Chlorination

General Information

Chlorine is the most readily available and widely used chemical disinfectant for water supply. The aim of chlorination is the destruction of pathogens and the protection of the water supply. To achieve this, a chlorine dose must be sufficient to:

- Meet the chlorine demand of the water, i.e. to oxidize the contaminants (including reacting with any organic or inorganic substances).
- Leave a residual to give protection against further contamination. This is achieved by ensuring a free residual of 0.2 0.5 mg/liter of chlorine in the disinfected water after a contact time of 30 minutes. The residual will inhibit any subsequent growth of organisms within the water supply system. Higher residuals may give an unpleasant taste and people may not drink the "safe water."

A precondition for effective chlorination is that the turbidity of the water be low. In emergency water supply the aim is to have a turbidity of less than 5 NTU (nephelometric turbidity units). Chlorination will function relatively effectively up to 20 NTU but steps should be taken to reduce turbidities as soon as possible.

At high turbidity levels, large quantities of chlorine are needed to oxidize the organic matter present. This leaves a strong chlorine taste that may cause people to use other, possibly contaminated, sources of water for drinking. Furthermore, some pathogens inside particles of organic matter may survive the oxidizing effects.

Chlorine may be added to a water supply by:

- Dosing with a continuous flow of a 1% solution of chlorine.
- Adding chlorine tablets or powder directly to a tank of water (for emergency chlorination).

Forms of Chlorine

Chlorine is available in the following forms:

- **Chlorine gas** is normally used in conventional water supply schemes of substantial size. Chlorine gas dosing equipment is expensive to install, complicated to operate and maintain, and it can be dangerous if not handled properly. Chlorine gas is unlikely to be used in an emergency water supply.
- **High Test Hypochlorite (HTH)** calcium hypochlorite granules supplied in drums (70% available chlorine).
- Sodium Hypochlorite supplied in liquid form as
 - Household disinfectant 5% to 15% available chlorine.
 - Laundry bleaches 3% to 5% available chlorine
 - Antiseptic solutions 1% to 2% available chlorine.
- Bleaching powder or chlorinated lime about 30% available chlorine when fresh.
- Chlorine tablets various relatively expensive types.
 - small calcium hypochlorite tablets (60% to 70% available chlorine) used in tablet chlorinators.
 - 'swimming pool' tablets containing trichloroisocyanuric acid. These tablets can be suspended in a tank with a purpose-made float to give a slow release of chlorine.

How Much Chlorine Is Required?

Enough chlorine must be provided to meet the chlorine demand and to leave a free residual of 0.2 - 0.5 mg/l after a contact time of 30 minutes.

There are two types of chlorine residuals – combined residuals and free residuals. Combined residual chlorine is the proportion of the original chlorine dose that combines with ammonia and organic nitrogen compounds to form stable but less effective disinfectants than free chlorine. Free residual chlorine is that part of the chlorine dose which remains after the chlorine demand has been fully satisfied.

The actual dose will depend on the condition of the water. It can be expected to be in the range of 1 - 5 mg/l. You can determine the actual dosage as follows:

- 1. Prepare a 1% chlorine solution (see section beneath).
- 2. Take 4 non-metallic containers of a known volume (e.g., 20liter buckets)
- 3. Fill the containers with equal amounts of water to be treated.
- 4. Add to each bucket a progressively greater dose of 1% solution with a syringe. For example, if we were using 20 liter volumes of water and we wanted to try doses of 1 mg/l, 2 mg/l, 3 mg/l and 4 mg/l, we would dose the containers as follows:

1st container: 2 ml

2nd container: 4 ml

3rd container: 6 ml

4th container: 8 ml

- 5. Wait 30 minutes for chlorine to react then measure free chlorine (see section beneath.
- 6. Choose the sample which shows a free chlorine residual between 0.2 0.5 mg/l. You may have to run the test again with stronger or weaker doses depending on the results.
- 7. Once you determine a proper dose, extrapolate the 1% dose to the volume of water to be treated.
- 8. Pour the solution into the water storage vessel, mix well and wait 30 minutes before distributing.

Example: Chlorination of water in a 2,000 liter reservoir

- Follow steps 1-8 above
- The free residual chlorine levels of the water in the buckets, measured half an hour after adding 2, 4, 6 and 8 ml of the 1% chlorine solution respectively are as follows:
 - 1^{st} container: 0 mg/l
 - 2^{nd} container: 0.1 mg/l
 - 3rd container: 0.4 mg/l
 - 4th container: 1 mg/l
- The dosing rate chosen therefore will be that for the 3rd container (result between 0.2 and 0.5 mg/l).
- If it needs 6 ml of a 1% solution to chlorinate 20l of water at the correct dosage, then it needs 100 times as much to chlorinate 2,000 l. E.g.:

•	6ml of 1% solution]_[$\begin{bmatrix} x \ ml \ of \ 1\% \ solution \end{bmatrix}$
	20 liters of water	_	2,000 liters of water

• Solving for x yields: x = 600 ml of 1% solution

Making A 1% Chlorine Solution

A comparatively stable working solution of chlorine is 1% available chlorine. This can be used to dose water in a water treatment plant. A 1% solution contains 10 g of chlorine per liter; i.e., 10,000mg/liter or 10,000ppm (parts per million).

Take care when mixing bleaching powder as it will form lumps when simply added to water. Add just enough water to the powder to form a cream. Use a wooden stirrer and gradually add water to make the required solution. Allow the sediment that will form to settle and decant the liquid before use.

Table 1 is an approximate guide to making 1 liter of a 1% solution from various sources. Remember that if the source has been stored for some time, its strength will have reduced.

Table 1

Preparation of 1 liter of 1% Chlorine solution

Chlorine Source	% Available Chlorine	Quantity Required	Approximate Measure
High Test Hypochlorite (HTH)	70	14 g	1 heaped tablespoon
Bleaching Powder	34	30 g	2 heaped tablespoons
Stabilized Tropical Bleach	25	40 g	3 heaped tablespoons
Liquid household disinfectant	10	100 ml	7 tablespoons
Liquid Laundry Bleach	5	200 ml	14 tablespoons
Antiseptic solution	1	1 liter	No adjustment needed

Table 2

Water Volume to be disinfected (liters)	Quantity of 1% solution (ml)	Quantity of HTH (70%) needed (g)	Quantity of Bleach Powder (35%) needed (g)	Quantity of Liquid Laundry Bleach (5%) required (ml)
10	5	0.07	0.14	1.0
100	50	0.7	1.4	10
1,000	500	7.1	14.3	100
10,000	5000	71.4	142.9	1,000

Chlorine Doses for Common Volumes (assumes dosage of 5 mg/l)

Analysis of Chlorine Residual and pH (Using color comparator)

- 1. Wash the comparator cells three times with the water that is to be analyzed and finally fill all three cells with the sample.
- 2. Drop a DPD No. 1 tablet into the right hand cell (C1₂) and a Phenol Red tablet into the left hand cell (pH).
- 3. Replace the lid of the comparator and push down firmly to seal. Invert the comparator repeatedly until the two tablets have dissolved completely. Do not shake, as this will introduce air.
- 4. Immediately read the free chlorine residual and pH concentrations by holding the comparator up to daylight and matching the color developed in the cells with the standard color scale in the central part of the comparator. If the color falls between two standard colors, then it will be necessary to estimate the concentration. Record the result on the daily report sheet.
- 5. To test for total chlorine residual, do not discard the liquid in the comparator, but remove the lid and add a tablet of DPD No. 3 to the right hand cell (C1₂).
- 6. Again, invert the comparator repeatedly to dissolve the tablet. The color developed after 10 minutes represents the total chlorine residual in mg/liter.
- 7. Subtract the free chlorine result from the total chlorine result to obtain the combined chlorine concentration:

a.	DPD No. 1	=	Free chlorine residual	
b.	DPD No. 1 + DPD No.	o. 3	=	Total chlorine residual
c.	Total – Free	=	Com	bined chlorine

Chlorine products available in Myanmar for the Nargis Response

1. WaterGuard

a. Product description

0.6% Sodium Hypochlorite Solution (NaOCl) (It is weak chlorine solution) Produced and distributed by **P**opulation Services International/Myanmar, 15/C, Aung Min Gaung Street, Kamaryut Township, Yangon. For supplies please contact Dr. Mya Than Tun

Tel: +95-1-526173, 524166, Fax: +95-1-527668

E-mail: wguard@psimyanmar.org

b. Product presentation

250 ML bottles - This is normal product size and meant for household level water treatment. Each bottle can be used to treat 1,000 liter of water. The dose is 5 ml of WaterGuard for 20L of water when the water is not too turbid.

<u>20 Liter container</u> – This is produced to response emergency relief, especially intended for the Nargis cyclone relief. This product will be faced out in rehabilitation and recovery periods. The dose is 10 ml for 20 L of water since the source will not be safe after the storm. 20L of WaterGuard can treat 40,000 liters of water with double dose.

2. Aquatabs

a. Product description

Sodium Dichloroisocyanurate (NaDCC)

This is product of Medentech Ltd., Whitemill Industrial Estate, Wexford, Ireland. For Samples and supplies, contact Mr. Michael Gately

Tel: +353 53 60040, Fax: +353 53 41271

E-mail: mgately@medentech.com

UNICEF is also distributing this 8.5 mg tablets currently.

b. Product presentation

Although Aquatabs are available in range of sizes to suit the different circumstances found in an emergency, 8.5 mg, 33 mg and 66 mg tablets are available. One 8.5 mg tablet can treat one litre of water.

3. Pur Sachet

a. Product description

Powdered coagulant and chlorine: Fe₂ (SO₄)₃; Fe (III); Ca(OCl)₂ PuR uses coagulation, flocculation, sedimentation, cloth filtration and chlorination for treating water.

This is a product of Procter and Gamble Co.

b. Product presentation

It comes in a sachet; each sachet can treat 10 litres of water Sachets are part of a larger kit for family use (two 10-12 L buckets with lids, cloth for filtration, scissors, elastic band, and stir rod)

4. HTH

- Product description a. 65% Calcium Hypochlorite
- Product presentation b. Powder form It comes in 45 Kg drum.