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MINISTRY OF HEALTH-ETHIOPIA
የዜጎች ጤና ለሃገር ብልጽግና!
HEALTHIER CITIZENS FOR PROSPEROUS NATION!

Standard Operating Procedures for Preparation of Commonly used Disinfectants and Fumigants against Coronavirus (SARS-CoV-2)

April, 2020

Addis Ababa, Ethiopia

Preface

Recognizing the need for standardization of measures taken to prevent and control of COVID-19, Ministry of Health of Ethiopia prepared this standard operating procedure for preparation of commonly used disinfectants and fumigants against Corona virus to assist the effort to prevent and contain the outbreak. According to available evidences, World Health Organization emphasizes droplet and contact precautions to prevent COVID-19 transmissions.Contact with contaminated fomites due to persistence of the virus on surfaces is among the route implicated in the transmission of SARS-CoV-2 virus. Due to this WHO recommends environmental cleaning and disinfection to minimize the transmission of the virus from reservoirs to new hosts.

Taking this into consideration this SOP is prepared to guide health professionals and other individuals at all level in preparation of chemicals used for disinfection and fumigation during COVID-19 outbreak in healthcare and non-healthcare facilities.

The ministry of health would like to acknowledge the following members of the technical committee and their respective organizations for their commitment and unreserved effort in finalizing the task in few days.

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Definition of Terms

Antiseptic: - A substance that inhibits the growth and development of microorganisms without killing them. It usually applied topically to skin.

Disinfectant: - A chemical used to reduce the microbial burden on a surface or object. It does not kill spores

Cleaning: - Cleaning is the physical removal of foreign material like dust, soil and organic material like blood, secretions, excretions, microorganisms. It is accomplished with water, detergents and mechanical action.It lowers their numbers and the risk of spreading infection.

Disinfection: - Disinfection is using chemicals to kill germs on surfaces. This process does not necessarily clean dirty surfaces or remove germs, but by killing germs on a surface *after* cleaning, it can further lower the risk of spreading infection.

Decontamination: - A thermal or chemical process for inactivating microorganisms on inanimate objects.

Sterilization: - a process that removes the total burden of all classes of microorganisms, usually using chemicals, heat, and/or pressure

Inactivation: -The process of rendering an organism inert by application of heat or other means.

Microbicide: -A chemical that kills all classes of microorganisms (synonymous with biocide, germicide, and antimicrobial).

Contact time: - It is the time that a disinfectant must be in contact with a surface or device to ensure that appropriate disinfection has occurred.

1. Introduction

1.1. Background

Coronaviruses (CoV) are a large family of viruses that cause illness ranging from the common cold to more severe diseases such as Middle East respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). Coronavirus disease 2019 (COVID-19) is an acute respiratory disease caused by a Coronavirus (SARS-CoV-2), transmitted primarily between people through respiratory droplets andcontact routes.

Contact with contaminated fomites due to persistence of the virus on surfaces is another route implicated in the transmission of SARS-CoV-2 virus. Faecal-oral and airborne modes have also been considered, but their role in the transmission of SARS-CoV-2 is currently unknown.

In a study of environmental contamination in a Chinese hospital during the COVID-19 outbreak, the most contaminated zones were the intensive care unit specialized for taking care of novel coronavirus pneumonia (31.9%), obstetric isolation ward specialized for pregnant women with novel coronavirus pneumonia (28.1%), and isolation ward for novel coronavirus pneumonia (19.6%). Besides, the most contaminated objects are self-service printers used by patients to self-print the results of their exams (20.0%), desktop/keyboard (16.8%), and doorknob (16.0%). Of the samples collected from health care workers' used personnel protective equipment; the highest positive detection rate found was from the hand sanitizer dispensers (20.3%) and gloves (15.4%).

Recent publications have evaluated the survival of SARS-CoV-2 on different surfaces. Theenvironmental stability of SARS-CoV-2 wasindicated that the virus can remain viable and infectious in aerosols for hours and on surfaces up to days. Different levels of environmental contamination have been detected in rooms of COVID-19 patients,ranging from 1 out of 13 to 13 out of 15 samples testing positive for SARS-CoV-2 before cleaning. No air sampleswere positive in these studies, but one sample from an air exhaust outlet was positive indicating that virus particlesmay be displaced by air and deposited on surfaces.

This evidence shows the presence of SARS-CoV-2 in the environment of a COVID-19 patient, therefore, reinforcing the belief that fomites play a role in transmission of SARS-CoV-2.

Detection of RNA in environmental samples based on PCR-based assays is not indicative of viable virus that could be transmissible. Further studies are needed to determinewhether it is possible to detect COVID-19 virus in air samples from patient rooms where no procedures or support treatments thatgenerate aerosols are ongoing.Though the virus survives on environmental surfaces for varied period of time, it gets easily inactivated by chemical disinfectants.In order to reduce the risk of infection through fomites, it is essential to establish procedures for the correct disinfection of environments that could have been contaminated with SARS-CoV-2.

1.2. Scope

This document aims to provide interim guidance on preparation of disinfectants and fumigants for the environmental cleaning or decontamination of healthcare and non-healthcare settings during the COVID-19 pandemic.The document is also intended for all personals that have a role in the preparation and use of disinfectants and fumigants, and management of environmental cleaning services for the healthcare and non-healthcare facilitiesduring the COVID-19 pandemic.

This SOP is consistent with national and international guidelines, including national comprehensive covid-19 management guideline developed recently by ministry of health.

1.3. Purpose

The purpose of this document is;

- ⇨ To provide standard procedure for preparation of chemicals used for disinfection and fumigation during COVID-19 outbreak in healthcare and non-healthcare facilities
- ⇨ To point out minimum requirements for preparation and use of disinfectants and fumigants inhealthcare and non-healthcare facilities during COVID-19 outbreak

1.4. Regulatory framework

This SOP is prepared complying with rules and regulations of national and regional regulatory bodies regarding preparations of non-sterile preparations specifically cleaning, disinfectants, and fumigants. Accordingly, health facilities and non-healthcare facilities,engaged in preparation and use of disinfectants and fumigants that are included in thisdocument, are expected to act upon the regulatory bodies' rules and regulation.

1.5. Selection of disinfectants and Fumigants

All products used for disinfection should possess the following ideal properties:-

- **Broad spectrum**: It should have a wide antimicrobial range.
- **Rapid action**: It should be fast acting and have a short contact time.
- **Remains wet**: it should keep surfaces wet long enough to meet recommended contact times with a single application.
- **Not affected by environmental factors**: It should be active in the presence of trace quantities of organic matter (e.g., blood) and compatible with cleaning supplies (e.g., cloths) and products (e.g., detergents) and other chemicals encountered in use.
- **Material compatibility**: It should be proven compatible with common healthcare surfaces and equipment.
- **Persistence**: It should have residual antimicrobial effect on the treated surface.
- **Cleaner**: It should have some cleaning properties.
- **Nonflammable**: It should have flash point of more than 65°C (150°F).
- **Stability**: It should be stable in concentration and use dilution.

Additionally, products need to be nontoxic, easy to use, acceptable odor, easily soluble in water, and affordable.

2. Sodium hypochlorite (0.1 – 0.5% w/v)

⇨ Synonyms: Bleach, sodium salt from hypochlorous acid

2.1. Physicochemical property

⇨ Molecular formula: NaClO

⇨ Molecular weight (g/mol): 74.439

⇨ Solubility: miscible with water

⇨ Clear to yellow colored liquid

⇨ Chlorine odor.

⇨ It is oxidizing agent

2.2. Solution preparation

2.2.1. General instructions

⇨ To ensure its effectiveness, it is advised to purchase recently produced bleach and avoid over-stocking

⇨ Ensure the area where solution preparation occurs is well ventilated.

⇨ Carefully handle the solution and use personal protective equipment like Chemical-resistant rubber gloves, gown and/or plastic apron, face mask, face shield /goggles.

⇨ Use preferably liquid, unscented bleach to prepare a disinfecting solution.

⇨ Verify the concentration every time a new solution is prepared

⇨ Cold water should be used for dilution as hot water decomposes the active ingredient.

⇨ Use plastic (not metal containers) containers for mixing and storing bleach solutions.

⇨ Prepare a fresh disinfecting solution daily, as sodium hypochlorite will dissipate over time and exposure to elevated temperatures.

⇨ The diluted solution should be labeled, dated and unused portions should bediscarded 24 hours after preparation.

⇨ Use calibrated measuring device for measurement of chlorine solution and water

2.2.2. Procedure

Step 1: Check the concentration of the chlorine product you are using.

Step 2: Determine the volume of the chlorine solution that needs tobe prepared

Step 3: Calculate the total parts of water required for each bleach part to make a dilute chlorine solution by applying the following formula:

$$\text{Total parts of water for each part bleach} = \frac{\%\ \text{chlorine in liquid bleach}}{\%\ \text{chlorine desired}} - 1$$

Example: To make a 0.5% chlorine solution from 5% bleach:

[5%⁄0.5%] − 1 = 9 parts water for each part bleach

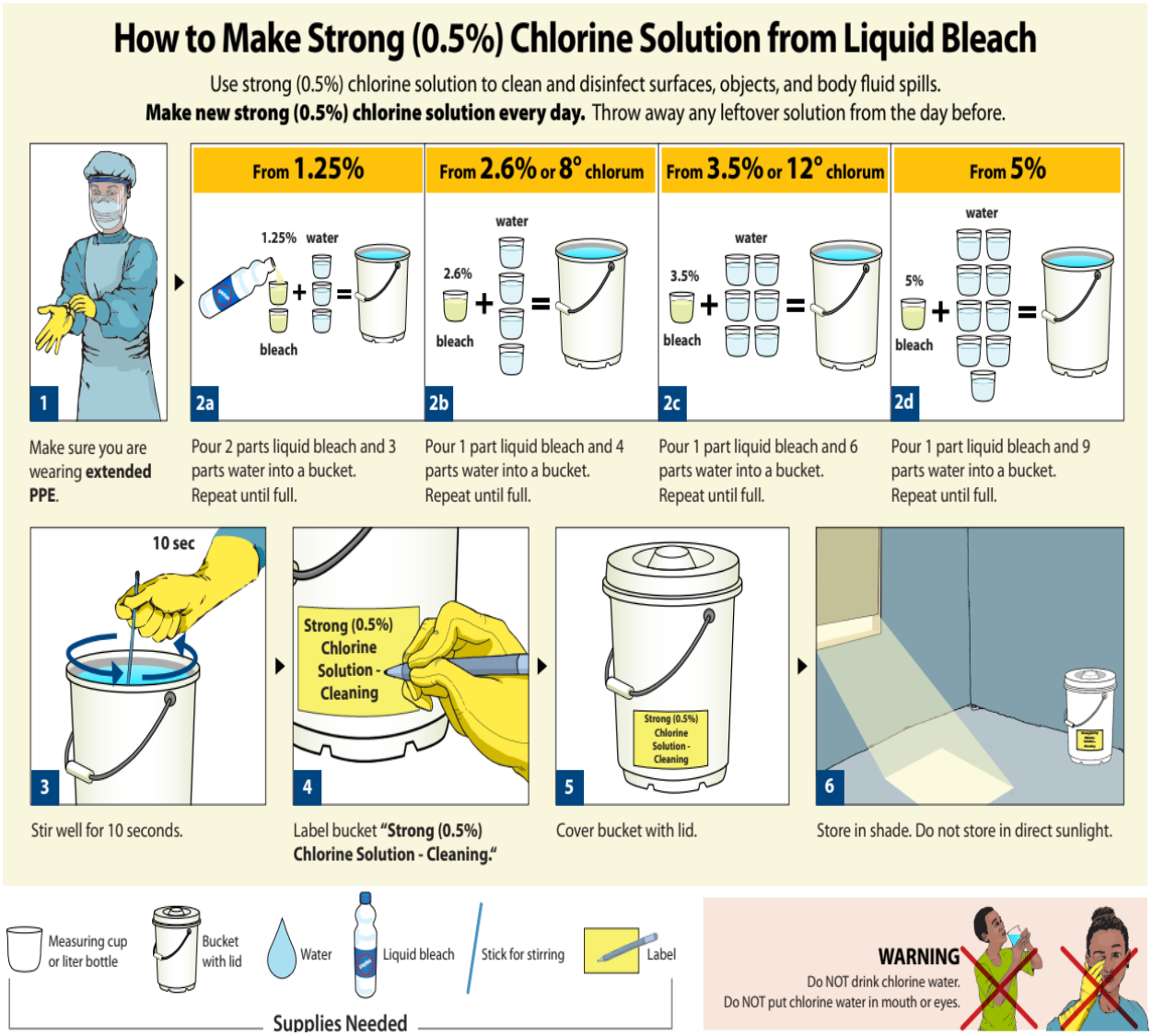
Therefore, you must add 1 part 5% bleach to 9 parts water to make a 0.5% chlorine solution (i.e. to prepare 1000 ml of 0.5% chlorine solution from 5% bleach, 100 ml of 5% bleach is mixed with 900 ml of water)

Step 4: Measure the calculated volume of bleach and pour to the mixing tank/vesselcontaining the required volume of water not vice versa.

Step 5: Agitate the mixture to assure uniform distribution of the acid using paddles orrecirculating pump

Step 6: Verify the desired concentration using chlorine test strips or titration kits.

Figure 1: How to make 0.5% Chlorine solution from liquid bleach



2.3. Application and Use

Table 1: Sodium hypochlorite strength and its application for disinfection

Strength	Application	Contact Time
0.5% (5,000 ppm)	Excreta	10 minute wet contact
	Bodies	
	Spills of blood & body fluids	
	Vehicles & tires	
0.1% (1,000 ppm)	Surfaces (not contaminated with blood or body fluids)	1 minute wet contact
	Surfaces and equipment not contaminated with blood or body fluids (e.g. counters, door knobs, stethoscope, BP cuff).	1 minute wet contact
	Bedding	10 minutes – infection control pretreatment if heavily soiled with excreta or body fluids
		30 minutes – disinfecting rinse if pretreatment was not performed
	Reusable protective clothing (before and after laundering or washing)	1 minute wet contact
	Disinfecting contaminated waste before disposal	10 minute wet contact

N.B. Gross contamination must be cleaned/removed first for final disinfection

2.4. Storage

- ⇨ Store in a dry, cool, and darkened area or in a lid fit container protected from light
- ⇨ Storage should be in a secure area, away from an excessive heat source, and free from combustible materials that could react in the presence of chlorine

2.5. Safety and Precautions

- ⇨ Chlorine solutions should never be mixed or stored with acid products and cleaning products containing ammonia, ammonium chloride, or phosphoric acid.
- ⇨ Avoid using bleach on metals, wool, nylon, silk, dyed fabric.
- ⇨ Avoid long term exposure for the bleach
- ⇨ Anytime the odour of chlorine is not present, discard the solution.
- ⇨ Avoid direct contact with skin and eyes.
- ⇨ Upon mild exposure the area should be thoroughly flushed with water.
- ⇨ If eyes have been exposed to chlorine, thoroughly flush them for 15 minutes.

- ⇨ If you are exposed to an unpleasantly strong odor following the mixing of a chlorine solution, leave the room or area immediately until the fumes have cleared completely
- ⇨ Chlorine solutions should not be conserved in uncovered containers for more than 12 hours due to the evaporation of the active product.
- ⇨ Do not autoclave bleach solutions

3. Calcium hypochlorite (0.1 – 0.5% w/v)

- ⇨ Synonyms: chlorinated lime or high test hypochlorite (HTH)

3.1. Physicochemical property

- ⇨ White powder/granules/tablets
- ⇨ chlorine like odour
- ⇨ Molecular formula : $Ca(OCl)_2$
- ⇨ Molecular weight (g/mol): 142.98
- ⇨ Water solubility: 214g/l at 20 ^oC
- ⇨ It is oxidizing agent

3.2. Solution preparation

3.2.1. General instructions

- ⇨ Ensure the area where solution preparation occurs is well ventilated.
- ⇨ Use appropriate personal protective equipment (as it irritates mucous membranes, the skin and the airway)
- ⇨ Cold water should be used for dilution as hot water decomposes the active ingredient of bleach and renders it ineffective.
- ⇨ Use plastic containers for mixing and storing bleach solutions as metal containers are corroded rapidly and also affect the bleach.
- ⇨ The diluted solution should be labeled, dated and unused portions should bediscarded 24 hours after preparation.
- ⇨ Availability of the desired concentration is key to ensuring proper disinfection
- ⇨ Use calibrated measuring and weighing device

3.2.2. Procedure

Step 1: Note the concentration on the starting bleach bottle/container

Step 2: Determine the volume of the chlorine solution that needs tobe prepared

Step 3: Calculate the amount of bleach to be mixed with each liter of water by using thefollowing formula:

$$\text{Grams of bleach powder for each liter of water} = \frac{\%\ \text{chlorine desired}}{\%\ \text{chlorine in bleach powder}}\ \text{X}\ 1000$$

Example: To make a 0.5% chlorine solution from calcium hypochlorite(bleach) powder containing 35% active chlorine:

[0.5%/35%] X 1000 = 14.3

Therefore, you must dissolve **14.3 grams** of calcium hypochlorite (bleach) powder in each litre of water to make a 0.5% chlorine solution.

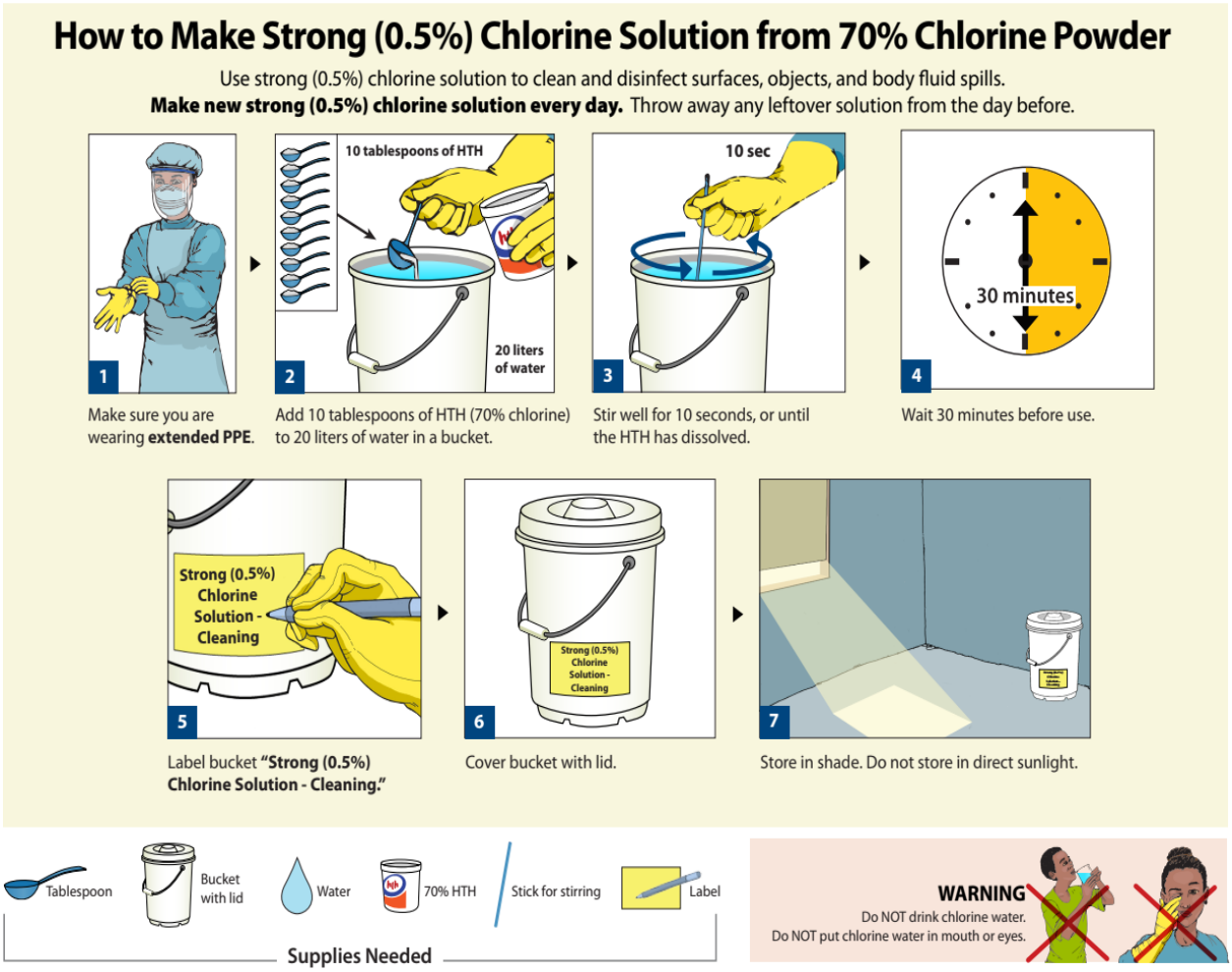
Step 4: Weighthe calculated amount of bleach powder and addto the mixing containercontaining the required volume of water not vice versa.

Step 5: Agitate the mixture to assure uniform distribution of the acid using paddles orre-circulating pump

Step 6: Decant off the clear supernatant chlorine solution from the mixingcontainer to the storage tank

Step 7: Verify the desired concentration of solution using chlorine test strips or titration kits.

Figure 2: How to make strong (0.5%) chlorine solution from 70% chlorine powder



3.3. Application/Use

Table 2: Calcium hypochlorite strength and its application for disinfection

Strength	Application	Contact Time
0.5% (5,000 ppm)	Excreta	10 minute wet contact
	Bodies	
	Spills of blood & body fluids	
	Vehicles & tires	
0.1% (1,000 ppm)	Surfaces (not contaminated with blood or body fluids)	1 minute wet contact
	Medical equipment (not contaminated with blood or body fluids) (e.g. counters, door knobs, stethoscope, BP cuff).	1 minute wet contact
	Bedding	10 minutes – infection control pretreatment if heavily soiled with excreta or body fluids
		30 minutes – disinfecting rinse if pretreatment was not performed
	Reusable protective clothing (before and after laundering or washing)	1 minute wet contact
	Disinfecting contaminated waste before disposal	10 minute wet contact

3.4. Storage

- ⇨ All forms of calcium hypochlorite should be stored in a cool, dry place in closed, corrosion- resistant container (e.g. plastic or dark glass).
- ⇨ Storage should be in a secure area, away from an excessive heat source, and free from combustible materials that could react in the presence of chlorine

3.5. Safety and Precautions

- ⇨ Never mix or store with acid products and cleaning products containing ammonia, ammonium chloride, or phosphoric acid.
- ⇨ Avoid exposure to the fumes from the acid container.
- ⇨ Avoid direct contact with skin and eyes.
- ⇨ Upon mild exposure thoroughly flush with water.
- ⇨ If eyes have been exposed to chlorine, thoroughly flush them for 15 minutes.
- ⇨ If there is severe exposure, keep the victim warm and cover with blanket and in comfortable position.

- ⇨ If you are exposed strong odor following the mixing of a chlorine solution, leave the room or area immediately until the fumes have cleared completely
- ⇨ Chlorine solutions should not be conserved in uncovered containers for more than 12 hours due to the evaporation of the active product.
- ⇨ All containers in which chlorine is stored should be labeled, identifying the contents and with a hazard warning
- ⇨ Storage site in any form should be secure against unauthorized access and especially against children

4. Ethanol (70% v/v)

- ⇨ Synonym: Ethyl alcohol

4.1. Physicochemical property

- ⇨ Molecular formula = C_2H_5OH
- ⇨ Molecular weight (g/mol) = 46.07
- ⇨ Colorless and volatile liquid which is flammable
- ⇨ Soluble in water

4.2. Solution preparation

4.2.1. General instructions

- ⇨ Ensure the area where solution preparation occurs is well ventilated.
- ⇨ Use appropriate personal protective equipment (as it irritates mucous membranes, the skin and the airway)

4.2.2. Procedure

Step 1: Check the initial concentration of stock solution of ethanol you are using.

Step 2: Determine the volume of the ethanol solution that needs to be prepared

Step 3: Calculate the total volume of ethanol from stock solutionrequired to make a diluteethanol solution by applying the following formula:

$$C_1V_1 = C_2V_2$$

- ⇨ Where, C_1 and V_1 are concentration and volume of stock solution respectively
- ⇨ C_2 and V_2 are concentration and volume of dilute preparation (70%), respectively

Example: To make a 1000 ml of 70% ethanol solution from 96% stock ethanol solution:

$$V_1 = \frac{C2V2}{C1} V_1 = \frac{70\%\ x\ 1000\ ml}{96\%}$$

$$V_1 = 729\ ml$$

Therefore, you must mix 729 ml of ethanol (96%) with sufficient water to make a total of 1000 ml mixture with 70% ethanol

Step 4: Measurethe calculated volume of stock solution of ethanol and pourto the vessel containing the required volume of water

Step 5: Gently shake the mixture using paddles

Step 6: Verify the desired concentration of solution

4.3. Application/Use

- ⇨ It is used for decontaminating surfaces (within 1 min exposure time), such as metals and table tops, where use of household bleach and hypochlorites is contraindicated.
- ⇨ Can be used on work surfaces of laboratory benches and biosafety cabinets, and to disinfect small pieces of surgical instruments.
- ⇨ It is often used to disinfect small surfaces (e.g. rubber stoppers of multiple-dose medication vials, and thermometers) and occasionally external surfaces of equipment (e.g. stethoscopes, ventilators, ventilation bags, CPR manikins, ultrasound instrument, thermometers, scissors etc).

4.4. Storage

- ⇨ Store in a cool and well-ventilated room and away from flames.
- ⇨ Solutions should be stored in proper containers to avoid the evaporation of alcohols.

4.5. Safety and Precautions

- ⇨ Alcohols are volatile and flammable and must not be used near open flames
- ⇨ Bottles with alcohol-containing solutions must be clearly labelled to avoid their accidental use and autoclaving
- ⇨ Since alcohol is flammable, limit its use as a surface disinfectant to small surface-areas and use it in well-ventilated spaces only.
- ⇨ Prolonged and repeated use of alcohol as a disinfectant can also cause discoloration, swelling, hardening and cracking of rubber and certain plastics.

5. Hydrogen peroxide (0.5 w/v %)

5.1. Physicochemical property

- ⇨ Molecular formula = H_2O_2
- ⇨ Molecular weight (g/mol) = 34.0147 g/mol
- ⇨ It is clear, colorless liquid and water miscible. The chemical is odourless at low concentration, at high concentrations is slightly pungent
- ⇨ H2O2 is a powerful oxidant

5.2. Solution preparation

5.2.1. General instructions

- ⇨ Ensure the area where solution preparation occurs is well ventilated.
- ⇨ Use appropriate personal protective equipment (as it irritates mucous membranes, the skin and the airway)

5.2.2. Procedure

Step 1: Note the concentration on the starting bottle/container

Step 2: Determine the volume of the hydrogen peroxide solution that needs to be prepared

Step 3: Calculate the total volume of hydrogen peroxide from stock solutionrequired to make a dilute hydrogen peroxide solution by applying the following formula:

$$C_1V_1=C_2V_2$$

- ⇨ where, C_1 and V_1 are concentration and volume of stock solution respectively
- ⇨ C_2 and V_2 are concentration and volume of dilute preparation (0.5%), respectively

Example: To make a 1000 ml of 0.5% hydrogen peroxide solution from 30% stock ethanol solution:

$$V_1 = \frac{C2V2}{C1} V_1 = \frac{0.5\% \; x \; 1000 \; ml}{30\%}$$

$$V_1 = 17 \; ml$$

Therefore, you must mix 17 ml of hydrogen peroxide (30%) with sufficient water to make a total of 1000 ml mixture with 0.5% hydrogen peroxide

Step 4: Measurethe calculated volume of stock solution of hydrogen peroxide and pourto the vessel containing the required volume of water

Step 5: Gently shake the mixture using paddles

Step 6: Verify the desired concentration of solution

5.3. Application/Use

⇨ Used for cleaning and disinfecting surfaces and medical equipment (e.g. tonometers, soft contact lenses, ventilators etc)

5.4. Storage

⇨ Hydrogen peroxide should never be used in ketone solvents or stored in the presence of aliphatic ketones or almost any aldehydes.

⇨ Solutions of hydrogen peroxide are best stored with venting caps.

5.5. Safety and Precautions

⇨ Personal protective equipment (e.g. splash-proof chemical monogoggles, neoprene or butyl rubber gloves etc) must be worn when opening storage vessels/containers containing hydrogen peroxide.

⇨ Leather gloves and boots should not be worn when working on hydrogen peroxide systems. They present a significant burn hazard to the wearer, if they contact hydrogen peroxide.

⇨ Hydrogen peroxide, by itself, is nonflammable. However, it is a strong oxidizer and contact with oxidizable organic material may cause spontaneous combustion.

6. Glutaraldehyde (2 w/v %)

⇨ **Synonyms: Cold sterilant**

6.1. Physicochemical property

⇨ Molecular formula = $C_5H_8O_2$

⇨ Molecular weight (g/mol) = 100.11

⇨ Aqueous solutions of glutaraldehyde are acidic

⇨ Color Colorless liquid

⇨ Solubility:

Water……51.3g/L

Other solvents….miscible with acetone and Iso-propanol

6.2. Solution preparation

6.2.1. General instructions

⇨ It should be used in highly ventilated environments and with personal protective equipment.

- ⇨ Good occupational hygiene principles and handling practices should be adopted to reduce exposures to glutaraldehyde to as low a level as is reasonably practicable.

6.2.2. Procedure

Step 1:-The glutaraldehyde solution is "activated" (made alkaline) by use of alkalinizing agents (0.3% w/v sodium bicarbonate) to pH 7.5 to 8.5

Step 2:-The required volume ofactivated solution (2.0% w/v) is then poured into container/ tanks for disinfection, as appropriate.

Step 3:-If the glutaraldehyde solution at hand is with higher strength (e.g. 25%), proper dilution is required after activation:

- ⇨ **Step 3.1:**Determine the volume of the glutaraldehyde solution that needs to be prepared
- ⇨ **Step 3.2:** Calculate the total volume of glutaraldehyde from stock solutionrequired to make a dilute glutaraldehyde solution by applying the following formula:

$$C_1V_1=C_2V_2$$

  - Where, C_1 and V_1 are concentration and volume of stock solution, respectively
  - C_2 and V_2 are concentration and volume of dilute preparation (2%), respectively

Example: To make a 1000 ml of 2% glutaraldehyde solution from 25% stock glutaraldehyde solution:

$$V_1 = \frac{C2V2}{C1} V_1 = \frac{2\% \; x \; 1000 \; ml}{25\%}$$

$$V_1 = 80 \; ml$$

Therefore, you must mix 80 ml of glutaraldehyde (25%) with sufficient water to make a total of 1000 ml mixture with 2% glutaraldehyde solution

- ⇨ **Step 3.3:-**Measurethe calculated volume of stock solution of glutaraldehyde and pourto the vessel containing the required volume of water
- ⇨ **Step 3.4:-**Gently shake the container holding the mixture using
- ⇨ **Step 3.5:-**Verify the desired concentration of solution using chemical test strips or dipsticks supplied with products

Note:

- ⇨ The glutaraldehyde product is not effective as a disinfectant unless it is activated correctly (with bicarbonate compound supplied with the product)

- Sometimes the glutaraldehyde solution is supplied as one-component (stabilized acidic formulated) which does not require any pre-activation and can immediately be used (either directly or by dilution in water)

6.3. Application and Use

- Glutaraldehyde is used most commonly as a high-level disinfectant for medical equipment and metal articles/surfaces (which are destroyed by sodium hypochlorite), such as speculums, ear, nose and throat and dental instruments, and the slides for laryngoscopes, catheters, endoscopes, endotracheal tubes, endocavitary probes, spirometry tubing, dialyzers, transducers, anesthesia and respiratory therapy equipment
- A time of 45 minutes is required to carry out high level disinfection at a temperature of 20 ºC.
- After disinfection with glutaraldehyde, the equipment should be thoroughly washed with sterile water.

6.4. Storage

- Once activated, the solution has a life span of one to two weeks.
- Glutaraldehyde solutions should be stored in tightly closed containers in a cool, secure area and properly labeled.
- Glutaraldehyde solutions should be discarded if they become turbid.

6.5. Precautions

- Use only with proper ventilation control, such as a chemical fume hood or specially designed slot hood.
- Solutions should be poured from the container disinfection basin by a method that will prevent employee contact with the solution and reduce exposure to glutaraldehyde vapors.
- Agitation and splashing during transfer should be avoided.
- It is not recommended as a spray or solution for the decontamination of environmental surfaces.
- Glutaraldehyde should not be used for cleaning noncritical surfaces because it is toxic
- Glutaraldehyde should only be used where other disinfecting techniques are inappropriate.

7. Formaldehyde (3.7%)

- Synonyms: formalin (10%)

7.1. Physicochemical property

- Molecular formula = CH_2O
- Molecular weight (g/mol) = 30.031
- It has a pungent smell
- Chemical name: Methanal; usually 37% aqueous solution is called formalin; solid polymer is called paraformaldehyde
- Color….colorless liquid
- Physical state….gas/liquid
- Solubility:
  - Fresh Water at 20°c.miscible
  - Organic solvent (s)….Ether, alcohol, acetone, benzene

7.2. Solution preparation

7.2.1. General instructions

- PPE must always worn when working with this compound

7.2.2. Procedure

Step 1: Note the concentration on the starting bottle/container

Step 2: Determine the volume of the formaldehyde solution that needs to be prepared for disinfection or room fumigation

Step 3: Calculate the total volume of formaldehyde from stock solutionrequired to make a dilute formaldehyde solution by applying the following formula:

$$C_1V_1=C_2V_2$$

- Where, C_1 and V_1 are concentration and volume of stock solution respectively
- C_2 and V_2 are concentration and volume of dilute preparation (3.7%), respectively

Example: To make a 1000 ml of 3.7 % formaldehydesolution from 37% stock formaldehydesolution:

$$V_1 = \frac{C2V2}{C1} \quad V_1 = \frac{3.7\% \; x \; 1000 \; ml}{37\%}$$

$$V_1 = 100\ ml$$

Therefore, you must mix 100 ml of formaldehydesolution (37%) with sufficient water to make a total of 1000 ml mixture with 307% formaldehydesolution

Step 4: Measurethe calculated volume of stock solution of formaldehyde and pourto the vessel containing the required volume of water

Step 5: Gently shake the container holding the mixture

7.3. Application/Use

- ⇨ For disinfection of medical equipment
- ⇨ The solution is recommended for decontamination of spills of blood and body fluids. It inactivates vegetative forms of bacteria, viruses, and fungi in less than 30 minutes.
- ⇨ Formaldehyde vapour is used for fumigating operation theatres, wards, beds, and laboratories.
- ⇨ Rooms can be fumigated by boiling off (for rooms up to 25–30 m^3) 4 liters of 10% formalin in an electric kettle (fitted with a timing or other device to cut off the electricity when the fluid level has reached the element) and leaving overnight (or no less than 4 hours from the point in time when the boiling process has been completed) before venting.
- ⇨ For formaldehyde fumigation, room temperature should be > 15 °C.

7.4. Storage

- ⇨ In general, hypochlorites are stable if kept in a cool place, out of direct sunlight and in purpose made containers
- ⇨ It must therefore be stored and used in a fume-hood or well-ventilated areas.

7.5. Safety and Precautions

- ⇨ Any equipment that is disinfected with formaldeyde should be thoroughly rinsed with sterile distilled water before reuse
- ⇨ Before fumigation commences, all windows, doors and other vents to the outside should be sealed with heavy adhesive tape.
- ⇨ Vaporization of formaldehyde should not be done with gas or other naked flame heaters
- ⇨ Avoid skin contact with formaldehyde solution or inhalation of formaldehyde vapors.

- ⇨ Neutralization of formaldehyde can be done using ammonia vapour (electric fan will assist in circulating the ammonia), but it may still be 24 - 48 hours before the room can be entered without a respirator.
- ⇨ The presence of absorbent material in the room (paper, cardboard, fabric, etc.) reduces the rate of clearance and, indeed, can reduce the effectiveness of the fumigation process. Where there is extensive absorbent material present, the exposure time and possibly the starting concentration of the formaldehyde should be raised to compensate. To ensure complete access of the fumigant, items of equipment should be held above bench or floor surfaces by racks or by tilting to allow the fumigant to penetrate underneath.
- ⇨ A fan, or fans, assists the extraction. Doors into the room should be kept closed and other personnel prevented from passing near or through them until venting is complete. If a formaldehyde meter is available, venting should not be considered complete until levels of less than 2 ppm have been reached. In the absence of a meter, the odor of formaldehyde should have become almost undetectable before entry into the room without a respirator is allowed.
- ⇨ Hazard warning notices should be posted on the door(s) and, if appropriate, windows of fumigation room.
- ⇨ All chlorine-releasing agents should be removed from areas where formaldehyde fumigation is to be done, in order to prevent release of carcinogenic products

Annex-1: List of materials and equipment

- ⇨ Opaque HDPE bucket
- ⇨ Test strips or titration kits
- ⇨ Chemical-resistant gloves (e.g., nitrile) or rubber gloves
- ⇨ Gown and/or plastic apron
- ⇨ Face mask
- ⇨ Face shield or goggles
- ⇨ A measuring cup
- ⇨ Clean water
- ⇨ Smaller containers with covers or lids
- ⇨ Sodium hypochlorite bleach
- ⇨ Sodium hypochlorite powder
- ⇨ Hydrogen peroxide solution
- ⇨ Ethanol solution
- ⇨ Povidone iodine
- ⇨ Glutaraldehyde
- ⇨ Formaldehyde

Annex-2: General characteristics of disinfectants

Disinfectant	**Characteristics**			
	Advantages	Disadvantages	Mode of action	Spectrum
Sodium/calcium hypochlorite	• No toxic residue • Unaffected by water hardness • Inexpensive • Fast acting	• Corrosiveness to metals in high conc (>500 ppm) • Inactivation by organic matter, • Discoloring of fabrics, • Release of toxic chlorine gas when mixed with ammonia or acid (e.g., household cleaning agents), • Relative lower stability • Polymerized by sun rays, and needs to be protected in opaque containers. • Produces irritation of the mucous membranes	It produces the inhibition of enzymatic reactions, denaturation of proteins and inactivation of nucleic acids	Broad spectrum (Bactericidal, Virucidal, Fungicidal, Mycobactericida, sporicidal)
Ethanol	• Fast acting • No toxic residue	• No toxic residue • Highly flammable • Reduced activity in presence of organic matter	• Protein denaturation	• They are active against vegetative bacteria, fungi and lipid-containing viruses
Hydrogen peroxide	• No activation required • No odor or irritation issues • Does not coagulate blood or fix tissues to surfaces	• Material compatibility concerns (brass, zinc, copper, and nickel/silver plating) • Serious eye damage with contact	• By producing destructive hydroxyl free radicals that can attack membrane lipids, DNA, and other essential cell	• Bacteria, yeasts, fungi, viruses, and spores