SECTION 7

Water Testing and Treatment

WATC	Chlorination Kit
WADELAGUA	DelAgua Kit

Shipping Specifications

WATC	0.53 x 0.34 x 0.29m – GW: 17kgs
WADELAGUA	0.47 x 0.47 x 0.49m – GW: 15kgs

Chlorination Kit Information

CHLORINE AS A WATER DISINFECTANT

WHY DO WE NEED TO DISINFECT WATER?

Dirty and polluted water can contain many organisms that are harmful to humans if we drink it. The disease causing organisms (pathogens) include bacteria, bacterial spores, viruses, cysts, protozoa and helminths. These can cause diseases like cholera, bacillary dysentery, typhoid, infectious hepatitis and diarrhoea. Disinfection of water aims to kill these pathogens without leaving any harmful chemical substances in the water.

Water treatments such as sedimentation and filtration can significantly reduce the number of pathogens in water. However, there is still likely to be a need to kill the remaining and subsequent pathogens. It is at this point that chlorine is used as a chemical disinfectant.

WHY USE CHLORINE?

Chemical disinfectants for water should have the following attributes:

- destroy all pathogens present in the water within an acceptable amount of time
- be able to perform within the range of temperatures and physical conditions encountered
- disinfect without leaving any harmful effects to humans
- permit simple and quick measurement of strength and concentration in water
- leave sufficient active residual concentration as a safeguard against contamination
- ready and dependable availability at a reasonable cost

Chlorine is the chemical most widely used as it fulfils the above criteria and is widely available in one form or another (see section below).

HOW DOES CHLORINE WORK?

The precise way in which chlorine kills pathogens is not known. It is believed that the compounds formed when chlorine is added to water interfere with the chemical processes which ensure the pathogens' survival.

When a suitable chlorine compound is added to water, only a part of it becomes effective at killing pathogens. This part is called "Free Active" or "Active" chlorine (AC) . AC is very good at invading the cells of pathogens. It is, therefore, a very efficient killer of pathogens. As a result, only small amounts of chlorine are required to disinfect polluted water.

WHAT AFFECTS CHLORINE'S EFFICIENCY?

After it has been added the active chlorine needs a certain amount of time to kill the pathogens in the water. This is called the "contact time". This amount of time **must** be allowed after adding chlorine before people drink the water. How much contact time is required for the active chlorine to be fully effective depends upon many factors. However, the most important are pH (level of acidity/alkalinity) and water temperature.

Most raw water sources have a pH value within the range 6.5 - 8. As pH levels rise the disinfecting properties of chlorine start to become weaker and at pH 9 there is very little disinfecting power. WHO guidelines recommend drinking water should have a pH therefore in the range of 6.5 ~ 8.5. pH can have a significant influence on the performance of chlorine in water which we are likely to be working with for drinking water supplies.

The temperature of the water to be disinfected can have a significant effect on chlorine efficiency. The time needed for disinfection becomes longer as the temperature of the water gets lower. There is a noticeable difference in the kill rate of bacteria between 2 and 200C .

If the water to be disinfected contains a lot of suspended solids and/or organic matter (i.e. is highly turbid) , it will have a high chlorine demand. It is, therefore, desirable to clean the water as much as possible before the chlorination process begins. This will significantly reduce the amount of chlorine needed and improve it's efficiency as a disinfectant.

If iron and manganese are present in the water to be disinfected a substantial amount of chlorine may combine with them to form compounds which are insoluble in water. It is, therefore, beneficial to remove the iron and manganese before chlorination. This may not always be possible, although simple aeration systems may be appropriate. It is important that the person responsible for disinfection is aware of the influence that the presence of these metals can have on chlorine demand.

HOW LONG DOES IT TAKE TO KILL THE PATHOGENS?

The disinfecting effect of chlorine is not instantaneous. The amount of pathogens killed is dependent upon the "contact time" between the dosing and the drinking. For our purposes, a minimum contact time of 30 minutes is essential. However, when considering this, account must be taken of the pH, temperature and turbidity of the water. For example a turbid water with a pH 7.5 - 8 and a temperature of 100C will require a longer contact time than a clear water with pH 6.5 - 7 and a temperature of 20'C.

MINIMUM CONTACT TIME MUST ALWAYS BE 30 MINUTES

TYPES OF CHLORINE

Chlorine gas and chlorine dioxide are widely used in water treatment. However, the handling and transport of them is considered too hazardous for the sorts of projects OXFAM or its partners are likely to be involved in.

CHLORINE IS DANGEROUS. THE SAFETY RULES CONCERNING ITS HANDLING MUST ALWAYS BE FOLLOWED.

CALCIUM HYPOCHLORITE - Ca(OC1),

Calcium hypochlorite, also widely known as bleaching powder or chlorinated lime, comes as a powder containing approximately 33% available chlorine. It is stored in corrosion resistant containers. Once the container is opened, the powder quickly loses its strength. This can be very significant e.g. about 5% in 40 days if the container is opened for as little as 10 minutes per day, or approximately 20% if left open for the whole period.

The powder is not added directly to the water to be disinfected. The usual method is to make a solution of 1% available chlorine and to add this to the water (see Table 1 for more information) .

Solutions of chlorine are more prone to loss of strength than bleaching powder. Sunlight and high temperatures can speed the amount of active chlorine lost. To minimise such losses, the solution should be stored in a dark dry place and at the lowest possible temperature. The solution should be stored in dark corrosion resistant containers (glass, plastic, wood, ceramic) which must be securely closed.

More stable bleaches are available on the market. They are more expensive to buy but, because they last longer in the store, can prove to be more economical in the long run. High Test Hypochlorite (HTH) is one such stabilised form of Calcium Hypochlorite. It contains between 60 - 70% available chlorine and with suitable storage will maintain its initial strength with little loss. It is available in tablet or granular form. Other prepared solutions include ICI Tropical bleach - 34% available chlorine and Stabochlor - 25%.

SODIUM HYPOCHLORITE (NaLCO)

Sodium hypochlorite is generally available as a solution commonly known as bleach. Typical available chlorine contents range from 1 - 5% but can be as high as 18%. Before using these solutions the available chlorine content should be checked. The solutions become less stable as the chlorine content rises. As with all chlorine disinfecting compounds extreme care should be used when handling these solutions.

Buying solutions of sodium hypochlorite is not economic for large scale use, as the transport costs associated with it are high. This results from the volume and weight to be transported. it is far better to buy powdered forms of chlorine and prepare

solutions for addition to the water on site.

SLOW DISSOLVING TRICHLOROISOCYANURIC ACID

This form of chlorine is used extensively to disinfect swimming pools. The chlorine, which comes in various sized tablets, is supplied by OXFAM as part of our emergency water supply packs. The compound dissolves very slowly in water and so it is suitable for disinfecting drinking water which is stored in large capacity tanks as used in emergency . It is recommended that this form of chlorine is not used in drinking water supplies for more than 3 months in one year. As such this compound is ideal for use during the first three months of disinfection or whilst another source of chlorine is being found locally. It should be noted that the health risks (which are not certain or proved at the time of writing) associated with prolonged use of the tablets are much less than the risks ensuing from drinking non - disinfected water.

This form of chlorine is relatively stable and if stored in non-humid conditions at temperatures below 250C, can retain its full strength for 2 years. OXFAM supplies these tablets with a small plastic basket which floats inside the reservoir or tank. The basket should be placed near the inflow of the tank so that the incoming water flows over the tablets. This is the best way of ensuring good contact between the water and the chlorine. When using the $45m^3$ OXFAM storage tank, initially use 3 tablets (4 for the $70m^3$, 5 for the $95m^3$) . The residual chlorine will need to be checked daily (see section below) and adjust the number of tablets accordingly. The tablets should last between 7 - 14 days.

USE OF CHLORINE - HOW TO MAKE CHLORINE SOLUTIONS

As we have already said, the most stable solution is 1% available chlorine, and so it is recommended that this should be the strength of solution to be prepared. The following tables give an approximate guide to producing 1% solutions from various chlorine compounds. It should be stressed that the strength of the solution will be dependent upon the chlorine content of the chemical used to make the solution.

TABLE 1

QUANTITIES REQUIRED FOR 1% CHLORINE SOLUTION

SOURCE OF CHLORINE	AVAILABLE CHLORINE	QUANTITY REQUIRED (g)
BLEACHING POWDER	34	30 - 40
HTH	70	14
TROPICAL BLEACH	34	25
STABILISED BLEACH (STABOCHLOR)	25	40
BLEACH (some forms eg. Milton)		1% SOLUTION

These quantities of chemicals should be added to 1 litre of water in the following way. The amount of chemical needed to make a 1% solution is placed into a suitable vessel and sufficient water is added to make a smooth cream, in the case of bleaching powder. It is best to use a wooden stirrer to break up the lumps. When all the lumps have been broken the cream should be diluted to the required amount using more water and thorough mixing. The sediment should be allowed to settle out, and then the clarified liquid taken off to be used as the disinfecting agent in the water to be treated. For granular forms, such as HTH, adding the required quantity to 1 litre of water and agitating will be sufficient to ensure good mixing.

The **1%** solution is used as the means of disinfecting larger quantities of water.

HOW MUCH CHLORINE TO USE?

When using chlorine to disinfect drinking water the aim is to kill off all of the pathogens and then to leave a small amount of active chlorine in the water. This remaining chlorine is called the "residual chlorine,,. The residual chlorine is desirable as it can disinfect further contamination of the water once it has been collected e.g. dirty water containers. It is desirable to have a residual chlorine level of 0.3 - 0.5 milligrams per litre (mg/1). This can be measured quite simply (see section below).

The chlorine demand of water will vary greatly from one location to another. It is, therefore, important that the person responsible for the chlorination process is able to calculate the actual chlorine demand of the water to be treated.

This is a simple process of trial and error. Specific quantities of a chlorine solution can be added to litre samples of the water to be treated, e.g. sufficient to give 3, 4, or 5 mg/1. The residual chlorine can then be tested after a minimum of 30 minutes contact time. The chlorine demand can then be determined by deducting the residual from the amount of chlorine added.

CHLORINE DEMAND = KNOWN DOSE - RESIDUAL CHLORINE

When the chlorine demand has been calculated, the desired residual level can be added arithmetically to give the required chlorine dose per litre of water, e.g. chlorine demand = 3.5 mg/1, desired residual = 0.5 mg/1, chlorine dose = 4 mg/1. This figure is then used to calculate the amount of solution to be added to the volume of water to be treated.

FOR REFERENCE When in water 1 mg/1 = 1 part per million (ppm)

TABLE 2

CHLORINE DOSE REQUIRED	VOLUME OF 1% SOLUTION TO BE ADDED TO 10 LITRES	100 LITRES	1000 LITRES
1 mg/1	1 ml	10 ml	100 ml
5 mg/1	5 ml	53 ml	533 ml
10 mg/1	10 ml	100 ml	1 litre

ml = millilitres

Using these figures to give a 5 mg/1 dose of chlorine to a reservoir of 45,000 litres will require 22.5 litres of **1%** solution.

MEASURING THE RESIDUAL CHLORINE

It is very important that the residual chlorine can be measured as this can tell the person responsible how effective the chlorination process has been. A very simple test involves the use of a kit designed for measuring the chlorine levels in swimming pools. It is called a "pool test kit".

A sample of the water to be tested is placed in the kit and a DPD No.1 tablet is dropped into it. The chlorine in the water reacts with the DPD tablet to give a level of coloration in the water. This colour is compared directly against the colour chart on the kit. The strength of colour then tells the operator the level of residual chlorine. The same kit can also measure the pH of the water sample in a similar comparative manner.

CHLORINATION RULES

- pre-treatment is important to get water as clean as possible before chlorination
- do not chlorinate before filtration
- check pH and temperature to help assess contact time
- ensure minimum contact time is always permitted
- always test for residual chlorine levels
- follow the storage guide for the particular chemical being used.

SAFETY RULES

ALL FORMS OF CHLORINE USED AS WATER DISINFECTANTS CAN BE DANGEROUS IF NOT STORED AND HANDLED IN THE CORRECT "MANNER.

The following simple rules must always be followed and any particular advice and precautions supplied with a specific product should likewise be closely followed.

- Only authorised personnel should be allowed into the chlorine store
- Chlorine is caustic i.e. can cause burning and must not come into contact with skin, eyes or clothing. Use of protective clothing including gloves, goggles and overalls or apron is advisable.
- Avoid breathing chlorine dust as it is an irritant to the nose and lungs
- Chlorine should be stored under dry, cool and dark conditions, preferably raised above the ground. Keep all containers closed and covered when not in use.
- Follow the instructions supplied by the manufacturer of the particular chlorine compound being used.

DelAgua Kit Information

The kit is designed for analysis of the following:

- Faecal coliform bacteria
- Free and total chlorine
- pH
- Turbidity
- Temperature
- Conductivity

It includes an incubator to operate from a 12 volt battery, sufficient tablets to provide 250 pH and free and total chlorine tests. Unlimited turbidity, temperature and conductivity measurements may be made.

Description of Tests and Test Procedures

1. **Faecal Coliform Count Test**

   Contaminated water from human or animal excrement is an obvious health hazard. The test procedure is an indication of the presence or absence of faecal pollution as it determines the presence of E-coli within the water sample.

   The test is carried out using membrane filtration in sterilised apparatus, incubation with lauryl sulphate nutrient at 44^{o}C for 12-16 hours and a colony count. Action is necessary if chlorinated drinking water contains more than 1 colony/100ml or if non-chlorinated drinking water contains more than 10 colonies/100ml. However, it would be wrong to condemn a water supply if no better were available.

2. **Chlorine and pH Test**

   Chlorinating chemicals are added to kill bacteria and oxidise organic matter. If enough chorine is present to form a residual as well as to satisfy the requirements of the oxidation process the water will be safe to drink. It is therefore essential to test for free chlorine residual wherever chlorination is practised to ensure that treatment has been effective. Over chlorination will result in an unpleasant taste.

   Water should not be chlorinated prior to slow sand filtration since this will reduce the effectiveness of the filtration. pH levels should be maintained above 5 and below 8.

   Residual free chlorine and residual total chlorine and pH are determined by colour comparisons after adding chemicals provided within the kit to test water samples.

3. Turbidity Test

This is caused by suspended materials, such as organic material, bacteria, algae, clay, mud, lime or rust. The first three types will consume chlorine, the last four types may interfere with disinfection. The highest level of turbidity recommended by WHO is 5TU which is approximately the density at which turbidity becomes visible within a drinking glass. Low turbidity assists filtration, it is tested by pouring the water sample into a long clear plastic tube and observing the depth at which it is just impossible to see through the tube.

4. Electrical Conductivity and Temperature Tests

Changes in electrical conductivity relate to either the level of dissolved salts or may indicate pollution of some description. A change in temperature of ground water may indicate contamination and this also affects the rate of bacterial and chemical reactions.

Temperature and conductivity can be measured with the meter and probes provided within the kit.

5. Filterability Analysis (an optional procedure)

This test is useful in deciding whether pre-treatment of raw water is required before slow sand filtration. The test does require a vacuum gauge which is not provided with the kit. A filterability index is found by comparing the rate of filtration of the test water with that of pure water. The pure water having been prepared by membrane filtration.