

Microbial control

Definition

Sterilization

- is the process of killing or removing all viable organisms
- achieved by: physical & chemical

Disinfection

- is the process of removing or killing most but not all, viable organisms

Antiseptics:

- A particular group of disinfectants – used to reduce the number of viable organisms in the skin.
 - act differentially on organism and host tissue
1. **Germicide**
 - chemical agent capable of killing microbes
 2. **Sporicide**
 - a germicide capable of killing bacterial spores

Mechanisms of action of antimicrobial agents:

1. Damage cell membrane
 2. Denature proteins
 3. Modify functional groups of proteins and nucleic acids
- Activity of a particular disinfectant may result from one or combination of pathways.

Factors affecting efficacy:

1. Physical environment
2. Presence of moisture
3. Temperature and PH
4. Concentration of the agent
5. Hardness of water
6. Mature and state of microbes
7. Ability of microbes to inactivate the chemical agent

Physical Methods of Microbial Control:

1. Heat: denatures proteins (enzymes) = death

A. Moist heat: coagulates molecules → denatures proteins

1. **Boiling**: 100°C, 10 min

Kills: vegetative cells, most viruses

Applications: sanitization of water, dishes, cookware, etc.

2. **Steam**:

Autoclave 15psi, 121°C, 15 min

Kills: vegetative cells, viruses, endospores (sterilization)

Applications: sterilization of any medical or research solutions and equipment that can tolerate heat and steam

3. **Pasteurization**

Reduces the total number of viable microbes in bulk fluids such as milk and fruit juices without destroying flavor and palatability.

Applications: milk and liquid foods

HTST (High Temperature Short Time): 72°C, 15 sec

Kills most vegetative cells

4. **UHT** (Ultra High Temperature) Treatment: 140°C, 1 sec

Kills: vegetative cells, viruses, endospores (sterilization)

B. Dry heat: oxidation of organic molecules → denatures proteins (cell destroyed)

1. Incineration: reduce to ash

Complete destruction of everything

Applications: sterilization of inoculating instruments, waste disposal

2. Sterilization oven: 170°C, 2+ hrs

Kills: vegetative cells, viruses, endospores (sterilization)

Applications: sterilization of instruments that can tolerate heat

2. Low Temperature: decrease chemical reaction rates → slow or stop cell division.

A. Refrigeration: 4°C

Static, except for psychrotrophs

Applications: short term food preservation

B. Freeze: -20°C or lower (liquid nitrogen -196°C)

Rapid freezing: static for many microbes, some sanitization especially during thawing.

Applications: long term food preservation (-20°C), specimen storage

(-80 to -196°C)

3. Filtration: remove microbes

Physically removed microbes from liquids or gasses

Applications: purification of heat-labile liquids, gasses

Filters:

0.2 µm pores: remove most vegetative cells and endospores.

0.01µm pores: remove virus and large proteins

HEPA (High Efficiency Particulate Air) filters: remove 99.97% of particles >0.3 µm

4. Desiccation: remove water → inhibit chemical reactions → stop microbial growth

Lyophilization/Freeze-drying: quick freeze -95°C with vacuum sublimation

Static for most microbes

Applications: food preservation, specimen preservation

5. Osmotic Pressure: hypertonic environment (remove water) → inhibit chemical reactions → stop growth

High salt or high sugar concentrations

Static for bacteria, fungi often resistant

Applications: food preservation

6. **Radiation**: high energy waves

A. Ionizing radiation

(1nm or less): ionizes organic molecules → molecular damage

Kills: vegetative cells, viruses, most endospores with adequate exposure

Applications: food preservation, sterilization of pharmaceuticals, medical supplies, mail.

Ionizing rays:

1. Gamma rays (radioactive elements)

Deep penetration, many hours exposure to sterilize

2. X-rays (machine generated)

Deep penetration, many hours exposure to sterilize

3. High energy electron beams (electron accelerator generated)

Low penetration, few second exposures to sterilize

B. UV radiation (260nm): → damage DNA

Kills: vegetative cells, DNA based viruses, most endospores

Requires direct exposure

Applications: sterilize/sanitize room, counter, and hood surfaces, medical products, water, air

Chemical Methods of Microbial Control

Disinfectants/Antiseptics

1. **Phenolics**

Action: denature proteins & disrupt cell membranes

Intermediate activity

Broad spectrum, most effective on Gram-positive bacteria

Positive aspects: -active in presence of organics

-stable

-persist long after application

Negative aspects: -corrosive to skin and instruments

-pungent odor

-not effective for endospores

Applications: surface disinfection,

bisphenols (e.g. triclosan): in lotions, soaps, toothpaste, kitchenware

2. **Biguanides (Chlorhexidine)**

Action: disrupt cell membranes

Low activity

Bactericidal on Gram-negatives and Gram-positives, fungicidal on yeast

Positive aspects: -strong affinity for skin

-low toxicity

Negative aspects: -damages eyes

-not effective on Mycobacterium, endospores, protozoan cysts & most viruses

Applications: Skin and mucous membrane disinfection

3. **Halogens**

A. Iodine

Action: impairs protein synthesis & disrupts cell membranes

Intermediate activity

Broad spectrum: bacteria, fungi, some endospores, some viruses

Positive aspects: -effective against all vegetative cells including

Mycobacterium

Negative aspects: -staining

-sometimes irritating to skin

-may trigger allergies

Applications: skin disinfection, wound treatment, water treatment

B. Chlorine

Action: forms hypochlorous acid with water → oxidizing agent, denatures proteins

Intermediate activity

Broad spectrum: bacteria, fungi, some endospores, some viruses

Positive aspects: –effective against all vegetative cells including

Mycobacterium

–cost effective

Negative aspects: –action inhibited by organics

–can form carcinogenic compounds

Applications: water and sewage treatment, surface and instrument disinfection

4. Alcohols

Action: denature proteins & dissolve membrane lipids

Intermediate activity as 70% solution with water

bactericidal, fungicidal, virucidal on enveloped viruses

Positive aspects: –degermation of greasy skin

–effective against vegetative cells

Negative aspects: –not effective for wounds

–volatile and flammable

–dries and irritates skin

–not effective on endospores, cysts, and non-enveloped viruses

Applications: skin and instrument disinfection

5. Heavy Metals (Silver, Copper, Zinc)

Action: bind sulfur groups causing inactivation or precipitation of proteins

Low activity

Most are bacteristatic & fungistatic, silver is biocidal

Positive aspects: –oligodynamic action

Negative aspects –effective on vegetative cells only

–inhibited by organics

Applications: wound dressings, newborn eyes, paints, water treatment

6. (Surfactant) Acid–Anionic Sanitizers

Action: disrupt plasma membrane & denature proteins

Intermediate activity

Broad spectrum

Positive aspects: –nontoxic

–non corrosive

–fast acting

–stable

Negative aspects: –expensive

–only effective at low pH

Applications: disinfection of food production surfaces

7. (Surfactant) Quarternary Ammonium Compounds (QUATs)

Action: denature proteins & disrupt cell membranes

Low activity

bactericidal on Gram-positive, fungicidal, amoebicidal, virucidal on enveloped virus

Positive aspects: –colorless, odorless, tasteless

–stable

–effective when diluted

–nontoxic

Negative aspects: –poorly effective against Gram-negative bacteria

–not effective against endospores, Mycobacteria, and non-enveloped virus

–*Pseudomonas* will grow in it

–inhibited by organics, soaps, hard water, and anionic sanitizers

Applications: skin antiseptic, mouthwash, throat sprays

8. Aldehydes (Formaldehyde, Glutaraldehyde)

Action: cross-link (thus inactivate) nucleic acids and proteins

High activity (sterilization)

biocidal including endospores

Positive aspects: –achieves sterilization

Negative aspects: –unstable

–toxic

–volatile with noxious fumes

Applications: specimen preservation (embalming), vaccine sterilization

9. Gaseous Chemosterilants

Ethylene Oxide gas (EO)

Action: binds to proteins causing inactivation

High activity (sterilization)

biocidal including endospores

Positive aspects: –safe for electronics

–highly penetrating

Negative aspects: –extremely toxic

–carcinogenic

–explosive

–requires long exposure (4–18 hrs)

–requires sealed chamber that can be safely vented

Applications: sterilization of equipment, medical supplies, bedding

10. Peroxygens

Action: oxidize cellular components: denature proteins

A. Hydrogen peroxide (H_2O_2)

Intermediate activity

Broad spectrum

Positive aspects: –cost effective

–sterilizing in vaporized high concentration form

Negative aspects: –inhibits healing

–toxic

Applications: surface, instrument, food package, & contact lens

disinfection, anaerobic wound treatment

B. Peracetic acid

High activity (sterilization)

biocidal including endospores

Positive aspects: –no toxic residues

–effective in presence of organics

Negative aspects: –corrosive on some surface

–pungent odor

Applications: disinfection of food-processing and medical equipment