Chlorine monitoring at point sources and in piped distribution systems

Chlorination in epidemic and disaster situations

Water supplies present a means by which epidemic diseases (such as cholera, typhoid, hepatitis A and many diarrhoeal diseases) can be transmitted to large numbers of people very rapidly. In situations where such diseases may spread, for instance when an outbreak is recognized or a disaster occurs, it is vital that adequate drinking water supplies are assured.

Adequate supplies must be :

- of good quality ;
- continuously available ;
- accessible to all of the population ;
- available in adequate quantities to maintain human health ;
- affordable.

Many measures to improve drinking water quality are medium or long term in nature.

The response to outbreaks of infectious disease and disaster situations must be immediate.

Attention should therefore focus on :

- protection of source water quality ;
- ensuring the optimal use of available treatment facilities ;
- emergency disinfection ;
- ensuring adequate household treatment and storage.

Inventory of sources and initial testing

Even where sources are adequately protected and water treatment undertaken, when there is an increased risk of water-borne disease it is good practice to instigate emergency disinfection. Emergency disinfection should cover *all* of the sources of drinking water used by the population. For this reason, it is important to make an inventory of water supply sources, both piped and non-piped, and organize regular monitoring of all of them.

Wherever possible, initial monitoring should include analysis for faecal indicator bacteria. Emergency disinfection should not await the results of water quality testing but be carried out immediately. Sources which are contaminated with faeces should be investigated, the source of contamination eliminated and the water re-tested. If contamination persists, then the population should be informed that the water is contaminated and that either alternative sources should be used or water should be treated in the home before use. Household water treatment is described in Fact Sheet 2.34.

Once the inventory is complete and initial testing has been undertaken, regular testing should be undertaken.

Testing for chlorine

Free chlorine in water is unstable and the amount of chlorine in water may go down quickly, especially in warm climates. Sunlight and mixing of the water will cause free chlorine to disappear more rapidly. For this reason, chlorine testing should be carried out on-site and samples should not be taken back to the laboratory for analysis later as this may give false results.

Equipment and methods for monitoring chlorine residual

The equipment needed and procedures involved in testing chlorine on-site are described in Fact Sheet 2.31.

Guidelines for chlorination of drinking water supplies

To make sure that drinking water is free of pathogens (disease-causing microorganisms), a free chlorine residual should be maintained. The level of chlorine residual required varies with type of water supply and local conditions. There should, however, be a minimum of 0.5 mg/l residual chlorine after 30 minutes contact time in water.

Where there is a risk of cholera or an outbreak has occurred, the following chlorine residuals should be maintained :

At all points in a piped supply	**0.5 mg/l**
At standposts and wells	**1.0 mg/l**
In tanker trucks, at filling	**2.0 mg/l**

In areas where there is little risk of a cholera outbreak, there should be a chlorine residual of 0.2 to 0.5 mg/l at all points in the supply. This means that a chlorine residual of about 1 mg/l when water leaves the treatment plant is needed. Chlorine residual can be tasted in water at 0.8 mg/l, thus unless higher levels are vital for health reasons, it is recommended that such high levels are avoided at points of consumption.

Disinfection by repeated addition of doses of chlorine

Disinfection by regular (daily or twice daily) addition of doses of chlorine is described for dug wells in Fact Sheet 2.21. In this case, the addition of chlorine may be conveniently combined with monitoring. The same person may be responsible for both testing and recording the concentration of free chlorine in the well, and for the addition of chlorine to the well.

Testing should be undertaken daily or more frequently if chlorine is added more than once per day. All results should be recorded.

The agency responsible for the surveillance of drinking water supplies should make periodic visits to inspect the installation, check that chlorine testing has been undertaken correctly, and take samples for testing for indicators of faecal contamination.

It is important that the person responsible for chlorine monitoring has clearly defined and readily accessible persons to contact when problems with either chlorination or chlorine monitoring are encountered.

Disinfection using a diffusion hypochlorinator

Disinfection of wells using a diffusion hypochlorinator is described in Fact Sheet 2.21. Where the operation of the equipment (cleaning, filling with chlorine and installation in the well) is undertaken by a member of the community or by a person based in the community, then the monitoring scheme may be similar to that described above. In this instance, regular monitoring will ensure that fresh chlorine is added to the equipment as soon as concentrations drop below required levels (generally 1.0 mg/l). Monitoring should be carried out daily during epidemic and disaster situations. The frequency of testing may be reduced under other circumstances in the light of experience with the well in question.

Other types of water sources - surface water and springs

Sources used for drinking water which are not enclosed (streams, lakes, and so on) should not be chlorinated without prior treatment. Such sources are usually contaminated. Alternative sources should be evaluated and, where appropriate, their use promoted. Where adequate alternative sources cannot be found, then the population should be informed of the contamination and of the need to treat water in the home.

Some other sources, such as springs, may be of good quality if adequately protected, but otherwise may be open to contamination. In these cases, disinfection at the source is generally impractical. Source protection is important and if there is any problem with water quality, the population should be encouraged to treat the water in the home.

Storage tanks in urban areas

In urban areas, and often following disasters, storage tanks from which water is collected (similar to public standpipes) may receive water from tanker trucks or by similar means. In this instance source protection, adequate treatment and addition of chlorine should be ensured at the source from which the water is collected for transport to the tank. In addition, regular testing should be undertaken by a responsible person at the site of the tank. Testing should be undertaken on each batch of water on delivery and thereafter daily if the frequency of delivery is less than this.

It is important for the storage tank to be hygienically constructed and operated (see Fact Sheet 2.15).

Piped water supplies

Where there is a risk of water-borne disease, piped water supply systems should be routinely chlorinated at the source or treatment plant and an adequate concentration of chlorine maintained throughout the distribution network. The purpose of monitoring is to ensure that chlorination at the source is continuous and that adequate concentrations are maintained in *all* parts of the distribution system.

Samples must be taken from locations which are representative of water from all sources after disinfection, including storage facilities, the distribution network, and points where water is delivered to consumers (domestic connections and public standposts).

Chlorine testing should be undertaken at least daily at sources and treatment plants, after disinfection of the water, and at storage tanks. A regular monitoring scheme should be established for water in the distribution network. The frequency of water sampling and analysis depends on the size and type of water supply. Tables 1 and 2 below give the minimum frequencies of routine sampling and analysis under non-epidemic conditions. In general, all protected groundwater supplies should be tested twice yearly, once in the wet and once in the dry season. Surface water supplies with treatment plants should be tested more often.

Table 1.
Minimum frequency of sampling and analysis of small community water supplies

Source and mode of supply	Bacteriological sampling and analysis	Physical/chemical sampling and analysis
Open wells	once monthly	once monthly
Covered dug wells and tubewells with handpumps	twice yearly	twice yearly
Springs and piped supplies	twice yearly	twice yearly
Rainwater collection systems	once yearly	once yearly

Table 2.
Minimum sampling frequency for large piped water supplies

Population served	Minimum frequency of sampling
Less than 5000	1 sample monthly
5000 - 100 000	1 sample per 5000 population monthly
Over 100 000	20 samples monthly plus 1 sample per 10 000 population monthly

During outbreaks of diarrhoeal disease, sampling and analysis should be done more frequently than routine sampling and analysis. All water supplies should be chlorinated, and tests for chlorine residual and turbidity should be carried out daily. Bacteriological tests should be carried out as often as is feasible with available resources. Where chlorine residuals are low and turbidity high, a bacteriological test should be carried out as soon as possible. Water quality requirements in emergencies are covered in Fact Sheet 1.7.

Sampling sites in the distribution network should be selected bearing in mind the density of population. Samples should be taken from sites which are most vulnerable to contamination and where there is a lack of persistence of chlorine residual. These include loops, low-pressure zones, dead-ends and sites known to be difficult.

It is essential to link chlorine monitoring to remedial actions, so that a course of action is agreed in advance and immediately implemented if results fall below agreed standards. Actions may include informing the public of the need to treat water in the home, increasing chlorine dosing and installing booster chlorinators where appropriate.

Household storage and disinfection

In many areas it is common practice to store water in the home before use. Where this is the case, water may become contaminated and, although good quality water is being delivered by the distribution network, the water which the population consumes may be dangerous. For this reason, it is vital to consider hygiene education regarding household water treatment and storage. Household water treatment and storage is covered in detail in Fact Sheet 2.34.

Chlorine testing

The importance of testing for chlorine in water

Chlorine is added to drinking water to kill the microorganisms which cause typhoid, cholera, hepatitis A and other diarrhoeal diseases. Chlorine testing is important for the following reasons :

- If there is not enough chlorine in the water, the microorganisms will not be killed.
- If there is too much chlorine in the water, the users may not want to drink it because of the taste of chlorine and may be tempted to use other less safe water supplies.

Chlorine residual

One of the advantages of chlorine as a disinfectant is that it is easy to measure both in a laboratory and in the field. Another advantage is that when chlorine is dosed correctly, it leaves a disinfectant residual which helps to prevent re-contamination in the distribution system or household storage tank. When chlorine cannot be detected in a distribution system, this may indicate that contamination has entered the system or that the dosing is incorrect.

Three types of chlorine residual can be measured :

- Free chlorine - which kills microorganisms most effectively.
- Combined chlorine - formed when free chlorine reacts with other chemicals in the water.
- Total chlorine - the sum of free and combined chlorine.

Free chlorine is the most important type of chlorine and a description of how to measure free chlorine is given below.

Sampling

Free chlorine in water is unstable and the amount of chlorine in water may go down quickly, especially in warm climates. Sunlight and mixing of the water will allow free chlorine to disappear more rapidly. For this reason, chlorine testing should be carried out on-site and samples should not be taken back to the laboratory for analysis later as this may give false results.