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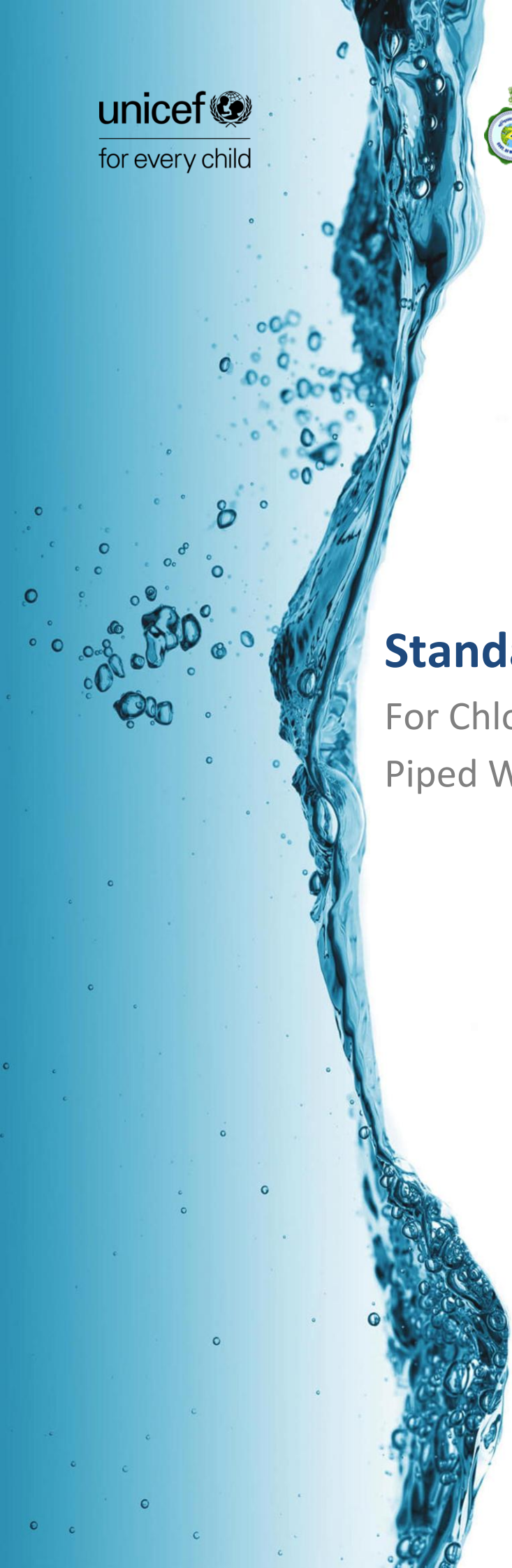
Public Health Engineering Department
Government of West Bengal



Standard Operating Procedure

For Chlorination in Groundwater Based Piped Water Supply Schemes

2021


PHE

SOP

SOP | **Standard Operating Procedure**

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উপক্রমণিকা

জল জীবনের আধার। পৃথিবীতে প্রাণের উদ্ভব এবং বিকাশে জলের ভূমিকা সবচেয়ে গুরুত্বপূর্ন। দূষণহীন পানীয় জল সুস্থ ও নীরোগ জীবনের একটি অতি আবশ্যিক উপাদান। কাঙ্খিত পরিমাণ ও গুণমানের পানীয় জলের অভাবে প্রতি বছর পৃথিবীতে লক্ষ লক্ষ মানুষের জীবনহানি ঘটছে, যার মধ্যে অধিকাংশই শিশু ও কিশোর। বিশ্ব উষ্ণায়ন এর প্রভাবে জলবায়ুর অভূতপূর্ব পরিবর্তন এই সমস্যাকে আরও প্রকট করে তুলেছে।

নদীমাতৃক পশ্চিমবাংলায় ভূগর্ভস্থ ও ভূপৃষ্ঠস্থ জলের যোগান পর্যাপ্ত। তবুও বিভিন্ন ভৌত, রাসায়নিক ও জীবনুদূষণ এই জলকে সরাসরি পানীয়রূপে গ্রহণ করার পক্ষে অন্তরায়। পশ্চিমবঙ্গের সব জেলায় ভূগর্ভ বা ভূপৃষ্ঠের জলে জীবনুদূষণ একটি স্বাভাবিক পরিবেশগত সমস্যা। তাই সঠিক প্রক্রিয়ায় জীবাণুমুক্তকরণ, যে কোন পানীয় জল সরবরাহ ব্যবস্থার একটি অন্যতম আবশ্যিক শর্ত।

পশ্চিমবঙ্গ সরকারের জনস্বাস্থ কারিগরী বিভাগ বিগত কয়েক দশক ধরে পশ্চিমবঙ্গের বিস্তীর্ণ অংশে বিশুদ্ধ ও নিরাপদ পানীয় জল সরবরাহ করে চলেছে। ভৌত ও রাসায়নিক দূষণ দূর করার পাশাপাশি সমস্ত নলবাহিত পানীয় জল সরবরাহ ব্যবস্থায় পানীয় জলকে উপভোক্তার কাছে পৌছে দেওয়ার আগে সম্পূর্ণ জীবাণুমুক্তকরণ একটি নিয়মিত প্রক্রিয়া। সহজলভ্যতা ও দীর্ঘ সময় কার্যকারিতার নিরিখে ক্লোরিন দ্বারা জীবাণুমুক্তকরণ সবচেয়ে জনপ্রিয় পদ্ধতি। ক্লোরিন দ্বারা জীবাণুমুক্তকরণ পদ্ধতিকে আরও কার্যকরী ও নিখুত ভাবে পরিচালন করা একটি আবশ্যিক ও পালনীয় কর্তব্য।

সেই কারণেই "ক্লোরিন দ্বারা জীবাণুমুক্তকরণের প্রামাণ্য নির্দেশিকা" টি তৈরি করা হয়েছে। এই নির্দেশিকা পানীয় জল প্রকল্পে নিয়োজিত সমস্ত স্তরের কর্মীবৃন্দকে ক্লোরিণের ব্যাবহার, সংরক্ষণ ও সঠিক ভাবে জীবাণুমুক্তকরণ পদ্ধতি অনুসরণ করতে প্রশিক্ষিত করে তুলবে তাতে কোন সন্দেহ নেই। নির্দেশিকাটির সাথে বাংলা ও ইংরেজি তে লেখা একটি সংক্ষিপ্ত পুস্তিকা সংযোজিত করা হয়েছে, যার দ্বারা পানীয় জল প্রকল্পে কর্মরত পাম্প ও ভালভ চালকেরা তাদের অবশ্য পালনীয় কর্তব্য সম্বন্ধে আরো সুচারু রূপে অবহিত হবেন।

আমি আশা করছি, রাজ্যের সমস্ত প্রান্তে ছড়িয়ে থাকা পানীয় জল প্রকল্পের পরিচালন কর্মীরা এই প্রামাণ্য নির্দেশিকা দ্বারা প্রশিক্ষিত হবেন এবং নিজ নিজ দ্বায়িত্ব সঠিক ভাবে পালন করে রাজ্যের মানুষকে বিশুদ্ধ ও নিরাপদ পানীয় জল সরবরাহ করতে রাজ্য সরকার কে সহায়তা করবেন।

পরিশেষে বলি, মাননীয় মুখ্যমন্ত্রীর অনুপ্রেরণায় এই বছর আমরা "জলস্বপ্ন" প্রকল্প গ্রহণ করেছি, যার দ্বারা ২০২৪ সালের মধ্যে রাজ্যের সমস্ত গ্রামীণ মানুষকে তাদের আপন গৃহদ্বারে নলবাহী পানীয় জল সরবরাহের সংযোগ প্রদান করা হবে। আসুন আমরা সবাই হতে হাত মিলিয়ে মাননীয় মুখ্যমন্ত্রীর এই স্বপ্নের প্রকল্প কে সার্থক ও সফল করে তুলি।

ধন্যবাদসহ

অধ্যাপক ডক্টর সৌমেন কুমার মহাপাত্র
ভারপ্রাপ্ত মন্ত্রী, জনস্বাস্থ কারিগরী বিভাগ
পশ্চিমবঙ্গ সরকার

Foreword

Water is considered to be the most important resource for sustaining ecosystems, which provide life-supporting services for humans, animals and plants. Globally, contaminated water is a major cause of illness and death, especially among children in developing countries. In addition to this, Climate Change has influenced predictability and frequency of natural disasters in the recent decade, ultimately affecting water quality, leaving communities at risk of outbreaks.

Prevention or minimization of water pollution is critical to improving water quality. One of the most important intervention to improve water quality is disinfection. Over the years, different types of disinfectants have been used to disinfect both ground and surface water based piped water supply schmes. Chlorination is the most popular method of disinfection and is used for water treatment all over the world as chlorine-based disinfectants are locally available, convenient to use and relatively economical.

Different types of chlorine-based disinfectants are easily available in the market and multiple disinfectants are being used having varying Available Chlorine concentrations, for disinfection. The quality, quantity, dosing of the disinfectants and disinfection process, were also not in uniformity across the different Piped Water Supply Schemes. Moreover, there is a lack of awareness among the operators who handle the entire disinfection process.

This has resulted in the **need to standardize chlorination practices** for rural piped water supply schemes across the State.

A team from WSSO and UNICEF visited various pump house sites across the State, in order to discern the existing understanding of field level operators (Pump and Valve) and practices related to the use of disinfectants, its storage, dosage including measurement of free residual chlorine in chlorinated supplies. The team interacted with field level Engineers (Junior Engineers and Assistant Engineers) of concerned water supply divisions to gain a thorough understanding of the piped water supply schemes and various factors that influence the concentration of free residual chlorine in distribution network.

The team had carried out field-based studies to understand effectiveness of different disinfectants and accuracy of various field test kits to monitor residual chlorine onsite in order to come up with a Standard Operating Procedure (SOP) on Chlorination.

This SOP on Chlorination has been conceptualized based on substantial information gathered, gaps identified and experience gained by the team. Each chapter has been prepared by the team in an effort to impart accurate, complete and current knowledge on chlorination. An Instruction Manual for Pump Operators in both Bengali and English has also been prepared for guidance.

I am hopeful that both the SOP on Chlorination and Instruction Manual prepared by the team, will be used as a reference document by all water supply divisions.

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Table of Contents

Abbreviations

AIRP	Arsenic & Iron Removal Plant
FIFO	First In First Out
FRC	Free Residual Chlorine
GP	Gram Panchayat
HDPE	High Density Polyethylene
HTH	High Test Hypochlorite
DPD	N,N-diethyl-p-phenylenediamine
IEP	Iron Elimination Plant
N	Normal
OHR	Over Head Reservoir
O&M	Operation & Maintenance
PHED	Public Health Engineering Department
PPE	Personal Protective Equipment
PVC	Poly Vinyl Chloride
PWSS	Piped Water Supply Scheme
SOP	Standard Operating Procedure
SSP	Street Standpost

Units of Measurement

m^3	cubic meter
cum/hr	cubic meter per hour
m^3/min	cubic meter per minute
gm	gram
Hr	hour
Kg	kilogram
L	litre
L/hr	litre per Hour
LPM	litre per minute
mg/L	milligram per litre
ml	millilitre
mm	millimetre

Introduction

Public drinking water supply systems are mandated to provide safe and adequate drinking water to serving communities. Consumption of water contaminated with pathogenic microorganisms is one of the leading causes of child mortality globally. Hence major emphasis is given on removing or killing such microorganisms from water used for public consumption.

One way of ensuring water safety is to disinfect water supplied through distribution lines. Residual protection of treated water supplied to long distances is a major concern in intermittent water supply schemes. All Piped Water Supply Schemes (PWSSs) in the State operationalize in a discontinuous mode, which makes it vulnerable to re-contamination, unless there is sufficient disinfectant residual maintained in treated water till it reaches consumer end.

The method of choice for disinfecting water for human consumption depends on a variety of factors (Symons *et al.*, 1977). These include:

- its efficacy against waterborne pathogens (bacteria, viruses, protozoa, and helminths);
- the accuracy with which the process can be monitored and controlled;
- its ability to produce a residual that provides an added measure of protection against possible post-treatment contamination resulting from faults in the distribution system;
- the aesthetic quality of the treated water; and
- the availability of the technology for the adoption of the method on the scale that is required for public water supplies.

Chlorination is the most popular method of disinfection in countries like India which may be attributed to its convenience and satisfactory performance as a disinfectant that also satisfies the above listed conditions. As stated in *Drinking Water and Health* (National Academy of Sciences, 1977), "chlorination is the standard of disinfection against which others are compared. “Calcium Hypochlorite is widely used to disinfect water supplied through PWSSs in rural areas by West Bengal.

Image 1: Free Residual Chlorine concentration in water sample collected from nearest street standpost (SSP) – Samuktala PWSS, Alipurduar

A. Purpose and Scope of Standard Operating Procedure (SOP)

SOP is an established or prescribed method to be followed routinely for the performance of designated operations or in designated situations.

This SOP provides information on chlorination practice by using disinfectant for disinfection of drinking water supplied through various Piped Water Supply Schemes (PWSSs) in West Bengal. This SOP includes a short instruction manual as well as detailed discussion on steps of chlorination practices which would be helpful for the concerned officials to train the respective pump operators on dosing practices to disinfect drinking water during supply. This SOP has been developed with an objective to implement uniformity in chlorination practices throughout the State.

This SOP will help the user to:

- Understand the key principles of drinking-water chlorination
- Apply these principles practically in the field
- Perform the basic calculations required to support effective drinking-water chlorination
- Follow protocols that will ensure correct and consistent chlorination
- Store and handle disinfectants containing chlorine

This SOP helps to follow a step by step process to disinfect drinking-water before it is supplied through piped network.

Image 2: Pump Operator measuring Free Residual Chlorine at pump house of Groundwater Based Water Supply Scheme for Gun Sankrul and Adjoining Mouzas, Malda

B. General Instructions on Chlorination Practices

1. Available Chlorine (%) in Disinfectant, Chlorine demand (mg/L) of tubewell water, Required Chlorine dosage (mg/L) and pumping rate of Chlorine solution (Chlorine Dose rate in ml/Hr) are to be determined in the stipulated periods as mentioned below.
    a. Frequency of testing: once every quarter

- First fortnight of January.
- Second fortnight of April.
- Second fortnight of July.
- Second fortnight of November.

2. Available Chlorine (%) in disinfectant and chlorine demand is to be analysed at the nearest rural water testing laboratory managed by PHED. Results for available chlorine in disinfectant are to be compared with the manufacturers' specification.
3. Disinfectant stock should be controlled in such a manner that storage of chemical is not prolonged & FIFO (First in First out) methodology for stock movement may be followed.
4. **Chlorinated water collected from Street StandPost (SSP) located at the farthest end of the piped water supply scheme should have minimum 0.2 mg/L Free Residual Chlorine (FRC) for bacteriological contamination and of 0.5 mg/L in case of virological contamination (Refer IS 10500:2012)**, but not more than 1.0 mg/L.
5. **Chlorinated water collected from the nearest SSP should have minimum 0.5 mg/L FRC**, **but not more than 1.0 mg/L.**
6. It is recommended to prepare a chlorine solution of 1 % strength for dosing at the injection point. Post treatment, if the required amount of free residual chlorine is not found at the nearest SSP, the required chlorine dose to be increased by the amount of FRC that is short of the required amount. Chlorine dose rate should be calculated and maintained accordingly. However, if the chlorine dozer pump is not equipped to pump the required quantity of chlorine solution, table no. 3 may be referred for maintaining necessary FRC concentration at the nearest SSP accordingly.
7. There should be a sampling point after the chlorine injection point in order to assess the dosage for all schemes and it is desirable to maintain a tap connection point within the headwork site after OHR (for schemes with reservoirs), for collection of water samples.
8. The pump operator should be equipped with a **residual chlorine kit** with colour comparator to test FRC at the sampling location after **injection point,** tap connection point within the pump house premises or the **nearest SSP** (according to nature of the scheme) and **SSPs located in the farthest end.**
9. The pump operator should also be provided with a **decent smart phone** that is **compatible** with **customised mobile application** used for collecting relevant water quality data from pump houses.
10. **Total chlorine** to be **tested every quarter** or as and **when the disinfectant dose is changed**.
11. **Total chlorine value (in mg/L)** should either be **equal to or very close to the FRC** value obtained in the sample collected from SSP. This **indicates breakpoint chlorination** has been achieved.
12. **FRC** at the nearest tap point at the inception point of the distribution system **after necessary dosing** has to be **checked daily** by the pump operator and **recorded** in the designated register.

13. All necessary **log books** and **registers** are **to be maintained** by the pump operator at the pump house site
14. **Concerned Junior Engineer / Assistant Engineer** should **physically inspect** the **headwork site / pump house site at least once every quarter** or as and when the disinfectant dose is changed (i.e. the quantity of HTH mixed in the tank is adjusted).
15. **Concerned Junior Engineer/ Assistant Engineer** should check free residual chlorine at the pump house site as well those SSPs marked and identified located in farthest end of the supply scheme, during the day of visit.
16. **Daily chlorine dose, FRC (found at the nearest SSP)** has to be **displayed on a white board inside the pump house site.** Similarly, **last date of cleaning of Overhead Reservoir (OHR) – last cleaned** and **next cleaning date,** also to be **displayed, if applicable.**
17. **Emergency contact numbers** to be **displayed inside the pump house**, including the agency responsible for O & M of machinery at pump house and supply of chemicals.
18. The **name** and **contact numbers of Pump operator** and **Valve operator** should be **painted** on the outer side of the **boundary wall** of pump house site, so that in case of any problem they can be contacted accordingly.
19. **Duration** and **frequency of water supply** should also be written on the outer side of the wall of pump house site.
20. All forms of chlorine are harmful to health – inhalation of fumes and skin contact to be avoided. Necessary **Personal Protective Equipment (PPE)** to be used at all times while **handling disinfectants**.
21. **Disinfectant** should be **stored in a cool, dark and dry place** inside the pump house. Date of opening of the container should be mentioned on the container.
22. **Chlorine dosing** to be done **after polishing unit** and **before** the treated water enters **OHR**, in case there is an **Iron Elimination Plant (IEP)/ Arsenic and Iron Removal Plant (AIRP)** at the head work site.
23. Chlorine dosing may be guided by the steps as illustrated in the instruction manual annexed with this SOP.
24. The **OHR** (as applicable) should be **cleaned once every quarter (minimum)** or **once every month (preferred).**
25. **Stairs leading to OHR** should be **properly maintained** to minimise risk of accidents. Damaged stairs may discourage cleaning staff to clean reservoirs.
26. **Protective nets** should be present to **prevent re-contamination** of disinfected water stored **inside OHR**.
27. To minimize misuse and to monitor dosing of disinfectant, supply to be maintained in such a way that no excess stock should be present at the end of a particular month. For pumps with varying capacities, chlorine dose rate for 0.25% dosing (fixed), monthly stock requirement has been illustrated in the following table. However, for varying pump capacities and chlorine dose rate both, the stock requirement to be changed accordingly.

C. Chlorination Steps at a Glance:

1. Determine available chlorine % in the disinfectant to be used.
2. Determine chlorine demand of groundwater to be chlorinated.
3. Calculate Required Chlorine Dose.
4. Prepare chlorine solution of required chlorine percentage.
5. Adjust the chlorine dose rate of the chlorine dozing pump.
6. Calculate the detention time to be considered to achieve breakpoint chlorination.
7. Check and record FRC and total chlorine at the nearest and farthest SSP (should be in the range of 0.2 mg/L – 1.0 mg/L).
8. Clean the OHR* once every quarter (minimum) or every month (preferred).

   *applicable if there is an OHR at the pump house site

9. Documentation to be done

Image 3: Pressure gauge at pump house of Jateshwar Water Supply Scheme, Jalpaiguri

D. Chlorination Steps in Detail:

1) Determination of Available Chlorine: to be determined quarterly in the nearest laboratory

a) Disinfectant (Liquid):

Principle: Available Chlorine is the measure of oxidizing power of chlorine present as hypochlorite. It is expressed in terms of chlorine with gram equivalent mass of 35.46.
The sample is added to an acidified solution of Potassium Iodide and released iodine is titrated with standard Sodium Thiosulphate solution to the usual starch end point.

Reagents:

1. Glacial Acetic Acid
2. Standard Potassium Iodate Solution (0.1N)
3. Hydrochloric Acid (0.1N)
4. Starch Indicator Solution (0.5%)
   Mix 0.5gm of soluble starch with 5 ml of cold water and add 95 ml of boiling water. Mix, cool and store in a glass bottle. Prepare it fresh every time.
5. Potassium Iodide- Iodate-free
6. Standard Sodium Thiosulphate solution (Hypo) – 0.1N
   Dissolve 25 gm of Sodium Thiosulphate crystals in freshly boiled and cooled water, and dilute to 1000 ml.
   Note: The solution is more stable if the glassware is cleaned with Sulphuric or Chromic acids and thoroughly rinsed with water.

Procedure:

a. Standardization of Sodium Thiosulphate solution:

1. Weigh accurately 3.567 gm of dry Potassium Iodate (KIO_3) and transfer it into a 1000 ml volumetric flask.
2. Dissolve in distilled water, mix thoroughly and make up to the 1000 ml mark with distilled water. This solution will be exactly 0.1 N.
3. Transfer 0.1N Sodium Thiosulphate to a graduated burette of 50 ml capacity.
4. Carefully pipette out a 50ml aliquot of Potassium Iodate solution into a 250ml clean conical flask and dilute to 100 ml with distilled water.
5. Add 1 gm of Potassium Iodide crystals. After it is dissolved, add 15ml of 0.1 N Hydrochloric Acid and titrate immediately with the Sodium Thiosulphate solution (already prepared).
6. When the solution becomes light yellow, add 1 ml of starch indicator solution and complete the titration till blue colour of the solution completely disappears. Solution has to be standardized each time whenever available chlorine is tested.

Calculate the normality of the Sodium Thiosulphate solution as follows:

$$Normality\ (N) = (50\ x\ 0.01)/V$$

Where “V” is the volume of standard Sodium Thiosulphate solution required for titration (in ml).

Box 1:

For example, if 4.2 ml of Sodium Thiosulphate is required to standardize, then Normality of Sodium Thiosulphate will be: (50 x 0.01)/4.2 = 0.11 N

b. Sample testing:

1. Dissolve 2 to 3 gm of Potassium Iodide crystals in 50 ml of distilled water in a 250-ml conical flask.
2. Add 10 ml of Acetic Acid, then pipette out the 5ml of aliquot of sample into the solution, keeping the tip of the pipette beneath the surface of the solution until drained.
3. Titrate at once with 0.1 N standard Sodium Thiosulphate solution until the Iodine colour is nearly gone, then add 1 ml of starch indicator solution and complete the titration to the disappearance of the blue colour.

Calculate Available Chlorine (as Cl), as follows:

$$Available\ Chlorine\ (as\ Cl), percent\ mass\ by\ volume = \frac{(A\ x\ N\ x\ 0.03546)\ x\ 100}{V}$$

Where,

A = Volume in ml of standard Sodium Thiosulphate solution required for titration of the sample;

N = Normality of the standard Sodium Thiosulphate solution and

V = Volume in ml of original sample in aliquot used.

Box 2 (a):

For example, if volume of standard Sodium Thiosulphate solution is 62.8 ml, Normality of standard Sodium Thiosulphate is 0.1 N and the volume of sample taken (V) is 5 ml then,

Available Chlorine (as Cl) percent, mass by volume = (62.8 x 0.1 x 0.03546) x 100/5 = 4.45%

b) Disinfectant (Pellets):

A. Reagents Required:

1) Potassium Dichromate Solution (0.02 N):

Carefully pulverize a quantity of Potassium Dichromate ($K_2Cr_2O_7$) and dry at 110 ± 5°C to constant mass. Dissolve 0.9808 gm of the dried reagent in water to make exactly 1 litre and mix thoroughly.

2) Standard Sodium Thiosulphate Solution (0.02 N):

In a 250-ml glass-stoppered flask, take 2 gm of Potassium Iodide and about 25 ml water to dissolve it. Then add approximately 2 gm of Sodium Bicarbonate and 5 ml of concentrated Hydrochloric Acid. Just before the effervescence subsides, add 25 ml of Potassium Dichromate solution. When the effervescence ceases, stopper the flask and allow to stand for 10 min in a cool dry place. Dilute with 50 ml of water and titrate against Standard Sodium Thiosulphate solution till liquid in the flask has assumed a yellowish green colour. Then add starch solution and continue with addition of Sodium Thiosulphate solution until the blue colour is just discharged.

3) **Starch Indicator Solution:**
   Titrate 1 gm of starch with 10 ml of cold water and pour, with constant stirring, into 200 ml of boiling water. Allow to settle and use the clear supernatant liquid.
4) **Potassium Iodide**
5) **Glacial Acetic Acid**
6) **Sodium Bicarbonate**
7) **Hydrochloric Acid — Concentrated**

B. Procedure

Weigh accurately about 2.5 gm of the material depending upon the size of the tablet and grind using mortar and pestle along with water till a smooth paste is formed. Add 15 to 25 ml of water and decant off the fine part into a 250-ml flask. Again, grind the material left behind and repeat the process of decanting off till no gritty material is left. Wash the pestle and mortar in the same flask. Make the solution to 250 ml. Take 25 ml of the solution, add 2 gm of Potassium Iodide crystals and 100 ml of water and then add 2 ml of Glacial Acetic Acid and titrate it against Standard Sodium Thiosulphate solution till the pale-yellow colour is disappears. At this stage, add starch indicator and continue the addition of Standard Sodium Thiosulphate solution till the blue colour is discharged.

NOTE — The grinding of the sample should be carried out with minimum delay, preferably within 10 mins after opening the sample container.

Calculate Available Chlorine (as Cl), as follows:

$$Available\ Chlorine\ (as\ Cl), percent\ by\ mass = \frac{(A\ x\ N\ x\ 35.46)}{M}$$

Where,
A = Volume in ml of standard Sodium Thiosulphate solution used;
N = Normality of the standard Sodium Thiosulphate solution and
M= Mass in gm of the material taken for the test.

Box 2 (b):

For example, if volume of standard Sodium Thiosulphate solution is 46.2 ml, Normality of standard Sodium Thiosulphate is 0.1 N and the mass in gm of sample material taken (M) is 10.0 ml then,

Available Chlorine (as Cl) percent by mass = (46.2 x 0.1 x 35.46)/2.5 = 65.53%

2) Chlorine Demand: (to be determined quarterly in the nearest designated laboratory)

Chlorine demand is the difference between the amount of chlorine added to water and the amount of residual chlorine left after disinfection.

$$Chlorine\ Demand\ (mg/L) = Actual\ Chlorine\ Dose\ (mg/L) - Free\ Residual\ Chlorine\ (mg/L)$$

Modified Horrock's method

Chemicals Required:

- Disinfectant powder/ granules (here it is pellets)

Apparatus & testing kits:

- One litre beaker(s)
- Spatula
- Free Residual Chlorine Test Kit with necessary chemicals
- Pocket Weighing Balance
- Graduated Pipette (10 ml)

Procedure:

a) Take 1 litre of raw water and add 1 g of disinfectant powder to prepare a solution of concentration 1000 mg/L. This is the stock solution.
b) Take out 2 ml, 4 ml, 6 ml, 8 ml and 10 ml of raw water from the labelled beakers in the order A to E respectively.
c) Add 2 ml, 4 ml, 6 ml, 8 ml and 10 ml of stock solution to beakers A, B, C, D and E respectively.
d) Mix the solutions and wait for at least 30 mins*.
*This is the minimum required contact time for chlorine to disinfect water.
e) After 30 mins, check free residual chlorine in water.
f) Beaker with the lowest concentration of chlorine which is equal to or more than 0.4 mg/L, is the amount of disinfectant powder to be added to 1 litre of water for disinfection.

Box 3:

For example, free residual chlorine in beaker C and D are 0.5 mg/L and 0.8 mg/L. We will select beaker C, with 0.5 mg/L. So, the actual chlorine dose is 6 mg/L.

So, the chlorine demand will be: 6 – 0.5 = 5.5 mg/L.

3) Required Chlorine Dose

It is the amount of chlorine dose to be maintained that takes into account the chlorine demand (if any) and the required residual chlorine to be maintained in the supplied water.

Formula:

$$Required\ Chlorine\ Dose\ \left(\frac{mg}{L}\right) = Chlorine\ Demand\ \left(\frac{mg}{L}\right) + Required\ Residual\ Chlorine\ \left(\frac{mg}{L}\right)$$

Box 4:

For example, if the required residual chlorine is 2.0 mg/L and the chlorine demand is 0.5 mg/L, then the required chlorine dose will be: 2.0 + 0.5 = 2.5 mg/L, based on which the HTH powder/pellet is to be mixed in the mixing tank/container.

Required chlorine dose at injection point and FRC concentration at nearest street standpost to be maintained as per the Table No 1:

Table 1: Chlorine Dose Required at Injection Point for Different Pumping Conditions		
#	**Type of Pumping**	**Required Chlorine Dose (mg/L) at injection point**
1	Scheme with OHR	1.5
2	Direct Pumping	1.5
3	Boosting Station	0.5

Note:

1. *Since considerable reduction in chlorine content occurs within the OHR due to presence of considerable chlorine demand (presence of organic matter inside the reservoir), required chlorine dose has been fixed at 1.5mg/L at injection point for schemes with OHR.*
2. *In case of direct pumping, required amount of contact time is not achieved. Hence, to compensate contact time with higher concentration of FRC, the required chlorine dose has been fixed at 1.5mg/L.*
3. *Boosting pump station helps to compensate the residual chlorine content in supplied water which may have been significantly reduced in the distribution pipeline. Hence, the required chlorine dose at booster pumping stations has been fixed at 0.5 mg/L to maintain FRC at tail end of the distribution network.*

4) Preparation of Chlorine Liquid Solution

a. Solid (Pellets)

Generally, desired chlorine liquid conc. is kept between 1 - 5%; 1% or 2% which is sufficient if high test hypochlorite (HTH) is used for disinfection.

Formula:

$$Weight\ of\ disinfectant\ powder\ (gm) = \frac{[1000\ x\ Vol\ of\ Cl\ Liq\ required\ (L)\ x\ Desired\ Cl\ Liq\ Conc.\ (\%)]}{Active\ Cl\ conc.\ in\ disinfectant\ powder\ (\%)}$$

Steps:

a. Two tanks/containers of same capacities should be present in the pump house at different levels (as shown in the image 4).
b. In case of preparation of chlorine solution of required concentration from liquid chlorine, the above formula may be referred and calculated by presuming 1Kg = 1L.
c. Weight of disinfectant required may be calculated by using percentage of active chlorine as per manufacturer's specification or as determined by the laboratory using above mentioned formula.
d. Use Personal Protective Equipment before the commencement of work. Refer F,(Page No.16) "Safe Handling of Disinfectant".
e. While using chlorine pellets, required amount of chlorine tablets to be crushed before mixing.
f. Fill up the top tank with required amount of water. Mix thoroughly the determined grams of disinfectant with the water in the tank placed at higher level. The disinfectant as determined may be weighed following manufacturer's instruction or using any other suitable method, at site.
g. Chlorine solution should be kept overnight.

h. Supernatant from the upper tank is to be decanted in the morning to the lower tank by opening the stop cork fitted in the pipe connecting the two tanks. Supernatant from the tank at lower level should flow into the chlorinator.

i. Powdery residue or precipitate settling at the bottom should be cleaned at frequent intervals.

j. Chlorine liquid solution is ready to use for dosing.

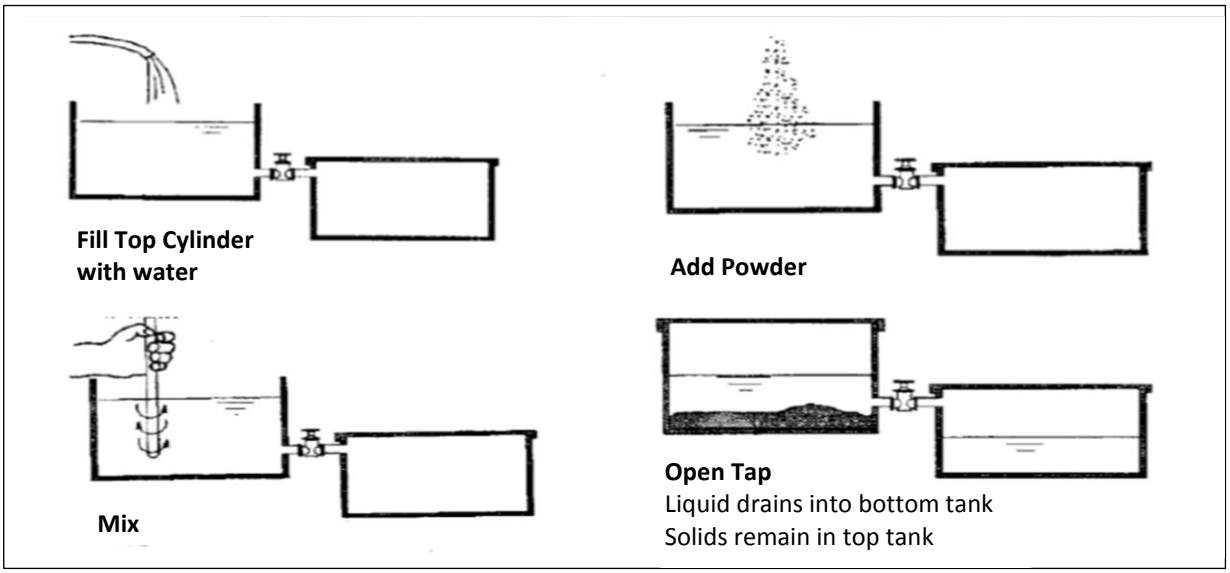


Image 4: Two-tank Chlorination

Box 5:

For example, if the volume of chlorine liquid required is 100 L, desired Chlorine liquid conc. is 1%, active chlorine conc. in disinfectant powder is 65%. Weight of disinfectant powder in gms will be: [1000 x 100 x 1]/65 = 1,538.4 gms of disinfectant will be required

For different types of pumping, the volume of chlorine liquid to be taken or amount of Chlorine pellet/Chlorine liquid required to prepare 1% / 0.5% / 0.25% / 0.1% chlorine solution for 100L tank has been ascertained and presented in table no 2 (Considering 65% Available Chlorine in pellets & 12% Available Chlorine in Liquid Chlorine and also 1Kg = 1Lit):

Table 2: Quantity of Disinfectant Required to Prepare Solutions of Varying Strengths

#	Percentage of Chlorine solution to be prepared (%)	Chlorine Pellets (65%)		Chlorine Liquid (12%)
		Wt to be taken (Kg)	Nos of pellets (considering 1 pellet = 19 gms approx.)	Vol to be taken (Lit)
1	1	1.54	81	8.33
2	0.5	0.77	40	4.17
3	0.25	0.39	20	2.08
4	0.1	0.15	8	0.83

5) Determination of Chlorine Dose Rate:

Chlorine Dose Rate is the rate at which the chlorinator pump is set to dose stipulated amount of chlorine solution to the supply system for disinfection.

$$Cl\ Dose\ Rate\ \left(\frac{ml}{hr}\right) = \left[\frac{Required\ Cl\ Dose\ \left(\frac{mg}{L}\right)\ x\ Treated\ water\ flow\ rate\ \left(\frac{m^3}{hr}\right) x\ 100}{Cl\ Liq\ Concentration\ (\%)}\right]$$

Box 6:

For example, if the required chlorine dose is 2.0 mg/l, treated water flow rate is 15000 litres per hour (which is 15 m^3/hr), chlorine liquid concentration (1%). So**,** the chlorine dose rate will be: (2.0 x 15 x 100)/1 = 3000 ml/hr

For different types of pumping for varying capacities of pump discharge, the Chlorine Dose Rate has been ascertained and presented in the following table (Considering 1%, 0.5%, 0.25% and 0.1% Chlorine solution):

Table 3: Varying Chlorine Dose Rates Based on Pump Capacity

#	Pump Capacity (Cum/Hr)	Chlorine Dose Rate (L/Hr)							
		For Boosting Station				For Schemes with OHR/Direct Pumping			
		For 1% Soln	For 0.5% Soln	For 0.25% Soln	For 0.1% Soln	For 1% Soln	For 0.5% Soln	For 0.25% Soln	For 0.1% Soln
1	10	0.5	1	2	5	1.5	3	6	15
2	20	1	2	4	10	3	6	12	30
3	30	1.5	3	6	15	4.5	9	18	45
4	40	2	4	8	20	6	12	24	60
5	50	2.5	5	10	25	7.5	15	30	75
6	60	3	6	12	30	9	18	36	90
7	70	3.5	7	14	35	10.5	21	42	105
8	80	4	8	16	40	12	24	48	120
9	90	4.5	9	18	45	13.5	27	54	135
10	100	5	10	20	50	15	30	60	150
11	110	5.5	11	22	55	16.5	33	66	165
12	120	6	12	24	60	18	36	72	180
13	130	6.5	13	26	65	19.5	39	78	195
14	140	7	14	28	70	21	42	84	210
15	150	7.5	15	30	75	22.5	45	90	225
16	160	8	16	32	80	24	48	96	240
17	170	8.5	17	34	85	25.5	51	102	255
18	180	9	18	36	90	27	54	108	270
19	190	9.5	19	38	95	28.5	57	114	285
20	200	10	20	40	100	30	60	120	300

6) Free Residual Chlorine (FRC): to be determined daily on field by DPD method

Steps:

a) Add 10ml of water sample into one cell; cap & Place it in the left side of colour comparator

b) Add 1 DPD No. 1 tablet to the other cell containing a small amount of water sample, crush tablet; fill sample till 10 ml mark

c) Cap and mix well by inverting the tube 2-3 times wait for a min for colour development

d) Place this cell in the right side of the comparator

e) Pink colour indicates presence of residual chlorine in water. Rotate the disc to match colour of the solution with the colour of the disc.

f) Value indicated against the shade which is closest to the sample colour is the residual free chlorine concentration (mg/L)

FRC at the nearest stand post to be maintained as per Table No 4.

Table 4: Required quantity of free residual to be maintained under different pumping conditions

#	Type of Pumping	Free Residual Chlorine (mg/L) at Nearest SSP	
		Minimum	Maximum
1	Scheme with OHR	0.5	1
2	Direct Pumping	0.5	1
3	Boosting Station	0.2	0.5

7) Determination of Total Chlorine: To be tested by DPD method

Total Chlorine is assessed to check if the breakpoint chlorination is achieved or not.

Steps

a) Follow steps a-f to test free residual chlorine in sample (as described above)

b) Add 1 DPD No. 3 tablet to the same cell, in which DPD No. 1 was added earlier.

c) Cap and mix well by inverting the tube 2-3 times wait for a min for colour development

Place this cell in the right side of the comparator

d) Pink colour indicates presence of residual chlorine in water. Rotate the disc to match colour of the solution with the colour of the disc.

e) Value indicated against the shade which is closest to the sample colour is the total chlorine concentration (mg/L).

8) Estimation of Detention Time

Detention time is the length of time water is retained in a tank (here it is OHR) of a specified volume. Detention time will vary depending on the volume of the OHR and treatment plant flow rate.

$$Detention\ Time\ (mins) = Volume\ of\ Storage\ Tank\ (m^3) \div Flow\ rate\ (m^3/min)$$

Box 7:

For example, **i**f the capacity of OHR is 120 M^3 and the plant flow rate is 15 M^3/ hr, then convert the flow rate in hour in to minutes. (Hour to Minutes: 15/60 = 0.25 M^3/min). Detention time = 120/0.25 = 480 mins or 8 hours

Image 5: OHR at Pump house of Baneshwar Water Supply Scheme, Coochbehar

E. Critical Points to be Considered Before Starting the Water Supply Daily:

a. Water to be pumped and stored in OHR (if present) the previous night, to save time during next day's supply
b. After the chlorine solution is prepared, dosing should be done for approximately 1 hour to prevent under dosing or over dosing.
c. A minimum of 30 minutes of detention time to be given prior to supply of chlorinated water.

Special conditions:

i. For all schemes (with OHRs or for direct pumping system), FRC is to be checked at the nearest SSP (should range between 0.5 mg/L – 1.0 mg/L), once the supply starts. If FRC conc. is found to be less than 0.5 mg/L, the OHR needs to be cleaned thoroughly.
ii. Even after cleaning the OHR, if FRC value shows less than 0.5 mg/L at the nearest SSP, required chlorine dose is to be increased from a value by which the residual chlorine falls short from 0.5 mg/L and accordingly chlorine dose is to be determined and adjusted.
iii. If FRC is within a range of 0.5 mg/L - 1.0 mg/L at the at the nearest tap connection point within headwork site/ SSP but shows values less than 0.2 mg/L in the designated farthest SSP, the pipeline should be thoroughly checked for any leakages and damages and residual chlorine at intermediate stand posts need to be tested also.
iv. If FRC is found to be more than 1.0 mg/L at nearest SSP or tap point at head work site (as applicable), the required chlorine dose to be decreased from a value by which the residual chlorine is found to be excess of 1.0 mg/L.

Box 8:

For example:

a. If the volume of top or bottom tank for preparing the HTH solution is 100 litres (V) and Available Chlorine in HTH is 65% (S) then the amount of HTH in gms (W) to be mixed with 100 litres of water, to prepare a solution of 0.25% strength is given as:

   Weight Required (gm) = (1000 x 100 x 0.25)/65 = 384.61 gm

b. If the pump extracting tube well water has a flow rate of 40 Cum/hr and required chlorine dose is 1.5 mg/L then Chlorine Dose Rate in mL/hr is given as
   Chlorine Dose Rate (ml/hr) = (1.5 x 40 x 100)/0.25 = 24000 ml/hr = 24 L/hr

F. Disinfectant Stock Management Practices

Safe Handling

Chlorine is a hazardous substance. Chlorine disinfection requires that water treatment plant staff work in contact with, and in proximity to, high strength forms of chlorine. Health and safety of staff is critical at all times. All staff in contact with chlorine should receive basic training on the dangers of chlorine, how to handle and store it safely and basic first-aid measures in the event of accidental contact.

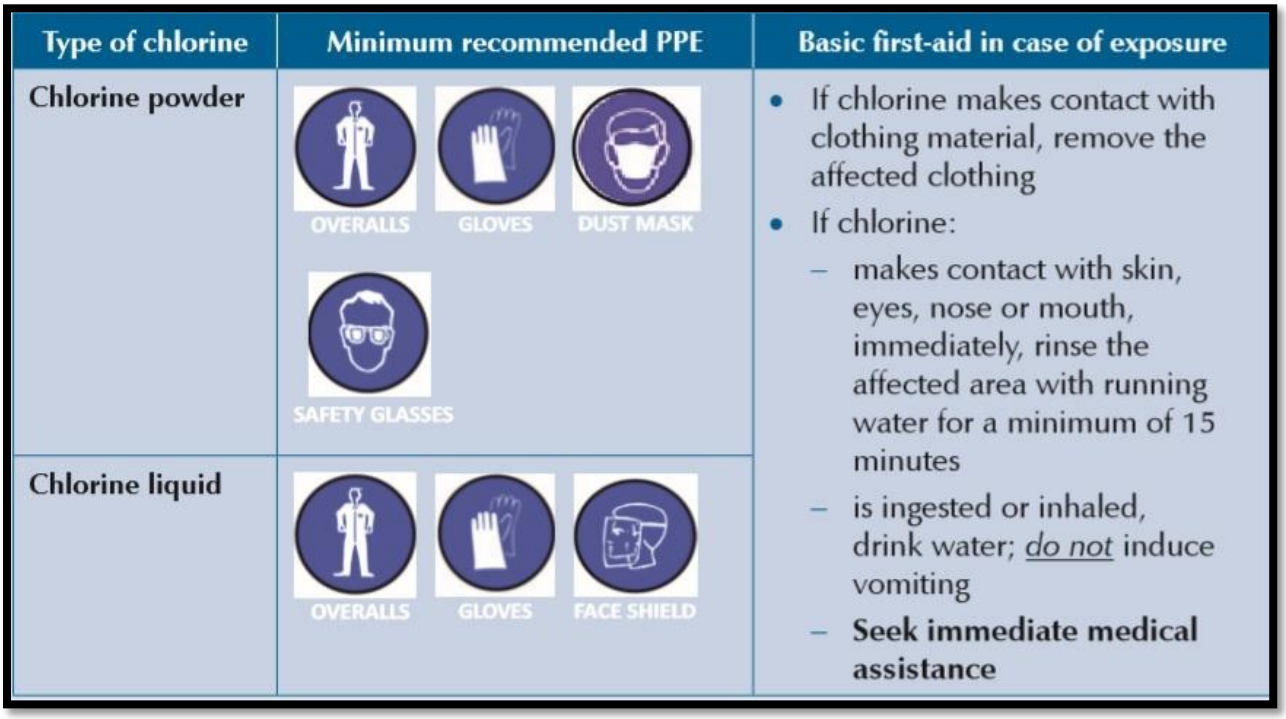


Image 6: Personal Protective Equipment and safety measures - sourced from Internet

Precautionary measures:

1. When handling concentrated chlorine solutions, appropriate precautions should be taken. Ideally, gloves and protective eye glasses should be worn. Avoid direct contact with skin. In the event of splashes and especially splashes to the eyes, it is important to immediately rinse thoroughly with clean (non-chlorinated) water.
2. When a disinfecting agent has to be transported under difficult conditions (for instance on foot), then solid forms (rather than hypochlorite solutions or pure chlorine in cylinders) are advantageous because they are less hazardous to handle. Although solid forms are generally less hazardous to handle, it is good practice to wash hands after handling.
3. All containers in which chlorine is stored should be labelled, identifying the contents and with a hazard warning in a form which is readily understood locally.
4. Storage sites for chlorine in any form should be secure against unauthorized access. Children or pets should be restricted from entering the premises unattended.

Proper Stock Storage Practices:

Over time, chlorine pellets and liquid will begin to degrade and lose strength. Rate of chlorine degradation may be accelerated through poor storage and stock management practices.

Table 5: Quantity of Available Chlorine

#	Type of Chlorine (approx. % of active chlorine concentration)		Loss of initial active chlorine concentration
1	Chlorine Pellets	High Test Hypochlorite (70%)	5-18 % after 40 days
2	Chlorine liquid	10 – 18%	The stability of hypochlorite solutions is adversely affected by heat, light, pH, and metal contamination. The rate of decomposition of 10% and 15% solutions nearly doubles with every 10°F rise in the storage temperature. Sunlight reduces the half-life of a 10%-15% hypochlorite solution by a factor of 3 to 5. If the pH of a stored solution drops below 11, decomposition is more rapid*

***Sourced from internet**

To minimize the rate and extent of chlorine degradation, appropriate storage conditions should be in place, which may be as follows:

- Always store in a cool, dry, dark and well-ventilated place;
- Store away from direct sunlight, excessive humidity and temperatures;
- Store in corrosion resistant containers (for example, light resistant plastic [poly vinyl chloride-PVC; high density polyethylene - HDPE]);
- Keep all storage containers fully sealed when not in use;
- Date and mark all stock upon receipt; and
- Use in first in, first out (FIFO) stock rotation principles (i.e, always using the oldest stock first)
- To minimize misuse and to monitor dosing of disinfectant, supply to be maintained in such a way that no excess stock should be present at the end of a particular month. Monthly requirement of stock may be calculated as per the following formula:

$$Monthly\ stock\ requirement\ (Kg)$$
$$= Chlorine\ Dose\ Rate\ \left(\frac{L}{Hr}\right) x\ Wt\ taken\ to\ prepare\ mother\ solution\ (Kg)\ x\ Supply\ Hour\ (Hr)\ per\ day\ x\ 0.3$$

Note: Weight has been calculated considering 100 litres of mother solution

For different pump capacities with different chlorine dose rate, a monthly stock requirement has been illustrated in Table 6, where 0.25% chlorine solution is fixed and schemes have OHR.

Table 6: Disinfectant Requirement for Varying Pump Capacities for Fixed Chlorine Dose Rate				
#	Pump Capacity (Cum/Hr)	Chlorine Dose rate (L/Hr) for 0.25% chlorine solution	Stock Requirement (Kg) per month for 8 hr of supply	Stock Requirement (L) per month for 8 hrs of supply
1	10	6	5.54	30.24
2	20	12	11.09	59.90
3	30	18	16.63	89.86
4	40	24	22.18	119.81
5	50	30	27.72	149.76
6	60	36	33.26	179.71
7	70	42	38.81	209.66
8	80	48	44.35	239.62
9	90	54	49.90	269.57
10	100	60	55.44	299.52
11	110	66	60.98	329.47
12	120	72	66.53	359.42
13	130	78	72.07	389.38
14	140	84	77.62	419.33
15	150	90	83.16	449.28
16	160	96	88.70	479.23
17	170	102	94.25	509.18
18	180	108	99.79	539.14
19	190	114	105.34	569.09
20	200	120	110.88	599.04

Note: Stock for a month to be procured to the nearest value of Kg/ Litre mentioned in the table. For eg. Chlorine dose rate of 6 L/Hr, pump capacity of 10 Cum/Hr, approx. 6 Kg of chlorine pellets may be procured. It may also be noted that % of Available Chlorine considered here is 65%, volume of chlorine liquid (mother solution) solution to be prepared is 100 litres per day.

Image 7: Inventory control methods - sourced from Internet

G. Housekeeping and pump house maintenance

Regular housekeeping and maintenance help ensure proper operationalization of the equipment and machinery at the pump house site. Thus, contributing to the longevity of the piped water supply scheme.

- Room housing all types of pumping machinery needs to be kept clean at all times
- Unwanted, empty bottles/ containers etc. should be removed from the pump house premises
- Bleaching powder, broom and other necessary cleaning equipment should be made available at the pump site
- Floor, ceiling, paint on walls, doors and windows should be in good condition
- Stairs leading to the reservoir must be kept in good condition; necessary checks to be done every month
- Regular maintenance checks of the machinery installed at pump site should be carried out as per schedule
- OHRs should be cleaned atleast once in 3 months and communities to be notified accordingly
- Pump house premises should be cleared off weeds and unwanted dense vegetation to discourage entry of cattle, strays and reptiles (if any)
- Necessary pest control measures to be taken within the pump house in case the area is prone to rodents or any other pests

Image 8: Pump house at Purba Durlavpur Water Supply Scheme, Uttar Dinajpur

H. Disaster Preparedness

Disaster preparedness helps in minimizing the impact of the disaster and managing the damage caused by it, thus, reducing the load on response to restore routine operations.

- Identify natural disasters that frequently occur in your area
- Train pump operators and valve operators on disaster preparedness and response mechanism
- Emergency contact numbers (Ambulance/Health Facility/Police Station/O&M Agency/GP Pradhan/Junior Engineer) to be displayed at the pump house site
- Consult with the concerned PHE Division and take necessary action based on the instructions given before, during and after the disaster has occurred
- Prepositioning of stock of chlorine tablets to avoid contamination or epidemic outbreak.
- Keep contingency stock of chemical and spares at all times
- Ensure all electrical equipment are SWITCHED OFF during the time of disaster and SWITCHED ON only after necessary instructions are received from the appropriate authority
- Voltage stabilizer and other electrical equipment should be placed above floor (at a height of 1 foot or as deemed appropriate) to avoid contact with water in the event of flooding
- A spout should be installed at the headwork site to dispense treated water from OHR during the time of emergency
- Prepare a checklist for the operators at each pump house site on “Do’s and Don’ts” with respect to different disasters (specific to the area being considered)
    - Checklist to be shared with the operators
    - Checklist to be displayed inside each pump house site
- Operators to be trained on specific “Do’s and Don’ts” for the type of disaster that occurs in identified vulnerable pockets
    - Mock drill may be conducted once every year

Image 9: Steps of disaster prepared ness – sourced from Internet

I. Super-Chlorination[12]

Definition

Super-chlorination is a water treatment process in which the addition of excess amounts of chlorine to a water supply to speed chemical reaction to ensure disinfection within a short contact time.

Super-chlorination, also known as hyperchlorination, temporarily increases the free chlorine residual in a water distribution system.

Super-chlorination provides a chlorine residual of **3.0-5.0 mg/L,** 10 times the recommended minimum breakpoint chlorine concentration. Retention time for super-chlorination is approximately 10 minutes.

Super-chlorination should be followed by de-chlorination

When to undertake super-chlorination

Super-chlorination may be carried out under the following circumstances:

1. As part of the commissioning process for new water supply infrastructure
2. For remediation of affected infrastructure following a natural disaster (like cyclones or floods etc.) or other microbial hazard that has been assessed as being of high risk to the local community
3. Based on the complexity of the distribution network in areas where biofilm growth is suspected (e.g. low flow pipe sections), on a scheduled basis (e.g. every six months or as and when required).

Steps

Main steps for super-chlorination should meet the following criteria:

- Ensure all appropriate safeguards are in place before commencing super-chlorination.
- Dose chlorine solution so as to obtain a free chlorine residual of at least 5 mg/L at each downstream sample location, and maintain the residual continuously and at a reasonable rate of water flow for at least 5 minutes. This may require dosing of chlorine at a level much greater than 5 mg/L for a long duration until the distal outlets are able to reach a consistent, measurable residual of 5 mg/L. (Note that the permissible limit for chlorine in drinking water is 1.0 mg/L according to IS 10500: 2012 Drinking Water Specifications. Therefore, no water with chlorine above this level should be supplied)
- Once a residual of 5 mg/L is reached at the furthest point in the water distribution system, and is maintained for at least 5 minutes in free-flowing water, keep this elevated level of chlorine held within the piping system for at least 2 hours by shutting off all taps.
- Following this duration of at least 2 hours, flush the system to remove the high chlorine solution.
- Repeat the above chlorination a minimum of 2 times (3 total cycles of treatment are recommended).
- All affected outlets are to be flushed following this practice.
- After completion, it is highly recommended that the piped water supply scheme maintains the recommended residual level of chlorine in supplied water
- Super-chlorinated water can be quite aggressive (potentially causing lead and copper to be released into the water from pipes and fittings) and so, the infrastructure, especially those older than 20 years,

[1] https://www.health.qld.gov.au/public-health/industry-environment/environment-land-water/water/risk-management/plan/manage/superchlorination

[2] https://www.water-research.net/index.php/water-treatment/tools/chlorination-of-water

pipes should be checked to ensure it is in an acceptable operating condition and free of excessive corrosion or wear. If it is not in good condition super-chlorination may not be suitable and alternative approaches to sanitation should be explored.

COVID-19

As per the advisory issued by Ministry of Health and Family Welfare, Govt. of India, *to ensure safe drinking water during lockdown and for effective management of pandemic caused by Corona virus, there is an urgent need to ensure availability of safe water particularly in rural areas where medical sanitizers may not be available.*

Public Health Engineering Departments/ Boards / Nigams of the State Governments need to accord top priority for taking measures to augment supply in areas where water supply may be deficient as of now and special care may be given to vulnerable sections of the society like people residing in relief camps, places of quarantine, hospitals, old age homes, poor strata of society, slums, etc. It will be appropriate to integrate the identified needs of potable water in the micro-plans of the districts being formulated to combat the spread of COVID-19 disease.

CDC has reported that there is no evidence showing anyone has gotten COVID-19 through drinking water, recreational water, or wastewater. The risk of COVID-19 transmission through water is expected to be low. However, considering studies are still being conducted to understand the nature of virus and its different routes of transmission, it is prudent to follow standard procedure to maintain sufficient residual chlorine in piped water supplies. IS 10500: 2012 Drinking Water Specifications states that when protection against viral infection is required, free residual chlorine should be minimum 0.5 mg/l at the farthest (consumer) end.

J. Roles and Responsibilities:

Defined roles and responsibilities provide clarity, alignment, and expectations to those executing the work and keeping PWSSs running in good condition. Roles and responsibilities also enable effective communications among officials, agencies and field level operators.

i. Assistant Engineer (Mechanical /Electrical Division)

- To visit the pump house site at least once every month to monitor operations at the pumping site
- To ensure necessary mechanical and electrical equipment required at the pump house are supplied and properly fitted at the pump house site
- To ensure uninterrupted, sufficient and timely supply of high-quality disinfectant with high strength of available chlorine for disinfection
- To facilitate assessment of % of available chlorine in disinfectant and chlorine demand of pumped water (ground water before chlorination – direct pumping system, non-chlorinated water after OHR – at headwork site) at the nearest rural water testing laboratory managed by PHED as per the frequency mentioned earlier in the document
- To provide residual chlorine kits that can determine both free and total chlorine in chlorinated piped water supplied from pump house
- To ensure supply and availability of chemicals required to test free residual and total chlorine

ii. Assistant Engineer (Civil Division)

- To visit the pump house site at least once every month to monitor operations at the pumping site
- To ensure the OHRs are cleaned at regular intervals and maintenance checks are carried out by the concerned agency as per the scheduled frequency
- To ensure all valves are in good condition for a daily uninterrupted water supply and maintenance checks are carried out by the concerned agency as per the scheduled frequency
- To coordinate and facilitate assessment of % of available chlorine in disinfectant (Disinfectant) and chlorine demand of pumped water (ground water before chlorination – direct pumping system, non-chlorinated water after OHR – at headwork site) at the nearest rural water testing laboratory managed by PHED as per the frequency mentioned earlier in the document

iii. Junior Engineer - Civil Division/ Mechanical Division

- To visit the pump house site at least once every month to monitor operations at the pumping site
- To coordinate, facilitate and ensure determination of chlorine demand of raw water and % of available chlorine in the disinfectant at the nearest at the nearest rural water testing laboratory managed by PHED as per the frequency mentioned earlier in the document

- Chemist of the nearest laboratory (managed by PHED) should collect water and disinfectant samples and determine chlorine demand and % of available chlorine respectively in the presence of the concerned Junior Engineer and District Consultant.
- Based on the variations in chlorine demand and % of available chlorine Junior Engineer should modify the chlorination dose without compromising the ultimate

iv. Pump Operator

b) To follow all necessary instructions given by the appropriate authority
c) To ensure proper chlorination of water before it is supplied daily
d) To check FRC conc. at the nearest SSP
e) To maintain and update all required registers, log books mentioned in the SOP
f) To ensure supply of water as per daily schedule
g) To inform concerned agency/ officials (Junior Engineer) at least 15 days before the stock gets exhausted
h) To promptly inform concerned agency/ official (Junior Engineer) in case of any emergency

Image 10: Sourced from Internet

ANNEXURES

ANNEXURE I

Instructions to Pump Operators

Step 1

- Determine weight of HTH (gm) of strength S (%) to be mixed in "V" (L) volume of tank or container to prepare 1% solution/ the required % of solution as per the pump capacity and requirement
- W (g) = 1000V x 1/S

Step 2

- Mix the quantity in upper tank and allow the supernatant to decant into the tank at the bottom.

Step 3

- Adjust Chlorine dose rate , q = 100 x 1.5 x Q. (Concerned JEs/AEs may assist) where q = pump flow rate (m^3/Hr) and Q = Cum/Hr

Step 4

- Determine FRC content of water collected from the nearest SSP/ tap point within pump house premises.

Step 5

- If the FRC concentration is found a less than 0.5mg/L at the nearest SSP then the OHR should be cleaned.
- In event of FRC still showing a value less than 0.5 mg/L, the dosage is to be increased from above by a value by which **FRC** falls short from 0.5 mg/L. Accordingly (q) is to be determined and adjusted.

ANNEXURE II

Documentation

Formats for registers and log books to be maintained at the pump house site

Every pump house site should have the following registers and log books to ensure proper operationalization of the scheme.

- Attendance Register
- Chlorination Register
- Pump Operation Log Book
- Water Supply Log Book
- Chemical Stock Register
- Register for Water Quality Test Results
- Maintenance Register
- Visitor Register
- Miscellaneous Register

Pump operators are required to maintain above mentioned documents as per the designated frequency. In addition to these, any receipt/ challan / manual pertaining to chemicals or equipment may be kept in a file separately.

i) Attendance Register (Daily)								
#	Name	Designation	Date DD/MM/ YYYY	Arrival (Time)		Departure (Time)		Signature
				Morning	Evening	Morning	Evening	

ii) Chlorination Register (Daily)							
a. Disinfectant Dose							
#	Date: DD/MM/YYYY	Tubewell No.	Weight of disinfectant added (gms)	Volume of tank (Litres)	Chlorine Dose Rate (Lit/hr)	Name of the Operator	Signature

b. Chlorine Demand and % of Available chlorine (Quarterly)								
#	Rural Water Testing Laboratory	Date: DD/MM/YYYY	Chlorine Demand (mg/L)	Batch No./ Lot No.	Disinfectant container opened on: DD/MM/YYYY	% of available chlorine (manufacturer's specification)	% of Available Chlorine (actual)	Signature

iii) Pump Operation Log Book (Daily)						
a. Submersible Pump						
#	Date: DD/MM/YYYY	Tubewell No.	Time (HH/MM) AM/PM		Name of the operator	Signature
			Start	Stop		

iv) Water Supply Log Book (Daily)								
#	Date: DD/MM/YYYY	Pump House No.	Tubewell No.	Time (HH/MM) AM/PM		Duration (Hrs/ Mins)	Name of the operator	Signature
				Start	Stop			

v) Chemical Stock Register (Monthly – to be filled on the last day of the month)									
#	Chemical name	Quantity (Kg)	Opening Stock (No. of bottle)	New stock (Nos)	Expired Stock (Nos)	Running stock (Nos)	Stock Consumed (Nos)	Closing Stock (Nos)	Signature

vi) Register for Water Quality Test Results (as per the mentioned frequency)										
a. Raw water (Pre-Monsoon)										
#	Date	Tubewell No.	Water Quality Parameters							Signature
			PH	Turbidity (NTU)	Total Arsenic (mg/L)*	Total Iron (mg/L)	Manganese (mg/L)	Total Coliform (CFU/100 ml)	*E. coli* (CFU/100 ml)	

*if applicable

b. Treated water Post-Monsoon -After disinfection/After polishing unit* (as per the mentioned frequency)											
#	Date	TW No.	Water Quality Parameters								
			pH	Turbidity (NTU)	Free Residual Chlorine (mg/L)	Total Arsenic (mg/L)*	Total Iron (mg/L)	Manganese (mg/L)	Total Coliform (CFU/100ml)	*E. coli* (CFU/ 100ml)	Signature

c. Supplied water from any nearby SSP							
#	Date	SSP location	Free Residual Chlorine (mg/L)	Total chlorine (mg/L)	Total Coliform (CFU/100ml)	*E. coli* (CFU/100ml)	Signature

*if applicable

Note: Test results shared by the concerned water testing laboratory to be updated.

vii) Maintenance Register							
a. Civil Faults (to be updated as and when required)							
#	Date and time of detection of fault	Type of fault	Date of repair	Name of the equipment	Details (Fault repair done; parts/instruments fitted/ replacement information/ parts or instruments rejected etc.) (To be filled by Technician)	Repair done by	Signature
b. Electromechanical Faults (to be updated as and when required)							
#	Date and time of detection of fault	Type of fault	Date of repair	Name of the equipment	Details (Fault repair done; parts/instruments fitted/ replacement information/ parts or instruments rejected etc.) (To be filled by Technician)	Repairing done by whom	Signature

viii) Visitor Register (to be updated as and when required)								
#	Name & Designation	Department / Institution	Purpose of visit	Date	Arrival Time	Departure Time	Remark	Signature

ix) Complaint Register									
#	Name	GP	Village	Habitation	Date of Complaint	Nature of complaint	Action taken	Time taken for redressal	Remark

x) Miscellaneous Register					
#	Particulars	Date of cleaning	Date of next cleaning	Remarks	Signature
1	Cleaning of overhead tank				
2	Cleaning of Clear Water Reservoir				
3	Change of media (Activated Alumina/GFH/ Any Other) *				

***if applicable**

ANNEXURE III

- **Details of Tubewell and pump to be displayed on the walls:**

Name of the piped water supply scheme
Pump House, Tubewell No. __, Tubewell Depth __,
Aquifer location: ft
Gram Panchayat
Block
District
Scheme Coverage: No. of Villages (Names)

Capacity of Submersible Pump (HP): __ HP /Head: __ Mtr / Flow: __ LPM
Elevated Service Reservoir Capacity (M^3): ___ M^3
Chlorine Dose: ___ mg/L

Total no. of stand posts: _____
Total no. of functional household tap connection: _____

Hours of supply

- Morning: 00:00 AM – 00:00 AM
- Afternoon: 00:00 PM – 00:00 PM
- Evening: 00:00 PM – 00:00 PM

Daily Water Supply Hours: **_ hours**

	Commencement	**Completion**
Work:	**DD/MM/YYYY**	**DD/MM/YYYY**
Maintenance Period:	**DD/MM/YYYY**	**DD/MM/YYYY**

Operation & Maintenance Agency: Name

Sanctioned Cost of the Scheme (in Rupees): _____
5 Year Maintenance Cost (in Rupees): _____
Augmentation Cost (in Rupees): _____
Rejuvenation Cost (in Rupees): _____

Work executed by: _____ **Division, PHE Dte., Govt. of West Bengal**

ANNEXURE IV

Determination of FRC in chlorinated sample using different commercially available chlorine testing kits

a. Aquasol – Free Chlorine (DPD) Test Kit; Range: 0.1 – 2.0 mg/L

a) Take 10 ml of water sample to be tested in the test jar
b) Add one spoonful (provided with the kit) of FC 1 to the sample water
c) Mix the contents well to dissolve and wait for a few seconds
d) If pink colour does not develop then free chlorine is absent
e) If pink colour appears, free residual chlorine is present
f) Now drop wise add FC 2 counting the number of drops while mixing, until the pink colour disappears

b. Checkit Comparator Kit (Lovibond); Range: 0.0 – 2.0 mg/L

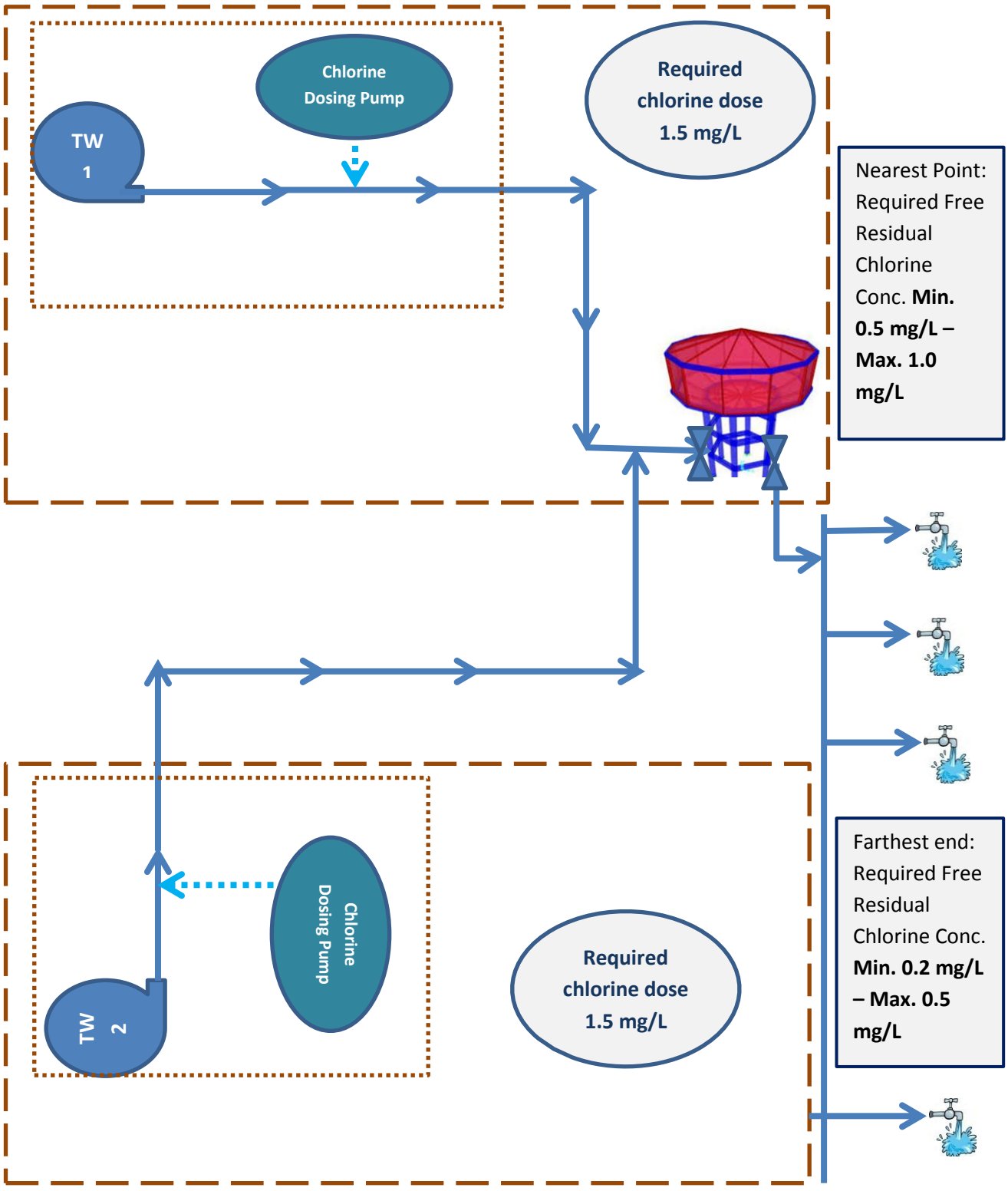
a) Measure 5 ml of reagent solution into a measuring cylinder made of glass (of capacity 100 ml)
b) Add 50 ml of water taken from the beaker
c) Mix the solution gently
d) Allow to stand for one minute (for the reaction to occur)
e) Compare the colour of solution with the colour chart on the surface of the bottle
f) Value indicated against the shade which is closest to the sample colour is the residual free chlorine concentration (mg/L)

It may be noted that DPD method is widely used for determining Free and Total Chlorine in chlorinated samples.

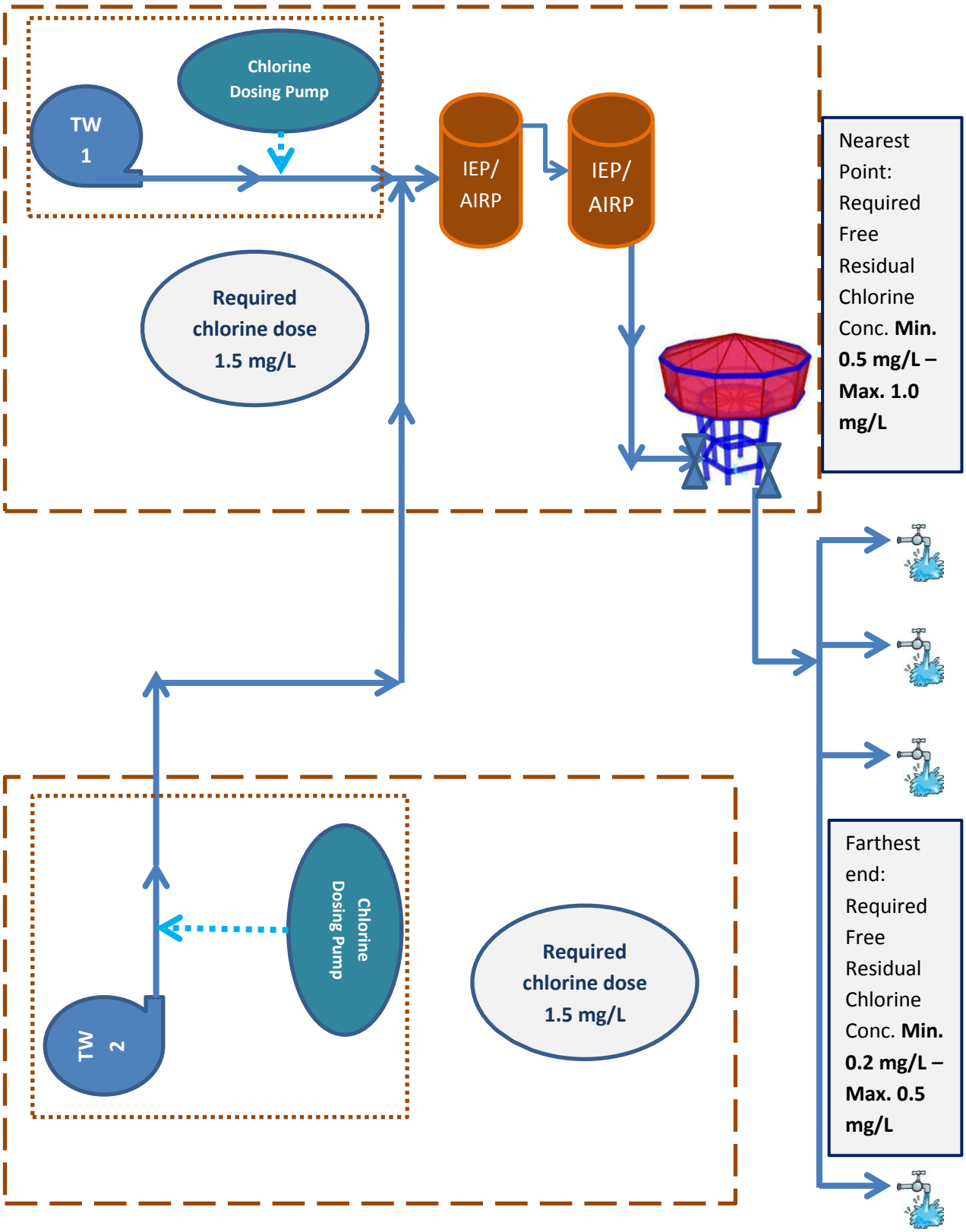
ANNEXURE V

Piped Water Supply Scheme Schematics

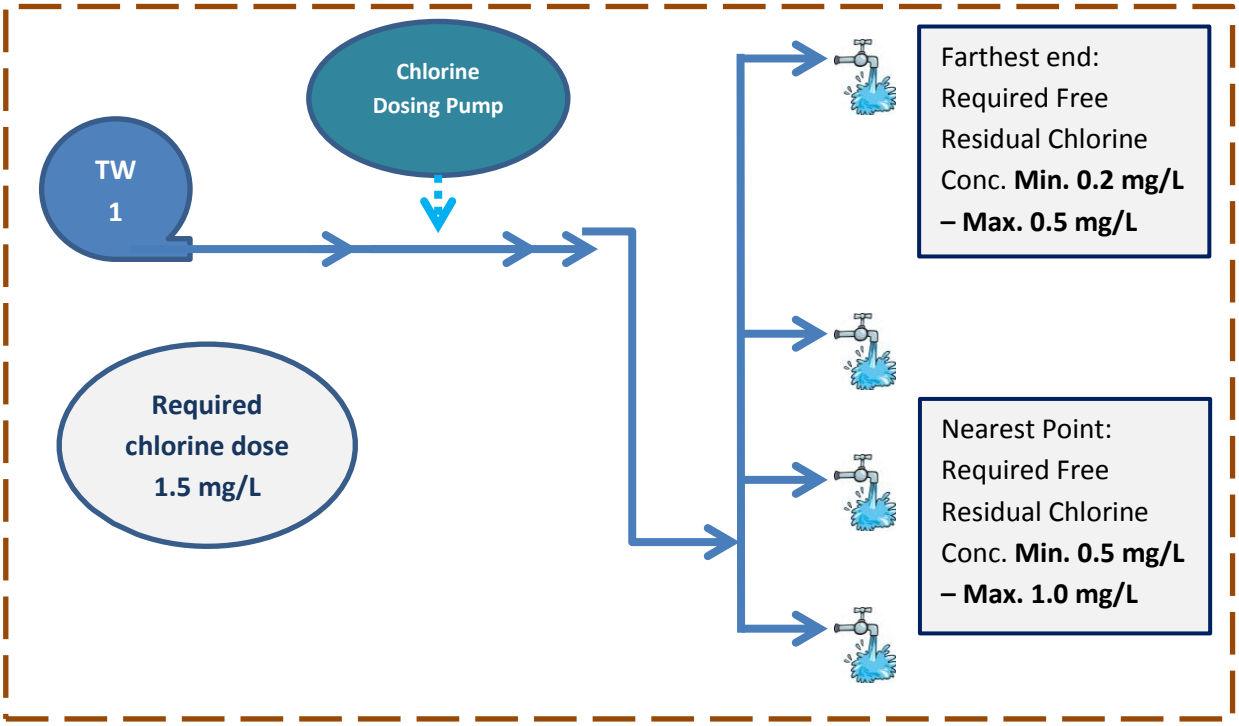
I. Groundwater based piped water supply scheme - single zone, multiple tubewells and also has OHR, water from all operational tubewells get collected in OHR.



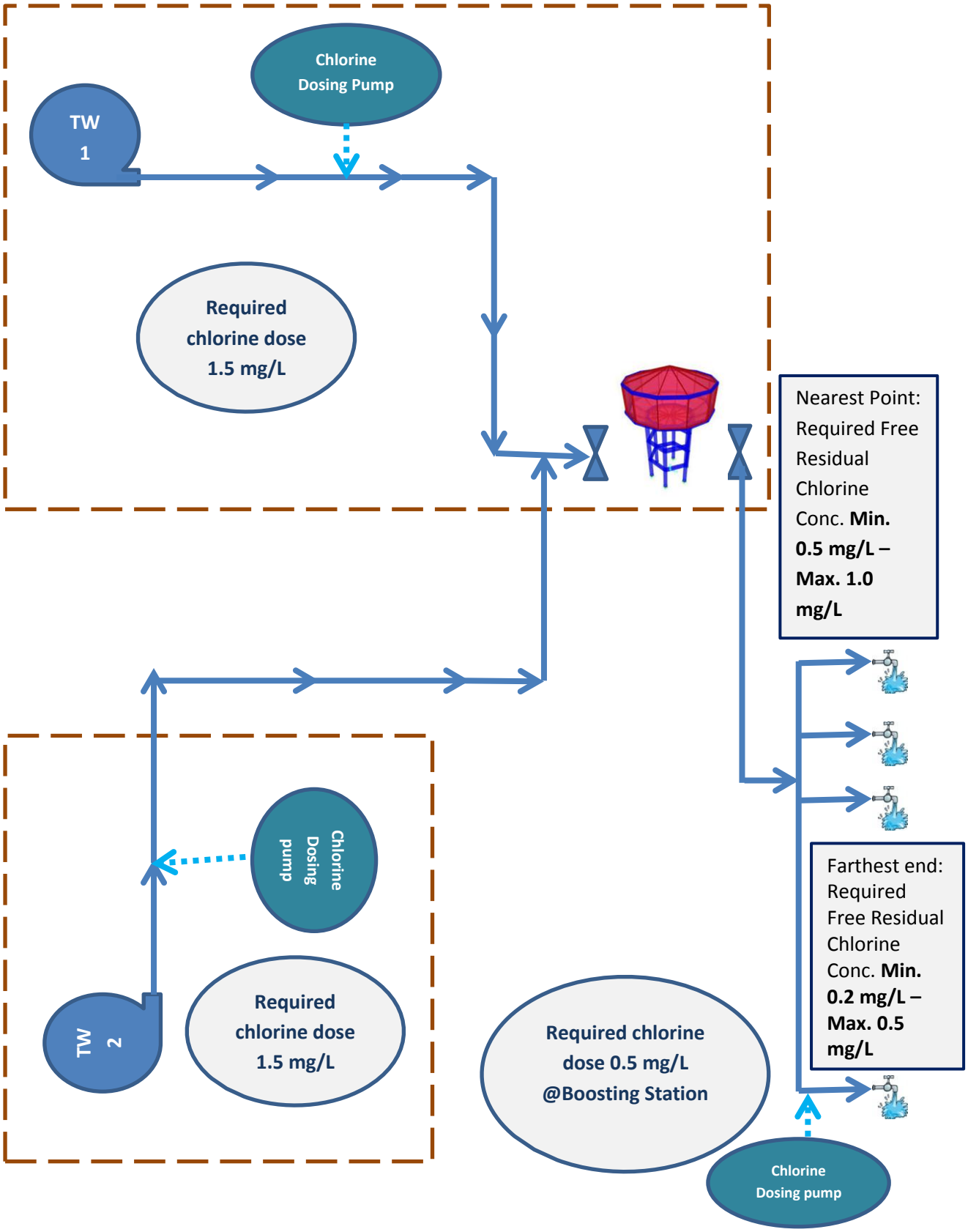
II. Groundwater based piped water supply scheme - single zone, multiple tubewells and also has OHR, with IEP/ AIRP, water from all operational tubewells gets treated in IEP/ AIRP and then collected in OHR



III. **Groundwater based piped water supply scheme (Direct Pumping) - single zone, single tubewell, water from one operational tube well gets supplied.**



IV. Groundwater based piped water supply scheme - single zone, multiple tubewells with boosting station



Glossary

Definitions and Equations:

a. **Chlorination**[3]

Chlorination is the process of adding chlorine to drinking water to disinfect it and kill germs. Different processes can be used to achieve safe levels of chlorine in drinking water. Chlorine is available as compressed elemental gas, sodium hypochlorite solution (NaOCl) or solid calcium hypochlorite ($Ca(OCl)_2$

b. **Breakpoint Chlorination**[4]

The type of chlorine dosing normally applied to piped water supply systems is referred to as breakpoint chlorination. Sufficient chlorine is added to satisfy all of the chlorine demand and then sufficient extra chlorine is added for the purposes of disinfection. Figure 1 shows the breakpoint chlorination curve. It indicates the effect of adding more chlorine to water which contains an initial ammonia nitrogen content of 1mg/l.

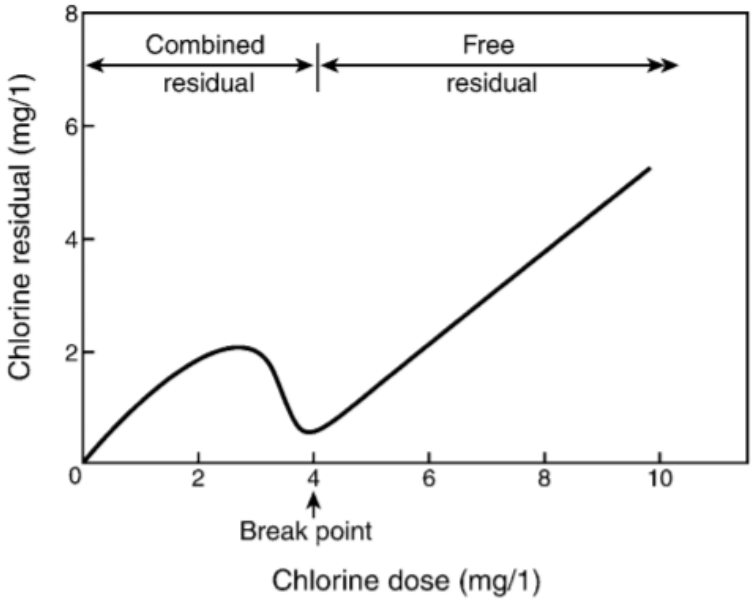


Image 11: Breakpoint chlorination diagram taken from Tebutt T.H.Y., 1992

The initial rise in residual is predominantly monochloramine (combined chlorine residual). The subsequent fall with further addition of chlorine is due to the decomposition of monochloramine to form nitrogen (the chlorine detected in this phase is also combined residual). Finally, the oxidation of ammonia is complete and any additional chlorine will cause an equal increase in the free chlorine residual.

c. **Available Chlorine: (Refer page 6)**

Available Chlorine is the measure of oxidising powder of the chlorine present as hypochlorite. It is expressed in terms of chlorine with a gram-equivalent weight of 35.46. It is expressed in percentage by weight.

Available Chlorine is analysed by Iodometric titration method IS 1065 (1989), IS 11673 (1992)

[3] https://www.cdc.gov/healthywater/drinking/public/chlorine-disinfection.html

[4] https://www.who.int/water_sanitation_health/dwq/S13.pdf

d. **Chlorine Demand: (Refer page 8)**

Chlorine demand is the difference between the amount of chlorine added to water and the amount of residual chlorine left after disinfection. (*Refer Annexure I, Point no. 2*)

$$Chlorine\ Demand\ (mg/L) = Actual\ Chlorine\ Dose\ (mg/L) - Free\ Residual\ Chlorine\ (mg/L)..[1]$$

Where Actual Chlorine dose is the amount of chlorine added in water.

e. **Free Residual Chlorine (FRC): (Refer page 13)**

Free Residual Chlorine is the total concentration of Hypochlorous Acid and Hypochlorite ions present in the water after breakpoint chlorination has been achieved.

Free Residual Chlorine is analysed through Visual Comparison method using DPD tablets

f. **Total Chlorine: (Refer page 13)**

Total Chlorine is the sum of Combined Chlorine and free chlorine. In all instances, the level of total chlorine is always above or equal to free chlorine levels. Measurement of Total Chlorine indicates if break point chlorination has occurred.

Total Chlorine is analysed through Visual Comparison method using DPD tablets

g. **Detention Time: (Refer page 14)**

Detention time is the length of time water is retained in a tank (here it is OHR) of a specified volume. (*Refer Annexure I, Point no. 8*)

$$Detention\ Time\ (mins) = Volume\ of\ Storage\ Tank\ (m^3) \div Flow\ rate\ (m^3/min)$$..... [2]

h. **Required Chlorine Dose: (Refer page 9)**

It is the amount of chlorine dose to be maintained that takes into account the chlorine demand (if any) and the required residual chlorine to be maintained in the supplied water.

$$Required\ Chlorine\ Dose\ \left(\frac{mg}{L}\right) = Chlorine\ Demand\ \left(\frac{mg}{L}\right) + Required\ Residual\ Chlorine\ \left(\frac{mg}{L}\right)..\ [3]$$

i. **Preparation of Chlorine Liquid Solution: (Refer page 10)**

$$Weight\ of\ disinfectant\ powder\ (gm) = \frac{[1000\ x\ Vol\ of\ Cl\ Liq\ required\ (L)\ x\ Desired\ Cl\ Liq\ Conc.\ (\%)]}{Active\ Cl\ conc.\ in\ disinfectant\ powder\ (\%)}$$

..... [4]

j. **Chlorine Dose Rate: (Refer page 12)**

Chlorine Dose rate is the rate at which the chlorinator pump is set to dose stipulated amount of chlorine solution to the supply system for disinfection.

$$Cl\ Dose\ Rate\ \left(\frac{ml}{hr}\right) = \left[\frac{Required\ Cl\ Dose\ \left(\frac{mg}{L}\right)\ x\ Treated\ water\ flow\ rate\ \left(\frac{m^3}{hr}\right)\ x\ 100}{Cl\ Liq\ Concentration\ (\%)}\right]$$

.....[5]

I. **CT Value:**

The contact time must be considered in conjunction with the chlorine concentration and other factors, to ensure that effective disinfection of drinking water occurs – this is referred to as the Ct concept for disinfection. The Ct value is the product of the chlorine concentration (C) and the contact time (t) with the drinking-water. **To ensure adequate disinfection, the WHO recommends a minimum Ct value of 15 min. mg/L for disinfection when the pH of the water is <pH 8.**

$$Ct\ \left(min.\frac{mg}{L}\right) = Free\ Residual\ Chlorine\ \left(\frac{mg}{L}\right)\ x\ Contact\ Time\ (\text{Min})$$

Notes

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unicef
for every child

Public Health Engineering Department
Government of West Bengal