlorine) to destroy them. Chemicals left in the water will, to some extent, protect it from further contamination. To obtain the desirable residual chlorine value of between 0.3 and 0.5 mg/l in the treated water, you will need to add a much higher value. This 'residual' effect cannot be obtained from solar disinfection or boiling.

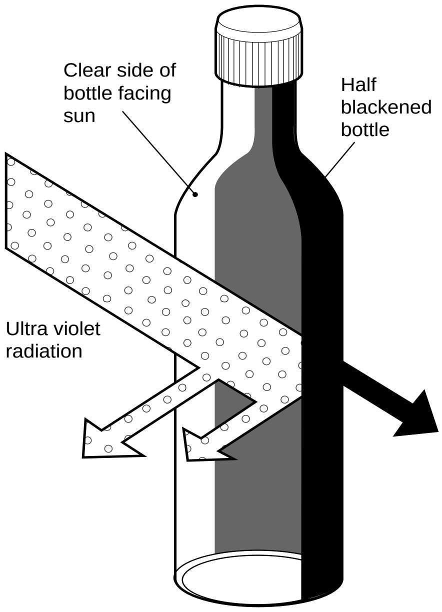
Chemical disinfection is only feasible if the disinfecting chemical is readily available and affordable – and if users accept the resulting taste. As outlined above, the householder needs a reliable way of accurately adding small amounts of chemical to the raw water. Regular disinfection is necessary, as people who drink disinfected water lose their immunity to some diseases.

Solar disinfection

Ultra-violet radiation in sunlight will destroy most pathogens. You can improve the effectiveness of this process by increases in temperature (although the temperature of the water does not need to rise much above 50°C). If clear water is exposed to sunlight, after a time it is usually rendered free of bacterial pathogens. In tropical regions, a safe exposure period is about five hours, centred around midday. One easy method of treating the water is to expose bottles of water to the sun. The SODIS system uses half blackened bottles to increase the heat gain, with the clear side of the bottle facing the sun. For greater effectiveness place the bottle (black side down) on a corrugated iron roof (see Wegelin and Sommer (1998)). Instead of using a bottle, water can be held in a plastic bag.

Reed (1997) has found that vigorously shaking three quarters full empty bottles to increase the oxygen content of the water to a high value before exposing it to sunlight considerably improves the effectiveness of solar disinfection. Further sporadic shaking during exposure is also beneficial. People are unlikely to want to drink the warm, treated water so allow it to cool.

Another method of solar disinfection (called solar pasteuration) uses solar radiation to **heat** water to about 70°C for about 15 minutes to kill off the pathogens and is not in this Technical Brief because it is considered too complicated for use by low-income households.



The SODIS system

Further reading

Heber, G., (1985), *Simple Methods for the Treatment of Drinking-water*, GATE, F. Vieweg, & Sohn, Braunschweig, Germany.

IRC (1988), *Community Self-Improvements in Water Supply and Sanitation: A Training and Reference Manual for Community Health Workers, Community Development Workers and other Community Based Workers,* Training Series No. 5, International Water and Sanitation Centre (IRC), The Hague, The Netherlands.

Miller, DeWolfe, (1986), 'Boiling drinking-water: A critical look'. *Waterlines* Vol. 5 No.1., IT Publications, London.

Wegelin M. and Sommer B., (1998), 'Solar Water Disinfection (SODIS): Destined for worldwide use?', *Waterlines,* Vol.16 No. 3., IT Publications, London.

Reed R., (1997), 'Sunshine and fresh air: A practical approach to combating water-borne disease', *Waterlines,* Vol.11 No. 4, IT Publications, London.

RELEVANT TECHNICAL BRIEFS: 11 Rainwater Harvesting, 15 & 21 Slow Sand Filter Design; 17 & 19 Health, Water and Sanitation (1 & 2); 40 Desalination; 46 Chlorination of Community Water Supplies; 47 Improving Pond Water.

Prepared by Brian Skinner and Rod Shaw

WELL

WATER AND ENVIRONMENTAL HEALTH AT LONDON AND LOUGHBOROUGH (WELL) is a resource centre funded by the United Kingdom's Department for International Development (DFID) to promote environmental health and well-being in developing and transitional countries. It is managed by the London School of Hygiene & Tropical Medicine (LSHTM) and the Water, Engineering and Development Centre (WEDC), Loughborough University.

Phone: +44 1509 222885 Fax: +44 1509 211079 E-mail: WEDC@lboro.ac.uk http://www.lboro.ac.uk/well/

Fifty-eighth in a series of Technical Briefs for fieldworkers. Technical Briefs Nos.1-32 are available in book-form: *The Worth of Water: Technical briefs on health, water, and sanitation* (ISBN 1 85339 069 0) is available at £10.95 plus £2.50 P&P from IT Publications, 103-105 Southampton Row, London WC1B 4HH, UK. Fax: +44 171 436 2013 E-mail: orders@itpubs.org.uk World Wide Web: http://oneworld.org/itdg/publications.html