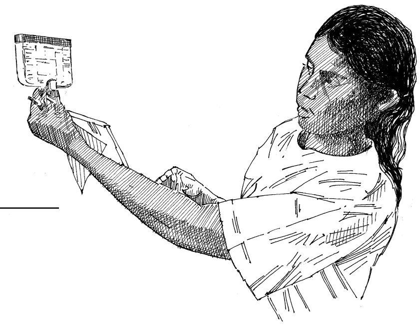
How to measure chlorine residual in water



World Health Organization

The importance of chlorine in water

Many of the most common diseases found in traumatized communities after a disaster or emergency are related to drinking contaminated water. The contamination can be from micro-organisms (Table 1) or natural and man made chemicals (Table 2). This fact sheet concentrates on the problems caused by drinking water contaminated by micro-organisms as these are by far the most common and can be reduced by chlorination. Chemical contamination is difficult to remove and requires specialist knowledge and equipment.

Table 1. Diseases related to drinking water contaminated with micro-organisms
Diarrhoea*
Typhoid*
Hepatitis*
Cholera*

*Contaminated water is not the only cause of these diseases; water quantity, poor sanitation and poor hygiene practices also play a role

Table 2. Some chemical contaminants of drinking water that may be a danger to health	
Arsenic	Fluoride
Cadmium	Lead
Chromium	Mercury
Cyanide	

People who live in the same place all their lives and regularly drink contaminated water may develop some resistance to the contaminants and suffer little or no health problems. Communities affected by an emergency, however, are very different. Emergencies have three relevant effects on people, they:

- force people to move to new places where the water quality is different from what they usually drink and for which they have no immunity;
- force people to live in poor conditions such as tents or temporary buildings which make it difficult to retain good hygiene practices; and they
- affect their diet, often lowering their nutritional level and making them more vulnerable to disease.

It is important, therefore, that all people affected by an emergency are provided with water of a high quality.

There are a number of ways of improving the quality of drinking water. The most common are sedimentation and filtration followed by disinfection. (These are discussed in other notes in this series). Disinfection (the killing of harmful organisms) can be achieved in a number of ways but the most common is through the addition of chlorine. Chlorine will only work correctly, however, if the water is clear (Box 1).

Box 1.
How chlorine kills

When chlorine is added, it purifies the water by destroying the cell structure of organisms, thereby killing them. The process only works, however, if the chlorine comes into direct contact with the organisms. If the water contains silt, the bacteria can hide inside it and not be reached by the chlorine.

Chlorine takes time to kill all the organisms. In water above about 18°C the chlorine should be in contact with the water for at least 30 minutes. If the water is colder then the contact time must be increased.

It is normal, therefore, to add chlorine to water as it enters a storage tank or a long delivery pipeline to give the chemical time to react with the water before it reaches the consumer.

The effectiveness of chlorine is also affected by the pH (acidity) of the water. Chlorination is not effective if the pH is above 7.2 or below 6.8.

How to measure chlorine residual

Chlorine residual

Chlorine is a relatively cheap and readily available chemical that, when dissolved in clear water in sufficient quantities, will destroy most disease causing organisms without being a danger to people. The chlorine, however, is used up as organisms are destroyed. If enough chlorine is added, there will be some left in the water after all the organisms have been destroyed, this is called *free chlorine.* (Figure 1) Free chlorine will remain in the water until it is either lost to the outside world or used up destroying new contamination.

Therefore, if we test water and find that there is still some free chlorine left, it proves that most dangerous organisms in the water have been removed and it is safe to drink. We call this measuring the *chlorine residual.*

Measuring the chlorine residual in a water supply is a simple but important method of checking that the water that is being delivered is safe to drink

When and where to test water

The most common place to use chlorine as a disinfectant is in a piped water supply. Regular chlorination of other water supplies is difficult and usually reserved for disinfection after repair and maintenance. The chlorine residual is usually tested at the following points:

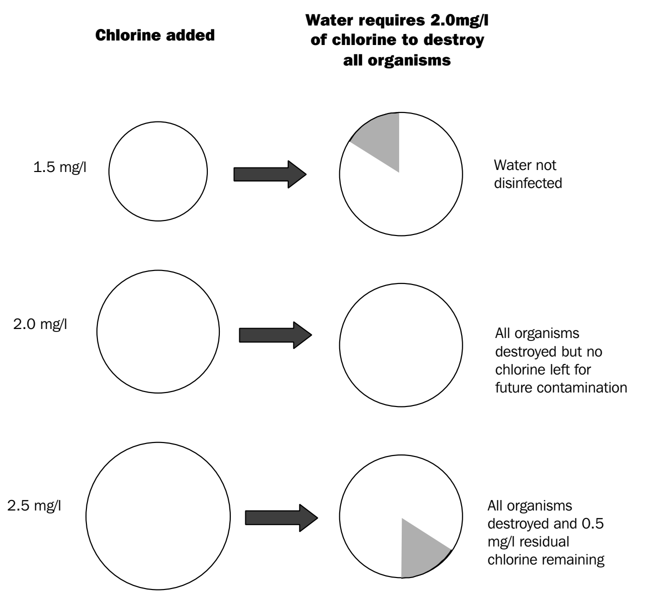


Figure 1. Effect of chlorine residual

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

- Just after the chlorine has been added to the water to check that the chlorination process is working.
- At the outlet of the consumer nearest to the chlorination point to check that residual chlorine levels are within acceptable levels (between 0.5 and 0.2 mg/l).
- At the furthest points in the network where residual chlorine levels are likely to be at there lowest. If chlorine levels are found to be below 0.2 mg/l it might be necessary to add more chlorine at an intermediate point in the network.

The amount of chlorine residual changes during the day and night. Assuming the pipe network is under pressure all the time (see Box 2, overleaf) there will tend to be more residual chlorine in the system during the day than at night. This is because the water stays in the system for longer at night (when demand is lower) and so there is more opportunity for the water to be contaminated which will use up the residual chlorine.

Chlorine residual should be checked regularly. If the system is new or has been rehabilitated then check daily until you are sure that the chlorination process is working properly. After that, check at least once a week.

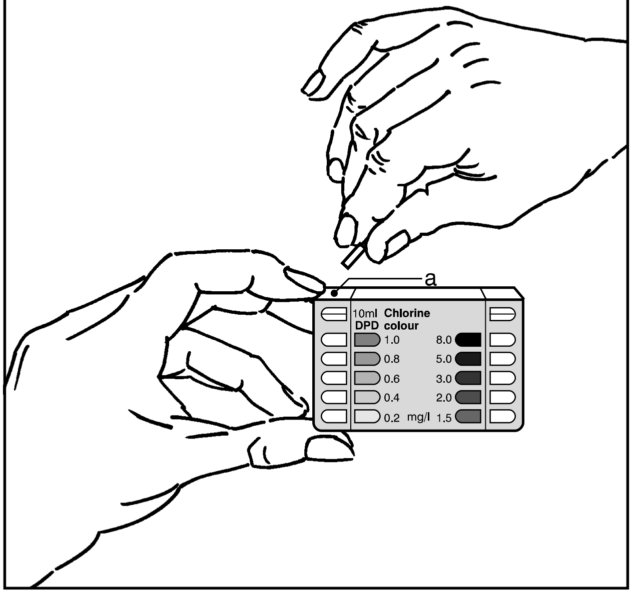
Testing for chlorine residual

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.

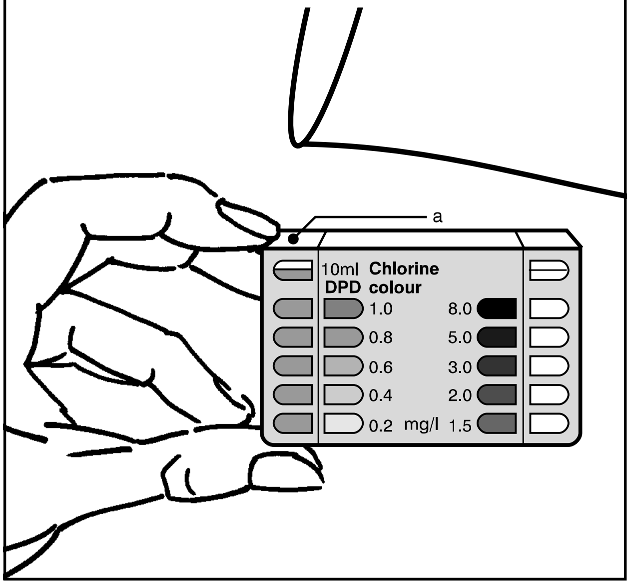
With this test, a tablet reagent is added to a sample of water, colouring it red. The strength of colour is measured against standard colours on a chart to determine the chlorine concentration. The stronger the colour, the higher the concentration of chlorine in the water.

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.

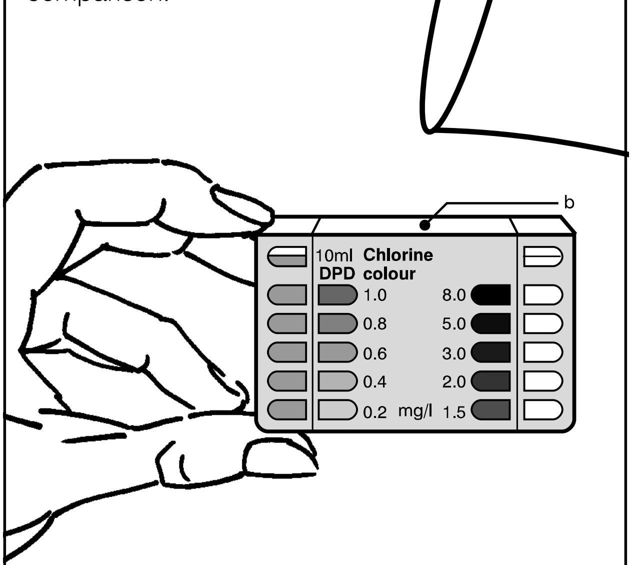
Step 1. Place one tablet in the test chamber (a) and add a few drops of the chlorinated water supply under test.



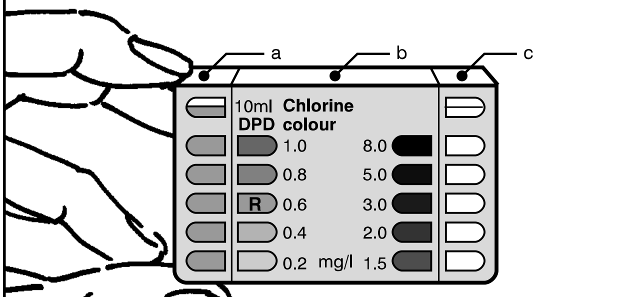
Step 2. Crush the tablet, then fill chamber (a) with the chlorinated water supply under test.



Step 3. Place more of the same water supply under test (without a tablet) in the second chamber (b). This is the blank control for colour comparison.



Step 4. The level of residual chlorine (R) in mg of chlorine per litre of water (mg/l) is determined by comparing the colour of the water supply under test in chamber (a) with the tablet added with the standard colours on the vessel (chamber (b)).

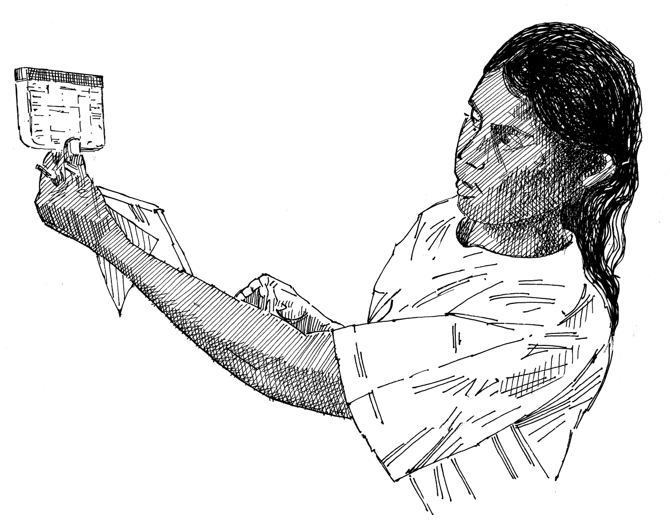


Note: Chamber (c) would be used if a higher chlorine residual is to be measured.

Figure 2. Steps in determining the chlorine residual in water using a comparator

Box 2.
Chlorination and intermittent supplies

There is no point in chlorinating pipe networks if the water supply is intermittent. All pipe systems leak and when the water supply in switched off, the pressure will drop and contaminated water will enter the pipes through the breaks in the pipe wall. No level of residual chlorine acceptable to consumers will be able to deal with such high levels of contamination. All intermittent water supplies should be assumed to be contaminated and measures taken to disinfect it at the point of use.



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.

Further information

WHO (2004) *Guidelines for drinking water quality*, 3rd ed., WHO, Geneva.

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