waterlines

Technical Brief No.46: Chlorination of community water supplies

Some water sources contain disease-causing organisms which need to be removed or killed before the water is safe to drink. If carefully undertaken and monitored, disinfection is an effective means of removing such organisms. Chlorine is the most widely used disinfectant, and one which is often the most readily available. This technical brief describes a method of calculating the dose of chlorine required to disinfect small community water supplies.

Why disinfect?

Water treatment processes such as storage, sedimentation, and sand filtration will reduce the content of disease-causing organisms in water, but will not leave it completely free of such organisms. Disinfection, when applied and controlled properly, is the most practical and effective means of removing such organisms.

Methods of disinfection

Boiling water may be effective as a method of disinfection, but it is not practicable for large quantities. Sunlight can also act as a natural method of disinfection, but it is difficult to control and manage. For these reasons, chemical disinfectants (especially chlorine and chlorine compounds) are used. Iodine may also be used as a disinfectant, but it is usually more expensive than chlorine compounds.

Chlorine compounds will destroy disease-causing organisms quickly — usually after 30 minutes. They are widely used and are relatively inexpensive. If carefully applied, chlorine has the advantage that a measurable residual of chlorine in solution can be maintained in the water supply. This residual provides further potential for disinfection and is also an important indicator of successful application.

When to use chlorine

Chlorine may be used:

- when suitable compounds are available and their application can be strictly controlled;
- when there is enough time between the addition of chlorine to water and the consumption of the water;
- where a community has a continuous supply of water, with storage capacity; and
- by individuals to provide additional protection.

When not to use chlorine

Chlorine should not be used:

- when a regular supply of chlorine compunds cannot be guaranteed;
- where chlorine may react with other chemicals in the water creating undesirable or dangerous by-products;
- to attempt to kill cysts or viruses; or
- when careful monitoring cannot be provided.

Chlorine demand and residual

When chlorine is added to a water source, it purifies the water by damaging the cell structure of bacterial pollutants, thereby destroying them. The amount of chlorine needed to do this is called the **chlorine demand** of the water. The chlorine demand varies with the amount of impurities in the water. It is important to realise that the chlorine demand of a water source will vary as the quality of the water varies.

The aim of chlorination is to satisfy the chlorine demand of the water source. Once the demand has been satisfied, any excess chlorine above the level needed to satisfy the demand remains as a **residual** of chlorine (chlorine residual) in the supply.

If a supply is to be adequately disinfected, therefore, there should be a chlorine residual in the supply, so that there is the capacity to cope with any subsequent bacterial contamination. The chlorine residual should generally be in the range 0.3 to 0.5 mg of chlorine per litre of treated water. Any more than this and the supply may taste bad and be harmful, and people may refuse to use it. Any less, and there is no guarantee that the supply is adequately protected. An example is given in Figure 1 below.

A water supply (from a spring, for example) has a chlorine demand of 2.0 mg/l.

If exactly 2.0 mg of chlorine is added per litre of water, then the chlorine demand will *just* be met and there will be no chlorine residual.

If 2.5 mg/l of chlorine is added, then the chlorine demand will be met and exceeded, so that a residual of 0.5 mg/l will be left in the water when it goes into supply.

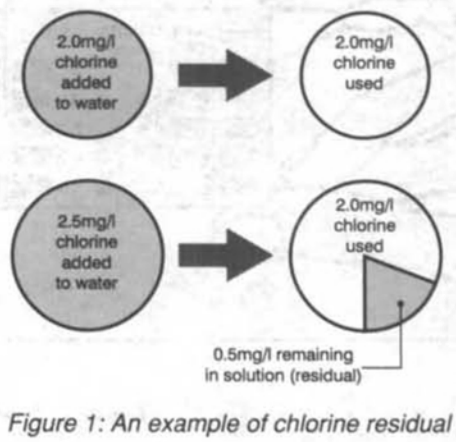

Figure 1: An example of chlorine residual

Testing for chlorine residual

The most common test is the dpd (diethyl paraphenylene diamine) indicator test, using a comparator. This test is the quickest and simplest method for testing chlorine residual.

With this test, a tablet reagent is added to a sample of water, colouring it red. The strength of colour is measured against standard colours on a chart to determine the chlorine concentration. The stronger the colour, the higher the concentration of chlorine in the water

Several kits for analysing the chlorine residual in water, such as the one illustrated in Figure 2, are available commercially. The kits are small and portable.

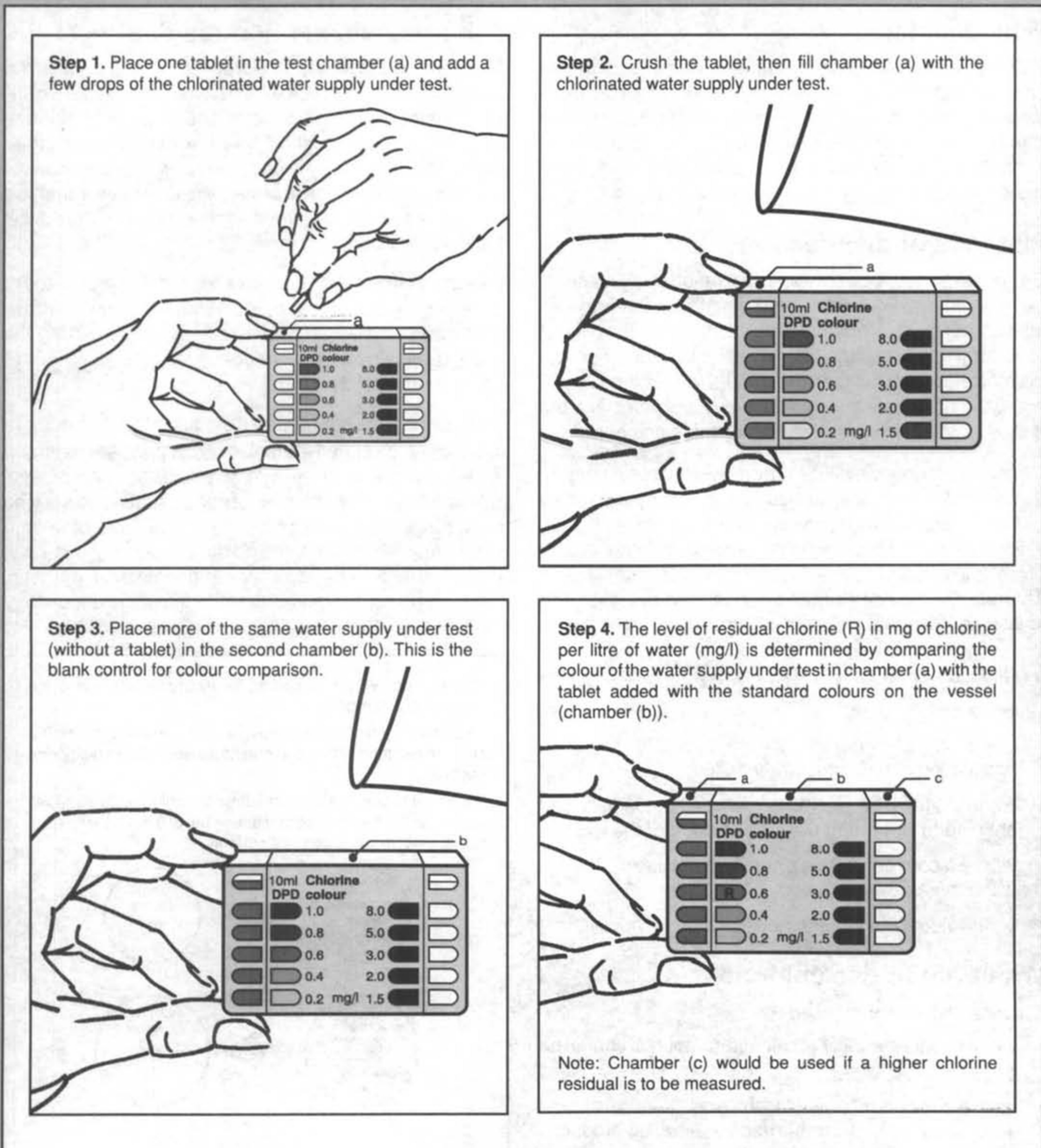

Figure 2: Procedure for testing for chlorine residual

Chlorinating water supplies

Chlorine is available in many forms — as chlorine gas and in compounds such as bleaching powder, high test hypochlorite (HTH), tablets, granules, and liquid bleach.

Each product contains a different amount of usable chlorine, so different quantities of each will be required for the same purpose. In addition, the chlorine content of each product will reduce over time as the source is exposed to the atmosphere. All products should be carefully stored to minimize deterioration.

The best practical method of chlorinating a supply of water is to use two storage tanks of suitable size alternately, one filled from the source, while the other is used for supply.

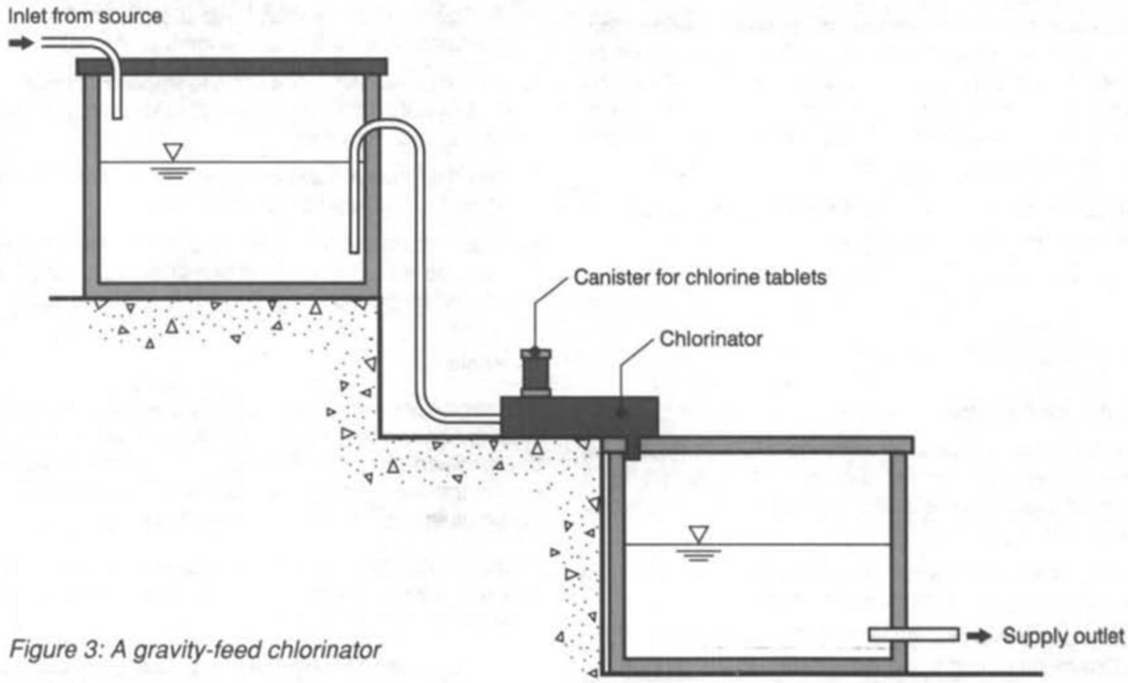

Figure 3: A gravity-feed chlorinator

A chlorination checklist

- ❍ Chlorine needs *at least* half an hour contact time with water to disinfect it. The best time to apply it is after any other treatment process, and before storage and use.
- ❍ Never apply chlorine before slow sand filtration or any other biological process, as the chlorine will kill off the bacteria which assist treatment, making the treatment ineffective.
- ❍ Never add any solid form of chlorine directly to a water supply, as it will not mix and dissolve. Always make up as a paste first, mixing the chlorine compound with a little water.
- ❍ Disinfection is only one defence against disease. Every effort should be made to protect water sources from contamination, and to prevent subsequent contamination during collection and storage.
- ❍ The correct procedure for applying a disinfectant to water should be strictly adhered to, and water supplies should be monitored regularly to ensure that they are free from bacteria. Otherwise, people may be misled to believe that the water is safe to drink when, in fact, it is hazardous to do so.
- ❍ The optimum chlorine residual in a small, communal water supply is in the range of 0.3 to 0.5mg/l.
- ❍ The chlorine dose required to disinfect a supply will increase if the water is very turbid. In such circumstances, it is best to treat the water to reduce turbidity before chlorination.

Caution

All forms of chlorine are harmful to health — avoid skin contact and do not inhale the fumes. Chlorine should be stored in cool, dark, dry and sealed containers, and *out of reach of children.*

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Modified Horrocks' method of chlorination

With most chlorination methods the operator should make up a solution of known concentration. For the reasons outlined on page 17, however, it is not usually possible to do this accurately. The Modified Horrocks' method of chlorination can be carried out without prior knowledge of the chlorine content of the chlorine product.

Equipment

- 5 containers (any type — as long as they are all the same size. Plastic drinks bottles may be used).
- A measuring device to measure out the solid chlorine product. An oral rehydration therapy (ORT) spoon would be suitable. The exact size of the spoon is not critical, but identical amounts must be measured out each time, so use a level spoonful, for example. Use a spoon which measures out about 1 gram, as this will help in the calculations.
- A device to dispense small quantities of liquid (a small 1 ml or 5 ml syringe would be suitable).
- Dpd test equipment

Method

1. Label the five containers 1 to 5.
2. Place one level spoonful of chlorine product (bleaching powder or HTH) into the first container. If the spoon has a capacity of 1 gram, there is now 1 gram of chlorine product in the container.
3. Add a few drops of the water to be chlorinated, and mix to a paste (dissolving the chlorine-product powder).
4. Dilute the paste with enough water to fill the container. If the container holds one litre, it now contains one spoonful per litre, or in this case, one gram per litre. **If we take 1 ml out of this container, this will contain 1 mg of chlorine product** (1 litre = 1000 ml, and 1g = 1000 mg).
5. Fill containers 2, 3, 4, and 5 to capacity (1 litre) with the water to be chlorinated.
6. Transfer 2 ml of the liquid from container 1 to container 2, 4 ml to container 3; 6 ml to container 4; and 8 ml to container 5. Container 2 will then have 2 mg/l; container 3, 4 mg/l; container 4, 6 mg/l; and container 5, 8 mg/l.
7. Leave containers 2, 3, 4 and 5 to stand for at least 30 minutes — this is the minimum *contact time* required for the chlorine to disinfect the water.
8. Test the water in each container for residual chlorine content using the dpd test kit (see page 16).
9. The container with the lowest concentration of chlorine equal to or more than 0.4mg/l indicates how much chlorine powder should be added to the water being disinfected.

Example

A water supply from a spring with a daily flow of 70 m^3/day needs chlorinating to make it safe to drink. Tests on the water — using the modified Horrocks' method — indicated residual chlorine concentrations (after 30 minutes) of 0, 0.2, 0.5 and 1.0 mg/litre in containers 2, 3, 4, and 5 respectively.

Therefore, container 4, with a residual concentration of 0.5 mg/l, had the lowest residual chlorine concentration equal to or exceeding 0.4 mg/l.

The concentration of chlorine product added to container 4 was 6 mg/l. For a supply of 70 m^3/day, therefore, the amount of chlorine product to be used is calculated as:

70 x 1000 litres x 6 mg/l = 420 000 mg = 420 grams = 0.42 kg.

(1 m^3 = 1000 litres)

Further information:

Cairncross, S. and Feachem, R.G., (1993). *Environmental Health Engineering in the Tropics: An introductory text,* John Wiley, Chichester, UK.

IRC (1986). *Small Community Water Supplies: Technology of small water supply systems in developing countries.* Technical Paper No. 18, IRC, The Hague, The Netherlands.

IRC (1982). *Practical Solutions in Drinking-Water Supply and Waste Disposal for Developing Countries.* Technical Paper No. 20, IRC, The Hague, The Netherlands.

Mann, H.T. and Williamson, D., (1993). *Water Treatment and Sanitation,* IT Publications, London, UK.

Twort, A.C., Law, F.M., Crowley, F.W. and Ratnayaka, D.D., (1994). *Water Supply,* Edward Arnold, UK.

White, G.C. (1972). *Handbook of Chlorination,* Van Nostran Reinhold, New York, USA.

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