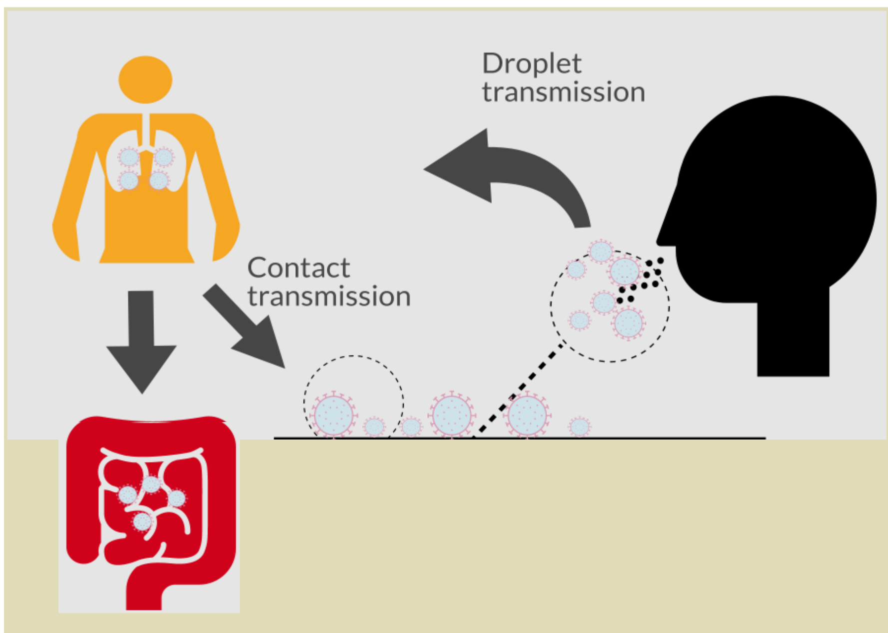
DISINFECTION TECHNIQUES FOR

WATER UTILITIES



PAKISTAN WATER OPERATORS NETWORK

(March-2022)

PREFACE

On behalf of All water utilities in Pakistan PWON is thankful to JICA for providing Support for ***Management of Water & Sanitation Services in Punjab against Covid-19*** through which lectures / webinars were arranged January 2022, to end March 2022, for ***Better Management of Water & Sanitation Services during Outbreak*** as well *as* ***Awareness & Preventive Measures against Covid-19*** *and* ***Preparation of in house Disinfection by Water & Sanitation Utilities*****.**

On demand of PWON members, lectures for capacity building of utilities in Pakistan about various important technical topics were also added along with above lectures / webinars / seminars. All these events were well participated and appreciated by all utilities

On demand of member utilities PWON has published these lectures for capacity building and references for improvement of their day to day working for the benefit of their consumers at large. This book on the topic of **PREPARATION OF IN HOUSE DISINFECTION BY W&S UTILITIES** is published by PWON for the benefit of all its members.

PWON is thankful to Capt. (R) Muhammad Hafeez for Preparing this valuable document.

(Syed Zahid Aziz)
CHAIRMAN
PWON, Pakistan

INDEX

1.DISINFECTION

- Disinfection is the process to kill or inactivate microorganisms to acceptable level in water, including essentially all pathogenic organisms.
- Pathogenic organisms: Three categories of human enteric pathogens are of concern in drinking water.
- These are bacteria, viruses, or cysts that can cause disease in a host.

1.2 MAIN DISINFECTION METHODS

- Chlorination
- Ozonation
- UV disinfection

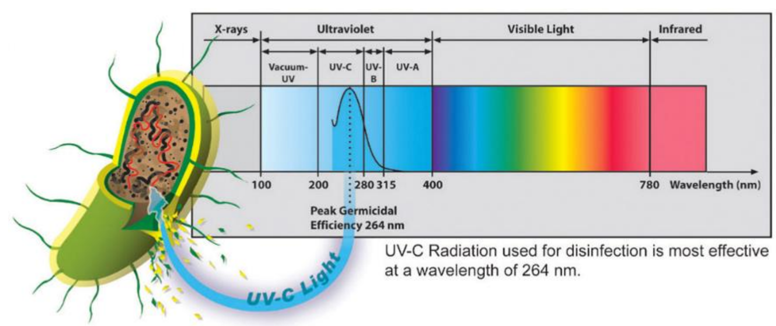
1.3 OZONATION (O_3)

- Ozone is the most powerful oxidizing and disinfecting agent.
- Requires the shortest contact time and lowest dosage (0.2-1.0 ppm for virus and bacteria).
- Because ozone does not produce a stable residual it is frequently followed by chlorination to produce a residual disinfectant.
- The cost of treatment is relatively high, being both capital and power-intensive

1.4 Limitation of Ozone

- Ozone is very reactive and corrosive, thus requiring corrosion-resistant material, such as stainless steel.
- There are chances of potential production of ozone byproducts that's why the U.S. Environmental Protection Agency strongly discourages the use of ozone system, if the upstream water treatment processes do not include filtration.
- The presence of TOC concentrations above 2 mg/L favors selection of a primary disinfectant that will not produce DBPs.

1.5 UV Technology for disinfection

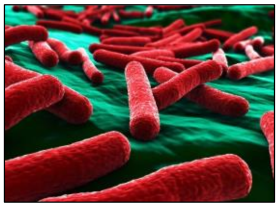


- It is a physical treatment, chemical-free process that adds no chemicals to the water.
- UV doesn't add color, odor, taste or flavor to the water and doesn't generate harmful by-products.
- The UV light penetrates the outer cell wall of the microorganism, passes through the cell body, reaches the DNA (deoxyribonucleic acid) and alters the genetic material

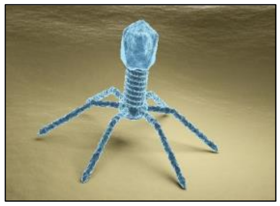
1.6 Chlorine

- Chlorine is the most common disinfectant used in the world. (Both liquefied and gaseous fractions).
- Sodium hypochlorite (NaOCl), also known as bleach, is a liquid form.
- Calcium hypochlorite ($Ca(OCl)2 \cdot 4H2O$), also known as HTH®, is sold as a granule, powder, and tablet.
- When chlorine is added to water, a mixture of hypochlorous acid (HOCl) and hydrochloric acid (HCl) is formed.
- This reaction is pH dependent and essentially complete within a very few milliseconds.

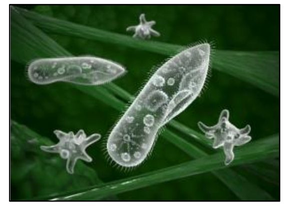
1.7 Relative effectiveness of chlorine



BACTERIA



VIRUSES



PROTOZOA

MOST EFFECTIVE → LEAST EFFECTIVE

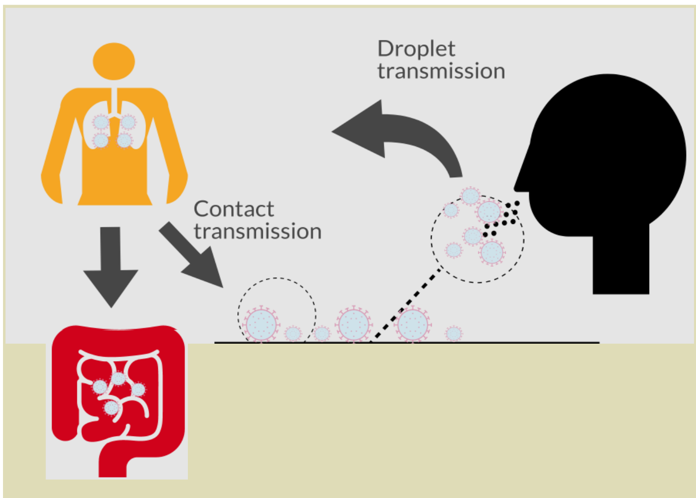
1.8 Advantage of chlorine over other disinfectants

- Most disinfection methods kill micro-organisms effectively but do not provide any protection against recontamination further along the supply system.
- Chlorine has the advantage of being both an effective disinfectant and its residual can protect the supply downstream from the disinfection point.

2.COVID-19 Transmission

Two main routes of transmission of Covid-19:

- Respiratory droplets coughs or sneezes
- Personal Contact



2.1 THE COVID-19 VIRUS SURVIVAL ON SURFACES

- It is not certain how long the virus that causes COVID-19 survives on surfaces, but it seems likely to behave like other coronaviruses.
- A recent review of the survival of human coronaviruses on surfaces found large variability, ranging from 2 hours to 9 days.
- The survival time depends on a number of factors, including the type of surface, temperature, relative humidity and specific variant of the virus.

3.Essential critical workers of water Utilities

- Operational staff at water Utilities.
- Operational staff at wastewater treatment facilities.
- Workers repairing water and wastewater conveyances.
- performing required sampling or monitoring, including field staff.
- Chemical and equipment suppliers to water and wastewater systems.

3.1 Water & Sanitation Utilities Main Challenges

1. Protecting the water supplies
2. Low access, reliability, and the quality of water and sanitation present risks in developing countries.
3. Protecting the health of workers.
4. Operations could be affected by the increased risk of contagion among utility staff, including both routine operations and construction works.

3.2 Issues of Water Utilities relating Covid-19

Water utilities in developing countries are confronted with various issues:

- infection prevention measures for employees and customers,
- continuation of services.
- revenue reduction due to the decline of water demand from economic stagnation and increase of non-payment.
- sustainability of water supply as an essential service.
- Suffering of tariff collection system.
- COVID-19 slowed down investments in the water sector worldwide

3.3 Lesson for water and Sanitation Utilities

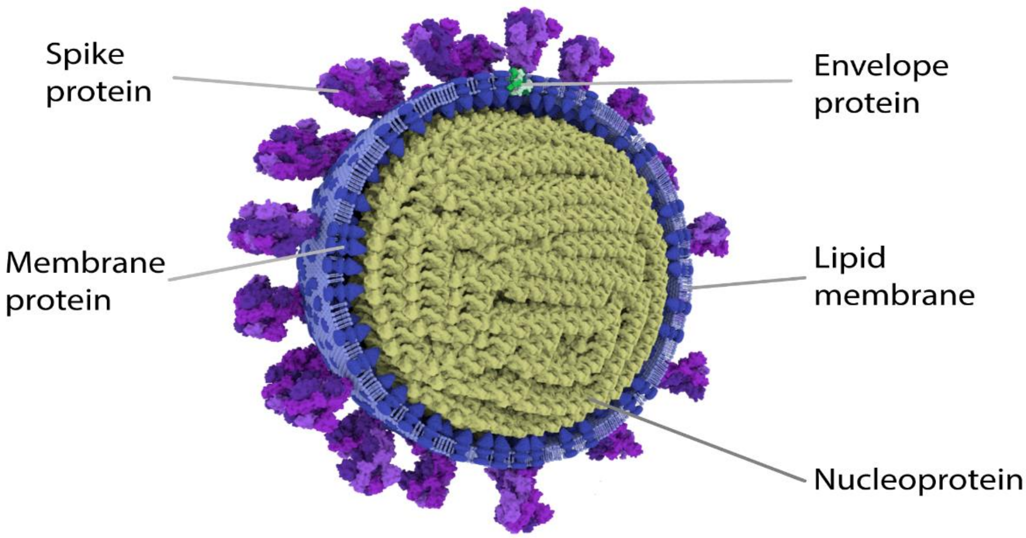
- COVID-19 has reinforced the importance of access to safe and reliable water.
- Lasting lessons on crisis preparedness and resiliency of staff, systems, and equipment could lead to increased investments in digital solutions.
- Automated customer interfaces today may allow for a change in culture going forward.

3.4 Persistence of the Covid-19 virus in drinking-water

WHO guidance on the safe management of drinking-water and sanitation services during COVID-19 outbreak say;

- ❑ The COVID-19 virus has not been detected in drinking-water supplies, therefore the risk to water supplies is low.
- ❑ There is no current evidence from human coronaviruses that:
- ➢ they are present in surface water or groundwater sources.
- ➢ transmitted through contaminated drinking-water.

3.5 What to do in the COVID-19 environment



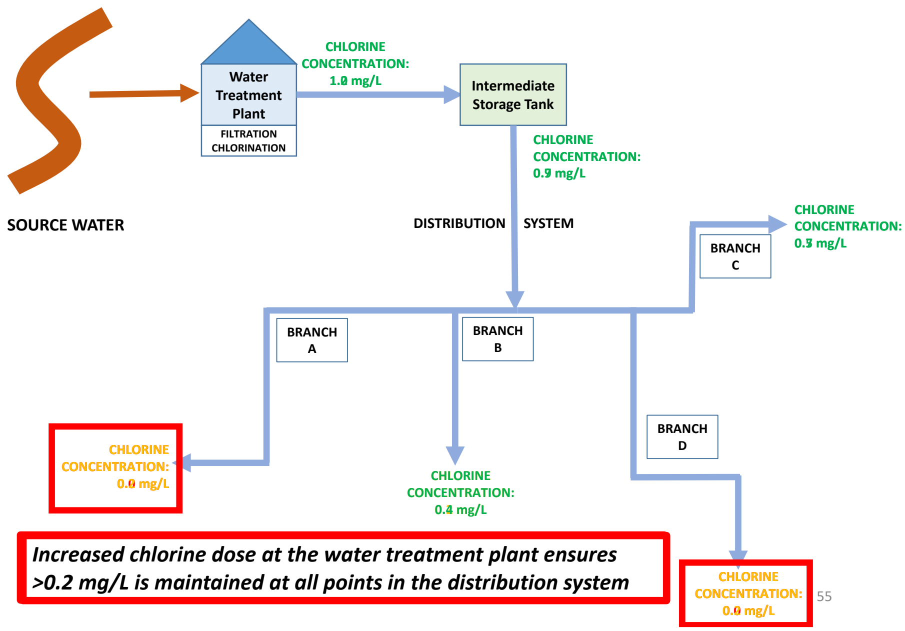
- As per WHO extra measures are not needed
- The COVID-19 virus is an enveloped virus, with a fragile outer membrane.
- Generally, enveloped viruses are less stable in the environment and are more vulnerable to oxidants, such as chlorine
- A recent review found that effective inactivation of virus on surfaces could be achieved within 1 minute using common disinfectants, such as 70% ethanol or sodium hypochlorite.

3.6 Protecting the water supplies by chlorination

- Conventional, centralized water disinfection methods that utilize disinfection at source should inactivate the COVID-19 virus.
- A chlorine residual should be maintained throughout the distribution system.

- That is only possible when you ensure sampling from the periphery and the farthest most point of the distribution system to be sure about required chlorine dose.

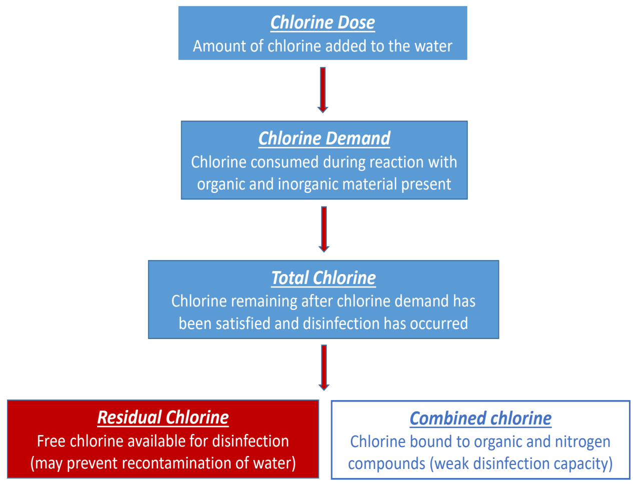
Maintaining chlorine residual



3.7 Efficiency of inactivation of microbes by chlorine

- For effective disinfection, there should be a residual concentration of free chlorine of ≥0.5 mg/L after, at least, 30 minutes of contact time at pH < 8.0.
- pH
- Contact time
- Reaction with water
- Microbes may be protected from chlorine if they are attached to or within particles in the water. Therefore turbidity should always be less than 5 NTU

3.8 Chlorine reactions in drinking-water

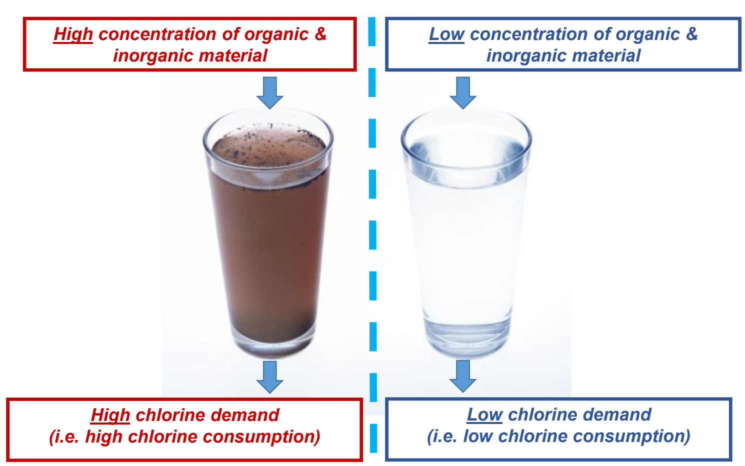


When chlorine is added to water, some of the chlorine reacts with nitrate to form chlorine-ammonia compounds. This is referred to as combined chlorine.

3.9 Chlorine demand

- Chlorine demand is the amount of chlorine required to react with all the organic and inorganic material.
- In practice, the chlorine demand is the difference between the amount of chlorine added and the amount remaining after a given contact time.
- Chlorine Doze = Chlorine Demand + Chlorine Residual
- When chlorine is added to water, it reacts with any organic and inorganic material (*chlorine reactive substances*)

3.10 Relationship between chlorine demand & chlorine dose

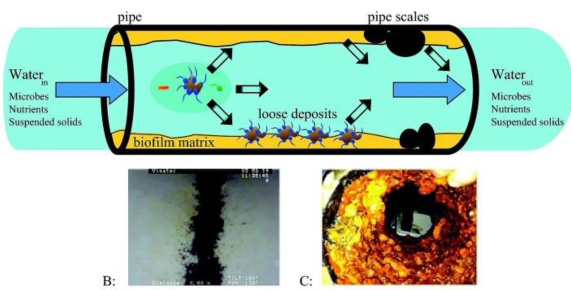


3.11 Residual chlorine (or free chlorine)

- Chlorine remaining after disinfection has taken place.
- Presence of residual chlorine indicates that disinfection has occurred
- the disinfected water has a degree of residual protection from microbial recontamination (e.g., during storage and distribution)

3.12 Chlorine demand of water may be constantly changing therefore fixing a dose is technically incorrect

- Examples of events that influence the chlorine demand include....
- leaking/burst water main,
- accumulation of sediment or microbial biofilm within water mains
- Seasonal changes in the raw water quality of surface water (e.g. dry/wet season, algal blooms, floods, landslides)



3.13 Strategies to minimize chlorine demand in a water supply system

- Ensure **high quality** treated water (i.e., water entering the distribution system has a low chlorine demand)
- Maintain intermediate storages and distribution pipes (e.g., for removal of **accumulated sediment and microbial biofilms**)
- minimize **water age** and low-flow/**stagnant areas**
- **Minimize leaks**, illegal connections which may be vulnerable points for entry of contamination
- Aim for 24 hours supply (where feasible) to maintain positive pressure in the system to minimize risks of contamination entry.

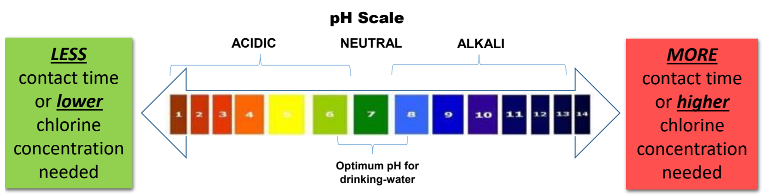
3.14 Optimizing the chlorine dose

Priority must always be to add sufficient chlorine such that:

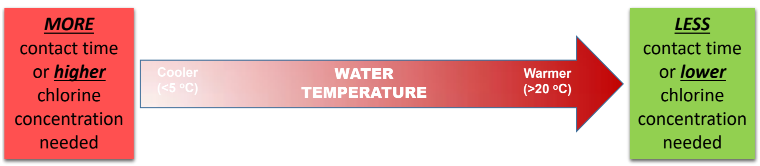
- ❖ The minimum required contact time for effective disinfection is achieved
- ❖ The residual chlorine concentration at all points in distribution system is ≥0.5 mg/L

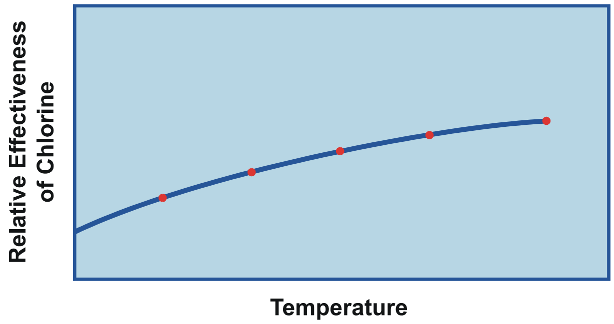
3.15 Influence of pH of water on disinfection

- ❑ "potential of hydrogen" is a scale used to specify the acidity or basicity of an aqueous solution
- ❑ pH is measured on a scale of pH 0 to pH14
- ❑ pH 7 considered neutral, pH <7 considered acidic and pH >7 considered alkali



3.16 Influence of water temperature & concentration on disinfection





Higher temperature will result in more efficient disinfection

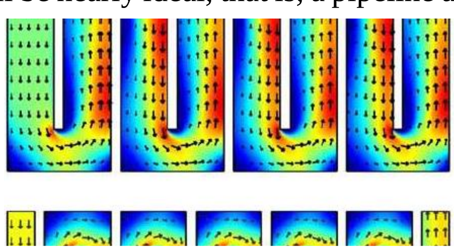
3.17 Influence of chlorine concentration on disinfection

Higher concentration will need less contact time and low concentration will need more time

3.18 Disinfection Reactors

- **Contact chambers**
- **A long pipeline reactor**

a pipeline that provides 30 minutes of contact time at a flow rate greater than 0.044 m3/s and a velocity greater than 0.6 m/s will be nearly ideal, that is, a pipeline about 1 km long (MWH, 2005).



3.19 How to calculate the detention time?

- **Detention time** (min) = Water storage volume (m3) ÷ Flow (m3/min)
- **Ct concept** (min.mg/L) = Residual chlorine concentration (mg/L) x Contact time (min)
- *WHO1 recommends a minimum contact time of 30 minutes where the residual chlorine is 0.5 mg/L and the pH is <8 (i.e., **15 min.mg/L)***
- For example if the residual concentration is **0.4mg/l** and contact time is 30 minutes, CT value will be=12.0min.mg/L that is less than required. In this case the contact time should be **38 minutes**

3.20 Calculation of the required chlorine dose

$$\text{Chlorine Dose Rate (mL/h)} = \frac{\text{Required chlorine dose (mg/L)} \times \text{Treated water flow rate } (m^3/h)}{\text{Chlorine liquid concentration (\%)} \div 100}$$

Assume:

- Require 1 mg/L chlorine dose
- Flow rate is 1 cusec (102 m3/h)
- Chlorine liquid concentration is 18 %
- Chlorine dose rate =1 x 102/0.18=567 ml/h=0.57 L/h
- Chlorine Dose (mg/L) calculation if injector is set at say 1 liters/h and concentration is 18%

Actual Chlorine Dose (mg/L) = (1000 mL/h x 0.18) /102 m3/h

=1.7 mg/l

3.21 Stability of liquid sodium hypochlorite solution

- The stability of hypochlorite solutions is greatly affected by concentration, heat, light, time, and the presence of heavy metals.
- The higher the concentration, the faster the rate of deterioration.
- The higher the temperature, the faster the rate of deterioration.
- To maintain a somewhat constant solution concentration, quantities should be used within 30 days and stored at 60 to 70^{o}F.
- Solutions exposed to light deteriorate faster than those kept in darkness.
- The presence of iron, copper, nickel, or cobalt increases the rate of deterioration; **therefore, piping systems should be plastic or other non-metallic material to prevent active corrosion of iron, copper or brass materials.**
- Dry material is relatively stable under normal atmospheric conditions and will lose 3 to 5 percent available chlorine per year.

3.22 Powder & liquid chlorine may lose strength over time

Type of chlorine (approx. % active chlorine concentration)		Loss of initial active chlorine concentration (%)
Chlorine powder	Bleaching powder (35 %)	5 to 18 % after 40 days
	High test hypochlorite (70 %)	
Chlorine liquid	Sodium hypochlorite (15 %)	50 % after 100 days
	Sodium hypochlorite (10 %)	50 % after 220 days

3.23 Storage Rooms for hypochlorite

- Hypochlorite will spontaneously react with organic materials. As a result, it should be stored separate from all organic materials such as:
- 4 Oils.
- 4 Fats.
- 4 Paper products.
- 4 Other oxidizable materials.
- **Temperature**
- Maintain temperature of storage rooms between 60 and 70° F
- **Ventilation: Forced** air ventilation should be provided.
  Operate fans when the room is occupied
- Store away from sunlight
- Do not store for excessive periods of time (i.e., many months,
- years)
- Store in chlorine resistant containers
- Keep containers closed/sealed when not in use
- Check for container leaks/spills regularly
- Avoid contact and breathing in chlorine powder dust or chlorine liquid splashes/mists/aerosols
- Always mark and date new chlorine stock individually
- Use '*First In First Out'* stock management principles

3.24 Remote disinfection

In places where centralized water treatment and safe piped water supplies are not available, a number of household water treatment technologies are effective in removing or destroying viruses:

- using high-performing ultrafiltration,
- UV irradiation and,
- appropriately dosed free chlorine
- Boiling water

4 Safely managing wastewater

- There is no evidence that the COVID-19 virus has been transmitted via sewerage systems with or without wastewater treatment.
- Workers should wear appropriate personal protective equipment (PPE), which includes protective outerwear, gloves, boots, goggles or a face shield, and a mask;
- They should avoid touching eyes, nose and mouth with unwashed hands.
- Hand hygiene should be performed at all five moments, including before putting on PPE and after removing it, when changing gloves, after any contact with a patient with suspected or confirmed COVID-19 infection or their waste, before eating and after using the toilet.

5 Hand hygiene

- Hand hygiene is extremely important.
- If hands are not visibly dirty, the preferred method is to perform hand hygiene with an alcohol-based hand rub for **20−30 seconds** using the appropriate technique
- When hands are visibly dirty, they should be washed with soap and water for **40−60 seconds**.

6. Implement Basic Infection Prevention Measures in Utilities

- Promote frequent hand washing by providing workers, customers, and worksite visitors with a place to wash their hands.
- Encourage workers to stay home if they are sick.
- Encourage respiratory etiquette, including covering coughs and sneezes.
- Provide customers with tissues and covered trash basket.
- Discourage workers from using other workers' phones, desks or other T&P, when possible.
- Routine disinfecting of surfaces, equipment, and other elements of the work environment.

6.1 Some Utilities took initiative to make safe environment against corona virus.

- WASA Lahore with the the help of UNICEF placed chlorinated water tankers and drums with hand washing facility at 20 different points around the city.
- The citizens of Lahore washed hands at these points free of cost.
- Utilities may distribute face masks and sanitizers to their workers just like WASA Lahore
- Online services:
  - ➢ Online bill collection
  - ➢ Online bill printing

References:

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