JoVE: Science Education

Decontamination for laboratory biosafety

--Manuscript Draft--

Manuscript Number:	10399
Full Title:	Decontamination for laboratory biosafety
Article Type:	Manuscript
Section/Category:	Manuscript Submission
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Science Education Title: Decontamination for Laboratory Biosafety

Overview:
Decontamination is essential for laboratory biosafety, as the accumulation of microbial contamination in the laboratory can lead to the transmission of disease. Depending on the degree of decontamination, it can be classified as requiring disinfection or sterilization. Disinfections aim to eliminate all pathogenic microorganisms with exception for bacterial spores on lab surfaces or equipment. Sterilization, on the other hand, eliminates all microbial life. Different methods are available which include chemicals, heat, and radiation, and once again depend on the degree of decontamination, as well as concentration of the contaminating microorganisms, presence of organic matter, and type of equipment or surface to be cleaned. Each method has its advantages and cautions that need to be taken to avoid hazards.

Principles:
Be clear about the degree of decontamination that needs to be conducted in the laboratory and then inspect the type, concentration, and location of microorganism present in the lab. With this information, choose the suitable methods depending on the features of each method and determine the most appropriate plan to resolve contamination issues. For example, if a chemical decontamination method is used, a decision must be made regarding the appropriate temperature and contact time applied. Precautions are needed for each method to avoid subjecting individuals to chemical and physical hazards and radiation during decontamination.

Procedures

1. Chemicals

   1.1 Liquid Chemical

   Liquid disinfectants are widely used for lab decontamination. The effectiveness of liquid disinfectants depends on a number of factors, such as the chemical nature of the disinfectant, concentration and quantity of disinfectant, contact time, and temperature. Remember, no liquid disinfectants are applicable at all conditions and make sure to select suitable disinfectants according to the detected microorganisms, using the following criteria.~~ Here listed the selection criteria when choosing suitable disinfectants.~~

   a. Type of contaminating microorganism. Different microorganisms have different resistant abilities towards disinfectants. For example, Bacterial Spores are much more chemical resistant than Lipophilic Viruses.
   b. Amount of proteinaceous material present. For example, high protein materials absorb and neutralize some chemical disinfectants such as formaldehyde and quaternary ammonium compounds.
   c. Amount of organic material present. For example, quaternary ammonium compounds ~~is~~are less effective in the presence of soap, detergents.
   d. Chemical nature, concentration, quantity, pH, application temperature, and toxicity of disinfectants.

Make sure suitable PPE is worn when working with chemical disinfectants.

1.1.1 Low-Level Disinfectants

A. Quaternary Ammonium (QA) Compounds: (~~—~~such as benzalkonium chloride, ammonium chloride~~-~~)

- ~~QA disinfectants are e~~Effective against Gram+ bacteria, Gram- bacteria, and enveloped viruses.
- ~~QA disinfectants are~~ NOT~~not~~ effective against non-enveloped viruses, fungi, and bacterial spores.
- ~~QA disinfectants c~~Contains NH_4^+ and ~~make~~ provide good contact with negatively charged surfaces, ~~.~~ making them ~~G~~good cleaning agents.
- Low in toxicity but can be irritating when exposed for long ~~time~~durations.
- Commonly used in noncritical surfaces such as floors, furniture, and walls.

B. Phenolics: (O-phenophenoate-based compounds)

- Effective against bacteria, especially Gram+ bacteria and enveloped viruses.
- NOT~~ot~~ effective against non-enveloped viruses and spores.
- Compatible with organic materials.
- Low in toxicity but can be irritating when exposed for long ~~time~~durations.
- Commonly used in hospital environments, laboratory surfaces.

1.1.2 Intermediate-Level Disinfectants

A. Alcohols (such as ethyl alcohol and isopropyl alcohol)

- Effective against Gram+, Gram- bacteria, and enveloped viruses.
- NOT~~ot~~ effective against spores and limited effective against non-enveloped viruses.
- Optimum concentration is in the range of 60-90%. Activity drops quickly when diluted below 50%.
- Commonly used in healthcare settings.
- Alcohols are flammable and quickly evaporate ~~fast~~.

B. Halogen-Based Biocides: (Chlorine-based compounds and Iodophores)

Chlorine Compounds.

- Hypochlorites are the most widely used chlorine disinfectants.
- Effective against both enveloped and non-enveloped viruses, fungi, bacteria, and algae.
- NOT~~ot~~ effective against spores.
- Quickly inactivated by organic matter.
- Degraded fast due to the high oxidizing power.

Iodophores: An iodophor is a combination of iodine and a solubilizing agent or carrier; the resulting complex provides a sustained-release reservoir of iodine and releases small amounts of free iodine in aqueous solution.

- Effective against bacteria, spores, and fungi.
- Needs prolonged contact time.
- NOT~~ot~~ effective in the presence of organic matter.
- Commonly used as antiseptics, used for blood culture bottles, and medical equipment.

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1.1.3 High-Level Disinfectants

A. Oxidizers and Acids (Hydrogen peroxide, Peracetic Acid)

The effect is not dependent on ~~the~~ pH alone. For example, weak organic acids are more potent than inorganic acids despite the low dissociation constant.

Hydrogen peroxide

- Effective against enveloped and non-enveloped viruses, vegetative bacteria, fungi, and bacterial spores.
- Often used as antiseptics to clean wounds and disinfect environmental surfaces.
- High concentration is harmful for tissues.

Peracetic Acid

- Effective against all microorganisms with ~~a~~ fast action.
- Effective in the presence of organic matter and low temperatures.
- Safe with no harmful decomposition products.
- NOT~~ot~~ suitable for metals due to corrosion.
- Commonly used in automated machines to sterilize medical, surgical, and dental instruments.

B. Aldehydes (Formaldehyde, Glutaraldehyde)

Formaldehyde

- Used as a disinfectant and sterilant both in gases and liquid states.
- Often used in 37% percent in water solution, known as formalin.
- Effective against bacteria, fungi, viruses, and spores.~~,~~
- Hazardous with 8 hour time weighted exposure limit of 0.75 ppm.
- Polymerized solid form—Paraformaldehyde—is also a strong disinfectant~~s~~.

Glutaraldehyde

- 10 times more effective than formaldehyde.
- Effective against vegetative bacteria, spores, and viruses.
- Used to sterilize equipment.
- Effective in present of organic material.
- Hazardous with ceiling threshold limit 0.2 ppm and avoid skin contact.

1.2 Gases or Vapor

Vapors and gases of disinfectants include chlorine dioxide, ethylene oxide, hydrogen peroxide, peracetic acid, and so on. These vapors and gases show excellent disinfection properties in closed systems such as biosafety cabinets and animal room facilities. However, well-controlled conditions of temperature, humidity, and inert gas—if flammable—must be maintained for safety. These gases or vapors are used in hospitals and commercial facilities with the need of a closed system with tight~~, well~~ control of the temperature, humidity, and concertation.

2. Heat

2.1 Dry Heat

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Dry heat is used under conditions of 160-170 °C for periods of 2-4 h in an appropriate oven. This method is often used for glassware or other non-porous heat conductive materials. However, it's ineffective for insulation materials or heat-labile materials.

2.2 Wet Heat

Wet heat, also known as autoclaving is usually under the conditions of at least 120 °C for periods of 30-60 min. It's the most convenient and dependable method to achieve effective and rapid sterilization of most forms of microbial life. Wet heat is more efficient than dry heat due to the shorter time and lower temperature required.

3. Radiation

3.1 Ionizing Radiation

Ionizing radiation is not used in general laboratory sterilization due to potential issues associated with radiation safety.

3.2 Non-ionizing Radiation (Ultraviolet, UV)

Ultraviolet radiation is typically used for decontamination in air, water, and surfaces due to its strong ability to destroy microorganisms. UV is also widely used in biological safety cabinets. The wavelength of ultraviolet radiation ranges from 250 nm to 270 nm with 265 nm as the optimum. However, UV lamp intensity drops with time, and maintenance need to be taken after certain time to maintain the power. Additionally, precautions need to be taken for UV light, as it can cause burns to the eyes or skin.

Summary:

To avoid infection transmission and maintain biosafety in the lab, periodic decontamination in the lab is important. Three methods are available including chemical, heat, and radiation. Each method has its own strength and suitable applications. Awareness of the type of microorganism in the laboratory environment is useful for selection of a suitable decontamination method. Appropriate safety protocols should be in place during the decontamination procedure.

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