

UNIT-III

DISINFECTANT



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RASMITA JENA
ASSISTANT PROFESSOR
SoPLS, CUTM, BBSR

Classification and mode of action of disinfectants

Definition

- **Disinfectant**
 - **No universally accepted definitions of disinfectants**
 - Minimum requirement: 3-Log reduction of effective microorganisms excluding spores
 - **Low-level disinfectant**
 - Most of vegetative bacteria
 - Lipid-enveloped virus (HIV)
 - **Intermediate-level**
 - Nonlipid or small virus (Poliovirus)
 - **High-level**
 - *Mycobacteria* spp. including *M. tuberculosis*
- **Sterilant**
 - **6-Log reduction of the most resistant spores achieved at the half-time of the regular cycle**

Characteristics of disinfectants

- **Materials used for elimination of microorganisms**
 - Physical aspect (Cleaning effect)
 - Biologic aspect (Antimicrobial activity)
- **Diverse applications and regulations**
 - Medical, veterinary, food, industrial, etc
 - Various application methods
 - Regulations differ from country to country
 - Associations of Official Analytical Chemists, Assications Francaise de Normalization, British Standards Institution, etc

Factors involved in the activity of disinfectants

- **Factors linked with the antimicrobial agents**
- **Factors linked with the microorganisms**
 - Nature of the microorganisms
 - Physiologic state of the microorganisms
 - Microbial communities (Flora) and biofilms
 - Natural and acquired resistance
- **Physical, physicochemical, and chemical environment of microorganisms**
 - Concentration
 - Temperature
 - Presence of organic matter
 - Electrolytes
 - Additives and components of excipients

Factors interfering with evaluation tests and criteria for activity

- Test strains: Representativeness and reliability
- Criteria for activity
- Critical point in the test method
 - Preparation of inocula
 - Neutralization or washing by membrane filtration
 - Detection and count of survivors
 - Quantitative recovery of microorganisms
 - Size of the sampling
 - Subculture and revival of survivors
 - Physical parameters of exposure: time, temperature, humidity, pH

Characteristics of disinfectants tests

- **Different from antimicrobial agent evaluation**
 - **Minimum inhibitory concentration cannot be used**
 - Not inhibition but killing
 - Neutralizer or elimination of disinfectants required
 - **Different mechanisms and of activity**
 - Non-linear killing curve of disinfectant
 - The rate of log killing decrease as the inoculum decrease
 - **Inhibitory effect and postexposure effect**
- **Broad spectrum of efficiency according to in-use environment**
 - Time, concentration, pH and temperature
 - Type and amount of microorganisms

- No acceptable method for the objective evaluation of disinfection procedure
- Various and numerous specific test methods
- Only extensive study of disinfectant capabilities
 - Biologic aspect was evaluated
 - Bactericidal, fungicidal, viricidal, sporicidal effect, etc
 - Standard strains of different species should cover
 - A sufficiently large spectrum
 - At least the targeted area
 - Technical considerations
 - Standardized methods to obtain reproducible results
 - The means of detection of surviving microbes

Disinfectants are classified as follows

- Air disinfectants
- Chemical disinfectants -
 - Organic
 - Inorganic
- Non- chemical disinfectants
- Oxidising disinfectants
- Home disinfectants
- Others disinfectants

Air disinfectants

- They are typically chemical substances capable of disinfecting microorganisms suspended in the air.
- An air disinfectant must be dispersed either as an **aerosol** or **vapour** at a **sufficient concentration** in the air **to reduce the number of viable infectious microorganisms** to be significantly reduced.
- Various **glycols**, principally **propylene glycol** and **triethylene glycol**, are **ideal air disinfectants** because they have both high lethality to microorganisms and low mammalian toxicity to inactive of diverse bacteria, influenza virus, and *Penicillium chrysogenum* (previously *P. notatum*) mold fungus

Chemical disinfectants

Organic disinfectant –

Alcohols : are most effective when combined with distilled water (concentration of 60% to 70% v/v) to facilitate diffusion through the cell membrane & have fairly rapid bactericidal action against vegetative bacteria. **Ethanol 60 to 70% v/v** and **isopropanol 50 to 60% v/v** are used as **skin disinfectants** while **methanol vapour** has been used as **fungicide**. Additionally, high-concentration mixtures (such as **80% ethanol + 5% isopropanol**) are required to effectively **inactivate lipid-enveloped viruses** (such as **HIV, hepatitis B, and hepatitis C**). The **higher alcohols** (**propyl, butyl, amyl** etc) are **more germicidal** than **ethyl alcohol**. **Alcohols** are used as **preservatives in some vaccines**.

- **Aldehyde : Formaldehyde (HCHO) is the main aldehyde used for disinfection, have a wide microbiocidal activity and are sporicidal and fungicidal.** Formaldehyde in solution is useful for sterilization of certain instruments. Sometimes, ortho-phthalaldehyde is also used.
- **Phenol and its derivatives :** Phenol is the **chief products obtained** by the **distillation of the coal tar. Phenol 1% has bactericidal action.** Many derivatives of phenol are more effective and less costly. Phenolics are active ingredients in some household disinfectants. They are also found in some **mouth washes** and in **disinfectant soap** and **hand washes**. Phenols are **toxic to cats and newborn humans**. *o-Phenyl phenol* is often used instead of phenol, since it is somewhat less corrosive

Inorganic disinfectants –

- **Acids and bases** : Sodium hydroxide, Potassium hydroxide, Calcium hydroxide, Magnesium hydroxide, Sulfurous acid, Sulfur dioxide
- **Metals**
- **Iodine** : **Iodophors are prepared by mixing iodine with the solubilizing agent**; Diluted iodophor is often used by brewers and wine makers to sanitize equipment and bottles; Its major advantage over other sanitizers is that when used in proper proportions, it does not require rinsing.

- **Chlorine** : This group comprises aqueous solution of **chlorine**, hypochlorite, or hypochlorous acid. Occasionally, chlorine-releasing compounds and their salts are included in this group. Frequently, a concentration of < 1 ppm of available chlorine is sufficient to kill bacteria and viruses, spores and mycobacteria requiring higher concentrations. Chlorine has been used for applications, such as the **deactivation of pathogens in drinking water, swimming pool water and wastewater, for the disinfection of household areas and for textile bleaching.**

Non-chemical disinfectants

- **Ultraviolet germicidal irradiation is the use of high-intensity shortwave ultraviolet light for disinfecting smooth surfaces such as dental tools, but not porous materials that are opaque to the light such as wood or foam.**
- **Ultraviolet light is also used for municipal water treatment.** Ultraviolet light fixtures are often present in microbiology labs, and are activated only when there are no occupants in a room(e.g., at night).

- The phrase "**sunlight is the best disinfectant**" was popularized in 1913 by United States. As sunlight's ultraviolet rays can act as a disinfectant, the Earth's ozone layer blocks the rays' most effective wave lengths. Therefore, ultraviolet light-emitting machines, such as those used to disinfect some hospital rooms, make for better disinfectants than sunlight.
- Heat treatment can be used for disinfection and sterilization.

Oxidising disinfectants

- Oxidizing agents act by **oxidizing the cell membrane of microorganisms**, which results in a **loss of structure and leads to cell lysis and death**. **Chlorine and oxygen** are strong oxidizers, so their large number of disinfectants operate in this way are as follows:
- Electrolyzed water or "**Anolyte**" is an **oxidizing, acidic hypochlorite** solution made by electro lysis of sodium chloride into sodium hypochlorite ; hypochlorous acid is the predominant oxychlorine species.

- **Hydrogen peroxide** is used in hospitals to disinfect surfaces and it is used in solution alone or in combination with other chemicals as a high level disinfectant.
- **Hydrogen peroxide is sometimes mixed with colloidal silver.** It is often preferred because it causes **far fewer allergic reactions than alternative disinfectants.** Also used in the **food packaging industry to disinfect foil containers.**
- **A 3% solution is also used as an antiseptic.**

- **Ozone is a gas used for disinfecting water, laundry, foods, air, and surfaces.** It is chemically aggressive and destroys many organic compounds, resulting in **rapid decolorization and deodorization in addition to disinfection.** Regardless, ozone has a very **wide range of applications from municipal to industrial water treatment due to its powerful reactivity.**
- **Potassium permanganate (KMnO₄) is a purplish-black crystalline powder that colours everything it touches, through a strong oxidising action.** It is used to **disinfect aquariums** and is used in some **community swimming pools** as a **foot disinfectant** before entering the pool.

Home disinfectants

- The most cost-effective home disinfectant is **chlorine bleach (typically a >10% solution of sodium hypochlorite)** which is effective against most common pathogens, including disinfectant-resistant organisms such as **tuberculosis (mycobacterium tuberculosis), hepatitis B and C, fungi, and antibiotic-resistant strains of staphylococcus and enterococcus.**
- It has disinfectant action against some **parasitic organisms.**

- The benefits of chlorine bleach include its **inexpensive and fast acting nature**. However it is **harmful to mucous membranes and skin upon contact**, has a **strong odour** ; and combination with other cleaning products such as **ammonia and vinegar** can generate **noxious gases like chlorine**.

Mode of action of disinfectants

- The exact mechanism of action of a disinfectant is not easy to elucidate. The notion of 'target' in the bacterial cell, frequently evoked for the antibiotics, is not clear for disinfectants (except for some, e.g. chlorhexidine).
- In understanding the mode of action of a disinfectant, it can be difficult to distinguish the primary stage (characteristic of the mode of action) and the secondary stage (consequence of the action).

- The actions of disinfectants on **the external membrane, cytoplasmic membrane and energy metabolism of cells**; these actions include **rupture of the membrane, loss of permeability and coagulation of the cytoplasm.**
- Disinfectants and biocides are a chemically diverse group of agents which are generally considered **to exhibit poor selective toxicity.**
- This **should not be mistaken for poor target specificity,** however, and much is now known concerning the damaging interactions which may arise between bacterial cell and disinfectant agent.

- Critical governing features of these interactions are the physicochemical characteristics of the chemical agent, cell morphology, and the physiological status of the microorganism.
- Antibacterial events include **membrane disruption, macromolecule dysfunction, and metabolic inhibition**; the consequential effect is determined by the relative contribution(s) of the target(s) to microbial cell survival and the possible initiation of self-destructive processes.
- Disinfection kinetics offer a **measure to differentiate between physiochemical and chemical interactions**.

Antiseptics and their evaluation

What is an Antiseptic?

- Antiseptics can be defined as **antimicrobial agents which can be applied on the body of living organisms to inhibit the action of microbes.**
- They are **not injected into the body like the antibiotics**, rather they are **applied on the surface of the skin to heal the living tissues** in case of wounds and cuts.
- **Dettol** is the most commonly used antiseptic. It is a **mixture of chloroxylenol and terpineol.**
- **Iodoform** is also used as an antiseptic for wounds.

Types of Antiseptics

- Some antiseptics are **germicial** in nature, implying that they have the ability to completely destroy microbes. These types of antiseptics are referred to as **bacteriocidal** antiseptics.
- Other antiseptics **only inhibit the growth of microbes** (or prevent the growth of microbes altogether). Such substances are commonly referred to as **bacteriostatic** antiseptics.

The Difference between Disinfectants and Antiseptics

- Disinfectants and antiseptics are both used for killing the microbes but still, there is a difference between them.
- An **antiseptic** is used for **killing the microbes on the living tissues** whereas a **disinfectant** is applied on a **non-living object**.
- Secondly, the **concentration of both differ**. We can use the **same chemical** as a disinfectant and an antiseptic by **varying its concentration**.
- For example, **phenol** can be used as an **antiseptic** if its concentration is **0.2 %** but to use it as a **disinfectant** the concentration should be **1%**.
- We can broadly conclude that the **cleaning products contain disinfectants** and the **healing products** (for curing the living tissues) contain **antiseptics**.
- Both are similar in nature but vary in their concentration. **Lysol is a disinfectant** whereas **Dettol is an antiseptic**.