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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – I – Medical Waste Management – SBM1608

UNIT 1

INTRODUCTION

Hospital and other health care establishment has a duty of care for the environment and for public health and have particular responsibility in relation to the waste they produce. The establishment is done to ensure that there are no adverse health and environmental consequences of the waste handling, treatment and disposable activities.

Definition of Biomedical Waste

Health care waste includes any solid or liquid waste, its container and any intermediate product which is generated during the diagnosis, treatment or immunization of human beings and animals.

Classification of Biomedical Waste:

Hazardous (10 – 2.5%)

i. Infectious (5 – 18%) (10 – 25%)
   - Non sharps
   - Sharps
   - Plastics disposables
   - Liquid waste

ii. Other hazardous (5 – 7%)
   - Radioactive waste
   - Discarded glass
   - Pressurized containers
   - Chemical waste
   - Cytotoxic waste
   - Incinerator ash Non – Hazardous (75 – 90%)

     Eg: Plastic, Glass, Cardboards.

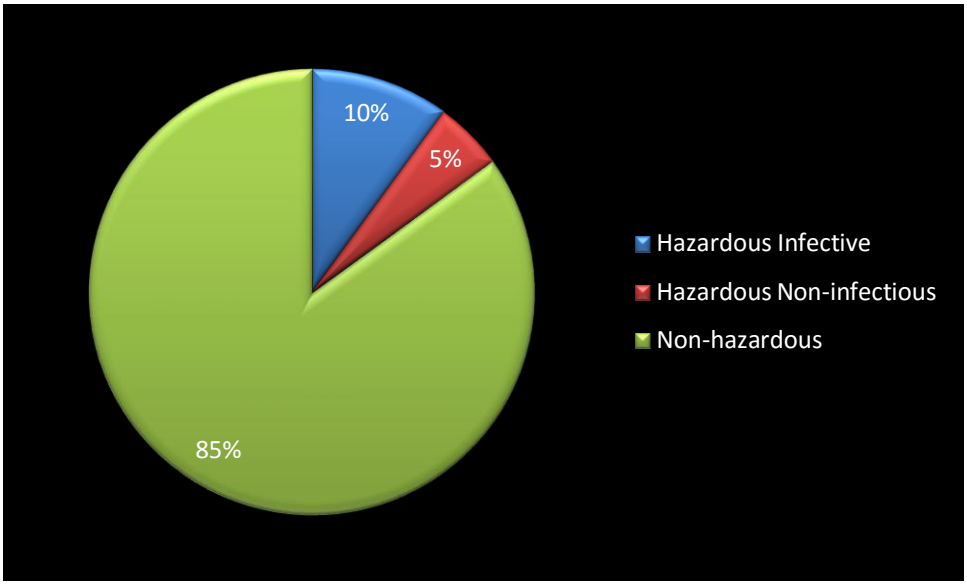


Figure 1

Rules for Biomedical Waste

28 July, 1988, Ministry of Environment & Forest has made BMW (Biomedical Waste Management) mandatory. The rule is applied to those who generate waste, collect, receive, store, dispose and treatment.

Health Care Waste Management

It includes all the waste generated by health care establishment, research facilities and laboratories. In addition, it includes the waste originating from minor sources produced in health care undertaken in the home. Eg: Dialysis & Insulin Injection.

Health care waste management includes

i. Health care general waste (75 – 90%)
   - Packaging
   - Food preparation & non-contaminated waste

ii. Health care risk waste (10 – 25%)
   - Infectious waste
   - Waste harmful to human & environment

Sources of Biomedical Waste

Hospital, nursing home, clinic, blood bank, medical lab, animal houses.

Need for BMW

i. The controlled nosocomial infection (acquired from hospital)

ii. Repackaging of disposed drug.

iii. Air and water pollution.

iv. Risk of infection outside the hospital for scavengers & waste handlers.

v. Indiscriminate disposal of biomedical waste ensure that such waste is handled without any adverse effect on the human health & environment.

Biomedical Waste Management

When hazardous waste not segregated at the source of generation and mixed with non-hazardous, it becomes 100% waste hazardous.

Reasons for Biomedical Waste Management

i. Injuries from sharp leading to infection to all categories of HCW's.

ii. Health care associate infection inpatient, poor infection control practices and poor waste management.

iii. Risk of infection outside hospital for waste handlers.

iv. Risk of air, water and soil pollution directly due to infective incineration, emission & ash.

v. Drugs which have been disposed of being repaired.

Approaches of Biomedical Waste

i. Segregation of waste

ii. Collection

iii. Storage

iv. Transportation

v. Treatment & disposal of hospital waste

vi. Safety measures

vii. Co-ordination between hospital & outside agencies.

General Hazardous Health Care Waste

It includes a large component of general waste & a small proportion of hazardous waste.

Types of Hazards

i. It contains infectious agent

ii. Genotoxic

iii. Toxic or hazardous chemical

iv. Radioactive

v. Sharps

Person's At Risk

The main groups at the risk are the following:

i. Medical doctors

ii. Nurses

iii. Health care auxiliaries

iv. Hospital maintenance personnel

v. Visitors to health care establishments

vi. Workers in waste disposal facilities (such as landfills, scavengers, incinerators).

Hazards from Infectious Waste and Sharps

Infectious waste may contain any of a variety of pathogenic microorganism.

Pathogens in infectious waste may enter the human body by number of route through a puncture, skin abrasion, through mucus membrane by inhalation & ingestion.

Sharp may not only cause cut & puncture but also infect the wound, if they are contaminated with pathogens.

Because of this double risk of injury & disease transmission sharp considered as a very hazardous waste class.

Eg: Hypodermic needle constitute an important part of the sharp waste category & are particularly hazardous because they are often contaminated with patient's blood.

Hazards from Chemical and Pharmaceutical Waste

Many of the chemicals and pharmaceuticals used in health care establishment are hazardous.

Eg: Toxic, Genotoxic, Corrosive flammable, Reactive & Explosive.

These substances are commonly present in small quantities in health care waste, larger quantities may be found when unwanted are outdated chemicals & pharmaceuticals are disposed off. These may cause intoxication either by acute or chronic exposure.

Intoxication can result from absorption of chemical or pharmaceutical through the skin, from inhalation or ingestion.

Injuries to the skin, eye, the mucus membrane of the airway can be caused by contact with flammable corrosive or reactive chemicals.

Eg: Formaldehyde & other volatile substances.

Disinfectants used in large quantities are often corrosive. These reactive chemicals may form highly toxic secondary products.

Pesticides stored in leaking drum, tom vase can directly or indirectly affects the health anyone who comes into contact with them.

During heavy rain leak pesticides can seep into the ground and contaminate the ground water.

Poisoning can occur through direct contact with the product, inhalation of vapors, ingestion of contaminated water & food.

Chemical residues discharge into the sewerage system may have adverse effect on the operation of biological sewage treatment plan on toxic effect on the natural ecosystem of sewing water.

Pharmaceutical residues which may include antibiotics, heavy metals, phenols & antiseptic.

Hazards from Genotoxic Waste

Exposure to genotoxic substances in health care may occur during the preparation or treatment with particular drug are chemicals.

The main pathway of exposure are inhalation of dust, aerosols, absorption through the skin, ingestion of food accidently contaminated with cytotoxic drug, chemicals or waste.

Exposure may also occur through contact with the body fluids and secretion of patients undergoing chemotherapy.

Many cytotoxic drugs are extremely toxic and irritant. They have harmful local effect on skin and eyes.

Hazard from Radioactive Waste

This type of disease caused by radioactive waste is determined by the type and extent of exposure.

Radioactive waste like certain pharmaceutical product is genotoxic. It may also effect genetic material (DNA & RNA).

Handling of highly active sources. Eg: Certain sealed sources from diagnostic instrument may cause severe injuries such as destruction of tissue & amputation of body parts.

Color Coding

Color	Container	Waste	Treatment
Yellow	Plastic bag	Anatomical Waste (tissue, organs, cultured samples)	Incineration
Red	Disinfected container, plastic bag	Microbiology, Biotechnology, Soiled solid waste	Shredding
Blue	Plastic bag, Puncture proof, Container	Sharp (needle, solid waste)	Shredding
Black	Plastic bag	Dental health care waste, Domestic waste, Discarded medicine	Landfilling
Brown	Plastic bag or container	Chemical and Pharmaceutical waste	Landfilling
Yellow marked sharp	Puncture proof container	Sharp	Shredding
Yellowmarked ‘Highly Infectious’	Strong, leak proof plastic bag	Highly infectious waste	Autoclaving

Container used in the Waste Disposal

Sharp should all be collected together regardless of whether or not they are contaminated.

Containers should be punctured proof usually made of metal or high density plastic and fitted with cover. They should be rigid and impermeable so that they safely retained not only the sharp but also any residual liquids from syringes.

Containers made up of dense cardboard are recommended by WHO in 1997, where plastic or metal containers are unavailable or too costly.

Plastic containers should be transported with the plastic lining.

Bags and containers for the infectious waste should be marked with the International Infectious Standard symbol.

Red bags suitably used for autoclaving are recommended for highly infectious waste which are parked in bags.

Cytotoxic waste should be collected a strong leak-proof container clearly labeled cytotoxic waste.

Pharmaceutical waste generated that is spilled or contaminated drug should not be returned because of the risk of contaminating the pharmacy. It should be deposited in the correct container.

Chemical waste – It should be packed in chemical resistant container and send to specialized treatment facilities.

The identity of the chemicals should be clearly marked on the container, hazardous chemical waste of different types should never be mixed.

Low level radioactive infectious waste. Eg: Swabs, syringes may be collected in yellow bag or container.

Domestic refuse is collected in black bag.

No health care waste other than sharp should be deposited in sharp container as these container are more expensive than the bags used for other infectious waste.

Appropriate container or bag holders should be placed in all locations where particular categories of waste may be generated.

Instruction on waste separation and identification should be posted at each waste collection point to remind the staff of their procedures.

Containers should be removed when they are three-quarter full.

Staff should never attempt to correct errors of segregation by removing items from a bag or container after disposal are by placing one bag inside another bag of a different color.

If general & hazardous waste are accidently mixed, the mixture should be treated as hazardous health care waste.

Health Care Waste Segregation

3 categories of health care waste are recognized –

i. Generals (non-risk) waste includes uncontaminated waste similar to domestic waste.

ii. Hazardous health care waste

- Infectious waste
- Anatomical or pathological waste
- Waste contaminated with human blood
- Chemical & Pharmaceutical residues.

Eg: Bottles, small quantities of outdated products.

iii. Highly Hazardous Health care waste

- Sharp

Eg: Hypodermic Needles

- Highly infectious non-sharp waste including microbial cultures
- Carcasses of inoculated laboratory animals.
- Stools from cholera patients
- Bulk quantities of outdated hazardous chemical Eg: Strong disinfectant mercury
- Genotoxic waste – Eg: radioactive or cytotoxic waste used in cancer chemotherapy.

Segregation

Segregation can substantially reduce the quantity of health care waste that requires specialized treatment.

To make separate collection, the hospital personnel at all levels especially nurses, staff and cleaners should be trained to sort the waste they produce.

Segregation of Health Care Waste

Waste		Receptacle		
Category	**Description**	**Type**	**Color & Marking**	**Characteristics**
Hazardous	Non-sharp infectious waste, pharmaceutical chemical residue	Container or plastic bag in a holder	Yellow	Leak-proof
Highly Hazardous	Highly infectious non-sharp waste	Container or plastic bag in a holder	Yellow marked "Highly Infectious"	Leak-proof suitable for autoclaving
Sharp	Sharp	Sealed box, drum, cardboard	Yellow marked sharp	Puncture proof, leak proof
General	Similar to Municipal waste not contaminated by hazardous substances	Plastic bag or container	Black	No special requirement

Packaging

Selection of appropriate packaging is difficult in establishment because they cannot afford disposal plastic bag or container.

Collection & Storage

- Nursing and other clinical staff should ensure that waste bags are tightly closed or sealed when they are about three quarter full.
- Light guage bags can be closed by tiring the neck, but heavier guage bags require a plastic sealing tag of the cell locking tie.
- Bags should not be closed by stapling.
- No bags should be removed unless they are labeled with the point of production & content.
- Waste should be collected and transported to the central storage site.

Storage of Waste

A storage location for health care waste should be designated inside the health care establishment or research facility.

- The waste, in bags or container should be stored in a separated area, room or building of a size appropriate to the quantity of waste produced and the frequency of collection.
- Unless a refrigerator storage room is available storage time for health care waste should not exceed.

  Eg: Temperate climate → 72 hours in winter, 48 hours in summer.

  Warm Climate → 48 hours during a cool season, 24 hours during the hot season.

Cytotoxic Waste

It should be stored separately from other health care waste in a secured location.

Radioactive Waste

It should be stored in container that prevents dispersion.

Waste that is to be stored during radioactive decay should be labeled with the type of radio nucleotide, the day and details of required storage condition.

Recommendations for Storage Facilities for HCW

- Storage area should have an impermeable hard floor standing with good drainage, it should be easy to clean and disinfectant.
- Water supply for cleaning purpose.
- Easy access of staff incharge handling the waste.
- It should be possible to lock the store to prevent the access by unauthorized person.
- It should be protected from sun.
- Easy access for waste collection vehicle is essential.

- A supply of cleaning equipment, protecting clothing and waste bag or containers should be located conveniently closed to the storage area.

Preparation of Transportation

- Before transportation of the waste, dispatched document should be computed.
- All arrangements should be made between consignor, carrier, consignee.
- In case of exportation, the consignee should have conformed with the relevant authorities that the waste can be legally imported and that no delay between the delivery of the consigner to its destination and it should be properly labeled if it is hazardous.

  Eg: UN No. 2814 Infectious substance affecting humans

Types of Transportation

i. Onsite Transportation:

- Health care waste should be transported within the hospital or other facilities by means of wheeled trolleys, container or carts.
- It must be easy to load and unload.
- No sharp edges that will damage waste bag.
- It must be easy to clean.
- The vehicle should be cleaned and disinfected daily with an appropriate disinfectant.
- All waste bags seals should be placed intact until the end of transportation.

ii. Off-Site Transportation:

- The health care waste produce is responsible for safe packaging and adequate labeling of waste to be transported offsite and for authorization its destination.
- Packaging and labeling should compile with national regulation governing the transport of hazardous waste.

- The transporting organization should be registered or should know to the waste regulation authority.

Transportation Vehicles or Containers

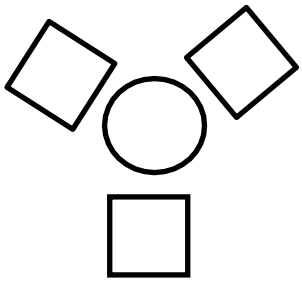
Waste bag may be placed directly into the transportation vehicle, but it is safer to place them in further container. Eg: Cardboard boxes (or) galvanized bins.

This has a advantage of reducing the handling of filled waste bag but results in higher disposal cost.

Labeling

All waste bags or containers should be labeled with basic information on the content & on the waste producer. This information may be written directly on the bag or container of on 3 printed labels securely attached.

For eg:



Labeling should contain –

i. Waste categories
ii. Date of collection
iii. Place in hospital where it is produced (Eg: ward)
iv. Waste destination

Labeling also warn staff and the general public of the hazardous nature of the waste.

Disposal of Waste

1. Autoclaving

It is an efficient wet thermal disinfection process. Typically autoclaves are used in hospital for the sterilization of reusable medical equipment.

They allow for the treatment of only limited quantities of waste and are therefore commonly used only for highly infectious waste such as microbial culture or sharp.

The physical requirement for effective steam autoclave treatment are normally different from those required for sterilizing medical supplies, minimum contact time and temperature will depend on several factors such as the moisture content of the waste and their penetration power.

Eg: Effective inactivation of all vegetative microorganisms & most bacterial spores in a small amount of waste about 5 to 8 Kg requires 121°C at 151 lbs for 1 hour. This allows full stream penetration of the waste material.

2. Screw feed Technology

If the basis non burn dry thermal disinfection process in which waste is shredded & heated in a “rotating auger”.

Waste is shredded to particular about 25 mm in diameter

↓

Waste enters the auger

↓

Which is heated to a temperature of 110° – 140° C by oil

↓

Circulating through its central shaft

↓

Waste rotates through the auger for about 20 minutes

↓

After which residues are compacted.

Application

This process is suitable for treating waste & sharp but it should not be used to process pathological, cytotoxic or radioactive waste.

3. Microwave Radiation

Most microorganisms are destroyed by the action of microwaves of a frequency of about 2450 MHz and a wavelength of about 12-24cm.

A water contained within the waste is rapidly heated by the microwaves and the infectious components destroyed by heat conduction.

Loading device transfers

↓

The waste into a shredder

↓

Where it is reduced into small pieces

↓

Waste is then humidified transferred to the irradiation chamber

↓

Which is equipped with a series of microwave generations

↓

Irradiated for about 20 minutes

↓

After irradiation the waste is compacted inside a container

4. Incineration

The process of incineration involves mining waste with cement before disposal in order to minimize the risk of toxic substances present in the waste migrating surface water or ground water.

It is especially suitable for pharmaceutical and for incineration ashes with high metal content.

Mechanism

Pharmaceutical waste

↓

Packaging should in removed

↓

Pharmaceutical ground

↓

Mixture of H_2O, lime and cement are added

↓

Homogeneous mass are formed

↓

Pellets are produced on site

↓

Transported to a suitable storage site

↓

Alternating the homogeneous mixture can be transported

In liquid state to a land fill

↓

Poured into municipal waste.

The following are typical proportion for the mixture 65% of pharmaceutical, 15% of lime and cement 5% of water.

Advantage

- The cost is reasonable
- The process is reasonable, in expenditure and can be performed using unsophisticated equipment.

Land Disposal

1. **Capsulation**: Disposal of health care waste in municipal land fill is less advisable if it is untreated. One option for pre-treatment is encapsulation.

Mechanism

Encapsulation which involves filling containers with waste

Adding immobilizing materials

Sealing the containers

The process uses either cubic made up of high density polyethylene (or) metallic drums

Which are three quarters filled with sharp, chemical and pharmaceutical residues

Containers is filled with medium such as plastic foam, cement mortar (or) clay

After medium is dried

Containers are sealed

Disposed off in land sites

Advantage

- It is relatively safe, sharp and widely used for sharp, chemical and pharmaceutical residues.
- It is very effective in reducing the risk of scavenger accessing the hazardous health care waste.

Safe burial on hospital premises

- It is usually done particularly in remote location. Eg. Refugee encampments.
- The burial site should be buried with a material of low permeability such as clay to prevent pollution of any shallow groundwater that may subsequently reach near by well.
- It should practicable only for limited period (1 – 2 years)
- Relatively small quantities of waste upto 5 – 10 tonnes in total.

Land disposal of residues

After disinfection or incineration infectious health care waste becomes nn-risk waste and may be finally disposed of in land fill sites.

Municipal disposal sites

- Open dumps are characterized by the uncontrolled and scattered deposit of waste at a site which leads to acute pollution problems.
- Health care waste should not be deposited around open dumps. The risk of either people or animal coming into contact with infections pathogens either directly through wound, inhalation or ingestion or indirectly through the food chain.

Sanitary land filling

It is designed to have atleast 4 advantages over open dump.

i) Geological isolation of waste from the environment.

ii) Appropriate engineering preparation before the site is ready to accept waste.

iii) Staff present on site to control operation.

iv) Daily courage of waste.

Disposing of certain types of health care waste and small quantities of pharmaceutical waste in sanitary land fill is acceptable.

Sanitary landfill prevents contamination of soil, surface water and ground water which also limits are pollution small and direct contact with public.

Pit should be 2 m deep

↓

And the waste is filled the depth of 1 – 1.5 m

↓

After each waste load

↓

Waste should be covered with a soil layer of 10 – 15 m deep of covered with lime

↓

Access to this disposal area should restricted

↓

Pits make suppression by land fill staff easier

↓

This presents scavenging.

TEXT / REFERENCE BOOKS

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UNIT 1:

2mks:

1. Define biomedical waste.
2. What are the classifications of biomedical wastes?
3. What is the need for biomedical wastes?
4. What are the approaches of biomedical wastes?
5. State the persons affected with biomedical wastes?
6. Differentiate between:(a) sharps and non-sharps

   (b) Hazardous and non-hazardous
7. Define genotoxic and radioactive wastes.
8. Differentiate between autoclaving and incineration.
9. Brief about segregation and packaging of biomedical wastes.
10. Define labelling.

12mks

1. Discuss the role of colour coding and type of containers for the disposal of medical wastes.
2. Explain in detail about the hazards from various types of hazardous wastes.
3. Explain briefly about the procedures of segregation, collection of biomedical wastes.
4. Explain briefly about the containers used in waste disposal.
5. Explain in detail about the transportation of medical wastes.
6. Explain in detail about the disposal of waste and its methods.
7. Explain the mechanism of land disposal and sanitary land filling.
8. Write in detail about health care waste and its segregation.
9. Write the different methods of decontaminating the biomedical waste before disposal for land filling.
10. Explain in detail about the mechanism of:

    (a) autoclaving

    (b) screw feed technology

    (c) microwave radiation

    (d) incineration

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UNIT 2

BIOMEDICAL WASTE

i) Infectious Waste

Infectious waste is suspected to contain pathogens (Bacteria, Viruses, parasites or fungi). Insufficient concentration or quantity to cause disease in susceptible course.

Category includes –

- Cultures and stock of infectious agent from laboratory work.
- Waste from surgery and atopsis on patient with infectious disease. Eg: Tissue and material or equipment that have been contact with blood or other body fluids.
- Waste from infected patient in isolation ward. Eg: Excreta, dressing from infected or surgical wound.
- Clots having soiled with human blood or body fluids.
- Infected animal from laboratories.
- Cultures and stock of highly infectious agent, waste from atopsis, animal bodies and other waste item that have been inoculated infected or in contact with such agents are called Infectious waste.

ii) Pharmaceutical Waste

It includes expired, unused, contaminated pharmaceutical product, vaccine, drugs and sera that are no longer required and need to be disposed off.

iii) Genotoxic Waste

- Highly hazardous and may have mutagenic, carcinogenic properties.
- It raises serious safety problems both inside hospital and after disposal and should be given special attention.
- It may includes cytotoxic drug. Eg: Tamoxifen.

Vomit, urine or faeces from patients treated with cytotoxic drugs, clinical and radioactive material.

- Cytotoxic drug or actineoplastic drug, the principle substance in the category, have the ability to kill or stop the growth of certain living cells and are used in chemotherapy of cancer.
- Cytotoxic drugs are widely used in neoplastic condition, organ transplantation and as immunosuppressive agents.
- Cytotoxic drugs are most often used in specialized department such as oncology and radiotherapy units and the usage in hospital department is increased.
- Harmful cytostatic drug can be categorized as

    i. Alkalytic agents – which causes alkalization of DNA molecules which leads to cross linking and miscoding of genetic stock.

    ii. Antimetabolites – which inhibits the biosynthesis of nucleic acid in the cell.

    iii. Mitotic inhibition – which presents cell replication.

Cytotoxic waste are generated from several sources

- Contaminated materials from drug preparation and administration such as syringes, needles, vial and packaging.
- Outdated drugs return from the ward.
- Urine, faeces and vomit from patients which may contain potentially hazardous amount of the administrated cytotoxic drug or the metabolites and which should be considered as genotoxic waste for atleast 48 hours and sometimes upto 1 week after drug administration.

iv) Chemical Waste

- Chemical waste consists of discarded solid, liquid and gaseous chemical. Chemical waste from health care may be hazardous or non-hazardous. Hazardous chemical will be toxic, corrosive, flammable, reactive and genotoxic.

- Non-hazardous chemical waste consist of chemicals with none of the above properties such as sugar, amino acids and certain organic and inorganic salts.

- The types of hazardous chemical commonly used in maintenance of health care centre and hospital are –

    i. Formaldehyde – is a significance source of medical waste in hospital. It is used to clean and disinfectant equipment and pressure specimen such as pathology and autopsy material. It is usually used disinfect liquid infectious waste, dialysis equipment and nursing unit.

    ii. Photographic chemicals – Photographic fixing and developing solution are used in X-ray department. The fixed solution contains 5-10% Hydroquinone, 1-5% Potassium hydroxide and 1% Silver. The developer contains approximately 45% Glutaraldehyde and acetic acid.

    iii. Solvents – Waste containing solvents are generated in various department of hospital including pathology and histopathology laboratory. Solvent used in hospital includes halogenated compound such as Chloroform, Trichloro ethylene and non-halogenated compound such as Xylene, Methanol, Acetone, Isopropanol, Ethylacetate and Toluene.

    iv. Organic Chemicals – Disinfectant and chemical solutions such as phenol based chemical used for scrubbing floors. Perchloroethylene used in workshop and laundry, insecticides and rodenticides.

    v. Inorganic Chemicals – Waste contains mainly acids and alkali's. Eg: Sulphuric acid, Hydrochloric acid, Nitric acid and Chronic acid. Eg: Sodium hydroxide and Ammonium solution.

    vi. Heavy metals – Waste with high metal content represent a sub category of hazardous chemical waste and are usually highly toxic. Mercury waste are typically generated by spillage from broken clinical equipment. Eg: Thermometer and BP equipment, Residues from dentistry have a high mercury content, Cadmium waste mainly released from discarded battery, Lead are still used in radiation proofing of X-ray and diagnostic department.

vii. Pressurized Container – Many types of gases are used in health care. Eg: Anesthetic acids, Ethylene oxide, oxygen and compressed air which are often stored in pressurized cylinder and aerosol cans.

Many of them ones empty must be disposed off immediately.

Potentially harmful gases in pressurized container always be handled with care. Containers may exploit if it is incinerated or accidently punctured.

viii. Pathological Waste – It consist of tissues, organ body parts, human fetus and animal carcasses, blood and body fluid. Within this category recognizable human or animal body part are also called anatomical waste.

ix. Radioactive Waste – Ionizing radiation cannot be detected by any of the sensor than burns, which may occur in exposed areas usually causes no immediate effect unless an individual receive a very high dose.

The ionizing radiation of interest in medicine includes X-ray, α and β and γ – rays emitted by radioactive substance.

An important practical difference between these types of radiation is that X-rays from X-ray tubes emitted only when equipment is switched ON whereas radiation from radio nucleus can never be switched off and can be avoided only by shielding the material.

α – particles – are heavy positively charge, low penetration power and are hazardous to humans via inhalation.

β – particles – They have the ability to penetrate the human skin. They affect to ionization of intra-cellular protein.

γ – rays – They have high penetrating power, similar to X-rays but shorter wavelength.

Generation of Radioactive Waste in Health Care

Radioactive waste includes solid, liquid and gaseous material contaminated with radio nucleus. It is produced as a result of invitro analysis of body tissue and fluid, invivo organ imaging, tumor localization and therapeutic practices.

Radionuclei is used in health care are usually conditioned as unsealed or sealed source.

Unsealed source. Eg: liquids that are applied directly

Sealed sources. Eg: Radioactive substance present in parts of equipment.

Sources of Radioactive Waste

1. Sealed source
2. Spend radionucleotide generator
3. Low level solid waste. Eg: Swab, glassware, syringe, vials.
4. Residues of radioactive materials
5. Unwanted solution of radionucleotide intended for diagnostic or therapeutic.
6. Liquid scintillation counter residues used in RIA
7. Waste from radioactive spill.
8. Waste Sharp – Sharps are item that cause cut, puncture, wound including needles, hypodermic needles, knife, scalpel, blade, infusion set.

   Whether or not they are infected such items are usually considered as highly hazardous health care waste.
9. Highly Infectious Waste – It is present in microbial culture and stock of highly infectious agent from medical analysis laboratory. They also include body fluid of patient highly infectious diseases.

Categories and Characterization of Biomedical Waste or Health Care Waste

10 – Categories of health care waste

Categories	Types of Waste	Origin	Treatment / Disposal
Category 1	Anatomical Waste i. Human tissues, organs, body parts ii. Animal tissue, organ, fluids, experimental animals used in research, discharge from hospital & animal house	Lab, isolation ward, OT	Incineration, Deep burial
Category 2	Pathological Waste i. Microbiology & Biotechnology waste. ii. Waste from culture, stock, specimens of live microorganism, vaccine, toxin.	Pathology lab, OT(Operation theatre), Operating room	Microwaving, Incinerators
Category 3	Hazardous Pharmaceutical Waste Expired, unused contaminated drugs & vaccines, discarded item like bottle, vials, connecting tubes and cytotoxic drugs	Pharmacy, OT	Incineration, secured landfill
Category 4	Hazardous Chemical Waste Discarded chemical(solid, liquid, gas material), unused lab reagent	Dark room (X-ray film developing rooms)	Autoclaving land burial
Category 5	High content of heavy metal – Mercury, Lead, Cadmium, Silver	Thermometer, Barometer, Portable equipment	Buried in safe land
Category 6	Pressurized Container	ICU, OT, patient operating room	Incineration, Deep burial
Category 7	Sharp needle, plastic needle	Patient operating room & clinical lab	Incineration, safe burial and shredding
Category 8	Solid waste items contaminated with body fluid (cotton, bandage plaster, sutures)	OT, Patient operating room	Incineration, Microwaving
Category 9	Radioactive waste Radioactive substance injected in blood, ionizing radiation α and β and γ particles	Nuclear medicine department	Burying in ground, nuclear reactor
Category 10	Liquid based incineration ash from laboratory & washing, housekeeping, feces, vomit, urine from patients treated with cytotoxic drug.	Patient operating room, lab and restroom	Liquid drains, disinfectant, disposal in land fill.

Liquid Biomedical Waste

Among all the category of biomedical waste, liquid waste possess a serious threat to human health and environment because of their ability to enter water shed, pollute ground water and drinking water when improperly handled and disposed.

At the same time, illegal and unethical reuse of this untreated waste can be extremely dangerous and even causes diseases like cholera, plague, hepatitis B and diphtheria in either epidemic or endemic form.

Waste water is not similar to sewage, waste water comprises liquid waste, either discharged from health care facilities, domestic residence, industry and agriculture with a wide range of potential contaminant and microbial concentration whereas sewage is a subset of waste water that is contaminated with feces or urine.

Types of Liquid Waste

The liquid waste generated from HCF is usually of following type –

1. Infectious waste: Eg – Blood and body fluid, laboratory waste.
2. Chemical hazardous: Eg – Formaldehyde, Mercury, Solvent, Radioactive isotope.
3. Pharmaceutical Liquid waste: Eg – Discarded and expired medicines.
4. Photographic chemical: Eg – 5-10% Hydroquinone, 1-5% Potassium hydroxide, 1% Silver (fixed & developer).
5. Disinfectant

Hazardous and Challenges of Liquid Biomedical Waste

Most existing system and technology being used in handling liquid biomedical waste are failing to address the problem of effective management of liquid waste. For instances, the routine exercise pouring biomedical liquid waste leads to higher infection threat to medical staff due to its susceptibility to spilling, splashing and aerosolizing. Untreated liquid biomedical waste contains a wide variety of containment that possess health hazard to the community.

Segregation and Management of Liquid Waste

According to the biomedical waste management and handling rules 1998, liquid and chemical waste should be appropriately treated before being discharge in public sewer system.

Pathological waste must be treated with chemical disinfectant and flushed into sewage system. Chemical waste need to be first neutralized with appropriate reagent before being flushed into the sewer. Waste should be first segregated and packed in a leak proof rigid container & then has to be disinfected or neutralized with an approved chemical reagent.

Container should be labeled with a "Biohazard" is to be clearly mentioned in the label.

If transport is required, it should be collected ideally in a twin-bin container. Twin-bin container consists of a primary container containing the liquid waste which is placed within another secondary leak proof rigid container as to avoid a spilling during transport.

Secondary container must be labeled with "Bio Hazard" symbol "Bio Hazardous waste".

Disposal Procedures for Infectious Liquid Waste

1. Sanitary sewer disposal method.
2. Liquid waste down the sanitary sewer.
3. Placing directly in the Bio-hazardous waste bin.
4. Solidification of the liquid waste.
5. Disposal procedures for chemically hazardous liquid waste.
6. Closed disposal systems
7. Waste water treatment plant.

1. Sanitary Sewer disposal method

The sanitary sewer system is designed for the disposal of certain liquid waste. Use of the sanitary sewer reduces a chance for leak or spill during transport and thereby reduces disposal cost. Chemical disinfection is done prior to sewer disposal to eliminate

microorganisms or to reduce the microbial load. Chemical treatment usually involves the use of 1% Sodium hypochlorite, 10-14gms of bleaching powder, 70% ethanol, 70% isopropyl alcohol, 4% formaldehyde and 6% H_2O_2.

2. Liquid waste down the sanitary sewer

All microbiological liquid bio-hazardous waste, animal cells, diluted blood, tissue fluid, plasma should be autoclaved in a certified autoclave and then finally put down the sanitary sewer system.

3. Placing directly in the Bio-hazardous waste bin

Infectious liquid waste can be placed into the red or yellow bio-hazard waste container depending upon the type of further treatment option as followed by the health cae facility.

If the HCF has an incinerator facility then it can be placed in the yellow bio-hazard bin. If there are no incinerators then it can be placed in the red bin to be autoclaved. Typical cycle time for sterilizing liquid waste range from 45-90 min at 250^o faranheit and autoclave pressure should be 15 psi.

4. Solidification of the liquid waste

Pouring powdered solidifying agent

Into a liquid waste container

Which turns liquid content into a gelatinous solid mass after 5-10 mins

It illuminates the need to transport bio-hazardous fluids in a liquid form

Solidification process waste on microencapsulation technology that converts liquid waste into solid waste

Polymers are used as an absorbent which absorb and retain large volume of liquid

Addition of sanitizing agents like chlorine

Then allow the medical waste to be disinfected prior to solidification

5. Disposal procedure for chemically hazardous liquid waste

Among the various hazardous waste, the important ones are formaldehyde and solvents like nylene, acetone, ethanol, methanol, ethlyacetate, toluene, isopropanol obtained from pathology laboratories, mercury from broken thermometer and radioactive isotopes. And some of the solvents are halogenated compound which has to be discarded by storing in gallon drum and then incinerated or recycling. Radioactive waste are usually generated from nuclear medicine department and from clinical laboratories. These materials can be retained on the site until they have been decayed to non-hazardous level.

6. Closed Disposal Systems

Closed disposal system are designed to collect the fluid waste and disposed it down the sewers in minimal contact of the waste with human. Most of them are stationary system mounted to the floor or wall with a vacuum system that uses the waste directly into the sanitary sewer thereby can help the facility to reduce infectious waste volume and exposure risk.

Waste Water Treatment Plant

Biomedical waste (management & handling) rules 1998 states that hospital should set up their own effluent treatment plant (ETP's) for treating the waste water that can be eventually reused. In hospital that do not have ETP's the water can be chemically treated and released into the common sewage pipeline, provided it is connected to the Local Municipal water treatment facilities.

This discharge base contains organic, inorganic solid and microbial contaminants which can be measured by the BOD & COD test. The BOD test measures the oxygen demand of biodegradable pollutant whereas the COD test measures the oxygen demand of the oxidisable pollutant. A high BOD indicates the presence of excess amount of organic carbon so the higher the BOD, higher is the polluting capacity of the waste water. This waste water is usually treated by a process that removes the majority of contaminant and produces a liquid effluent that is suitable for both disposal to the natural & generation of a sludge which can be incinerated, composed or apply directly to the land as a soil amendment.

In hospital that have ETD facility, the treatment is guide out using special scientific process which involves 3 stages of treatment –

Primary Treatment

Sewage

Temporarily held in a basin

Settled and floating materials are removed

Remaining liquid is subjected to secondary treatment

Primary treatment usually removes 30-40% BOD

BOD, COD levels comes down to 25% of its initial level.

Secondary Treatment

Removes the dissolved & suspended biological activities

The treatment uses microbial degradation such as

Aerobic, anaerobic

To reduce the concentration of organic compounds

Combined use of primary and secondary treatment reduces approximately 80-90% of the BOD.

In this stage there is formation of solid waste

Thick slurry called sludge

Treated fluid undergoes tertiary treatment

Where 95% of the pollutants from the waste water is removed.

Tertiary Treatment

- Chemicals are added to remove inorganic compounds and pathogens.
- This is final stage of effluent treatment.

After secondary treatment the effluent is mixed with sodium hypochlorite

Then passed through dual medial filter (DMF)

Passed through activated carbon filter (ACF)

Sand, anthracite, activated carbon used as filtration media.

Finally, the treated water is let into a small well to recharge the water level.

Treated waste water now can be used for

- Gardening
- Toilets
- Laundry purposes.

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UNIT 2:

2mks:

1. Define infectious wastes.

2. Define genotoxic wastes.

3. What are the sources of radioactive wastes?

4. How are radioactive wastes generated in health care?

5. What are contagious wastes?

6. What are the difference between genotoxic and chemical wastes?

7. What are the sources of cytotoxic wastes?

8. Give the types of liquid biomedical wastes.

9. List out the disposal procedures for infectious liquid waste.

10. What is waste water treatment plant?

12 mks:

1. Write notes on infectious waste, genotoxic waste and hazardous wastes.
2. Explain in brief the various categorization and composition of biomedical waste.
3. Explain in detail about chemical waste.
4. Explain in detail about the liquid biomedical waste and its treatment.
5. Write in detail about the disposal procedures for infectious liquid wastes.
6. Liquid wastes possess threat to the human health and environment. Explain.
7. Discuss the types of hazardous chemicals used in the maintenance of HCF and hospitals.
8. What are radioactive wastes? Explain the sources of its generation in health care facilities.
9. Examine the types of biomedical wastes.
10. What is waste water treatment plant? Explain the different stages of the plant.

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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – 3 – Medical Waste Management – SBM1608

UNIT III

BLOOD PRODUCTS

HUMAN BLOOD AND BLOOD PRODUCTS

Donors

Blood and blood components described in this Circular have been collected from volunteer blood donors for use in other patients (allogeneic transfusions) or from patients donating for themselves (autologous transfusions). The blood donors have satisfactorily completed a health assessment that includes a questionnaire on past and present illnesses, and have satisfied minimum physiologic criteria. The allogeneic donors have been questioned about risk factors for transmissible infectious agents and have been given instructions to call the blood center after donation if they develop illness or have concerns that their blood may not be safe to give to another person.

Testing of Donor Blood

Testing of a sample of donor blood is performed before units of blood or blood components are distributed for routine transfusion. The donor's ABO group and Rh type have been determined, including testing for the presence of weak D antigen. A sample from each donation intended for allogeneic use has been tested by FDA-licensed tests and found to be nonreactive for antibodies to human immunodeficiency virus (anti-HIV- 1/2), hepatitis C virus (anti-HCV), human T-cell lymphotropic virus (anti-HTLV-I/II), and hepatitis B core antigen (anti-HBc), and nonreactive for hepatitis B surface antigen (HBsAg). Licensed nucleic acid tests (NAT) for HCV ribonucleic acid (RNA), HIV-1 RNA, and West Nile virus (WNV) RNA have been performed and found to be nonreactive. A licensed nucleic acid test (NAT) for HBV DNA has been performed and found to be nonreactive. A serologic test for syphilis has been performed and found to be nonreactive. All blood has been collected from donors who have tested negative by a licensed test for antibodies to Trypanosoma cruzi either on the current donation or at least one previous donation. For units labeled "FOR AUTOLOGOUS USE ONLY," infectious disease testing requirements vary, depending on whether the unit will be drawn in one facility and infused in another facility and whether the unit might be made available for allogeneic transfusion. Infectious disease testing may be omitted for autologous units drawn, stored, and infused at the same facility. Autologous units

for which testing has not been performed are labeled “DONOR UNTESTED.” Autologous units with reactive test results may be used for transfusion to the donor-patient with appropriate physician authorization. A biohazard label will be applied to autologous units that are tested for evidence of infection as listed above and determined to be reactive. If the units labeled “FOR AUTOLOGOUS USE ONLY” are infused at a different facility, at a minimum the first donation from the donor-patient in each 30-day period is tested for evidence of infection as listed above. Subsequent units that are not tested will be labeled as “DONOR TESTED WITHIN THE LAST 30 DAYS.” Autologous units may be used for allogeneic transfusion only if the autologous donors meet all the allogeneic donor selection and testing requirements for each donation. Tests for unexpected antibodies against red cell antigens have been performed on samples from all donors. The results of these tests are negative or have been determined to be clinically insignificant unless otherwise indicated on the label. Other tests may have been performed on donor blood as indicated by information that has been provided by the blood bank or transfusion service on an additional label or tie tag, or in a supplement to this Circular.

Blood and Component Labeling

All blood components identified in this Circular have the ISBT 128 product name listed first and other recognized component names in parentheses. Blood and blood component labels will contain the following information:

1. The proper name, whole blood or blood component, including an indication of any qualification or modification.
2. The method by which the blood component was prepared, either by whole blood or apheresis collection.
3. The temperature range in which the blood component is to be stored.
4. The preservatives and anticoagulant used in the preparation of the blood or blood components, when appropriate.
5. The standard contents or volume is assumed unless otherwise indicated on the label or in Circular supplements.
6. The number of units in pooled blood components and any sedimenting agent used during cytapheresis, if applicable.

7. The name, address, registration number, and US license number (if applicable) of the collection and processing location.

8. The expiration date (and time if applicable), which varies with the method of preparation (open or closed system) and the preservatives and anticoagulant used. When the expiration time is not indicated, the product expires at midnight.

9. The donation (unit or pool) identification number.

10. The donor category (paid or volunteer, and autologous if applicable).

11. ABO group and Rh type, if applicable.

12. Special handling information, as required.

13. Statements regarding recipient identification, infectious disease risk, and prescription requirement.

Instructions for Use

The following general instructions pertain to Whole Blood and all the blood components described in this Circular:

1. All blood and blood components must be maintained in a controlled environment and stored under appropriate conditions as described in the AABB Standards for Blood Banks and Transfusion Services.

2. The intended recipient and the blood container must be properly identified before the transfusion is started.

3. Aseptic technique must be employed during preparation and administration. If the container is entered in a manner that violates the integrity of the system, the component expires 4 hours after entry if maintained at room temperature (20-24 C), or 24 hours after entry if refrigerated (1-6 C).

4. All blood components must be transfused through a filter designed to remove clots and aggregates (generally a standard 150- to 260-micron filter).

5. Blood and blood components should be mixed thoroughly before use.

6. Blood and blood components must be inspected immediately before use. If, upon visual inspection, the container is not intact or the appearance is abnormal (presence

of excessive hemolysis, a significant color change in the blood bag as compared with the tubing segments, floccular material, cloudy appearance, or other problems), the blood or blood component must not be used for transfusion and appropriate follow-up with the transfusion service must be performed.

7. No medications or solutions may be added to or infused through the same tubing simultaneously with blood or blood components with the exception of 0.9% Sodium Chloride Injection (USP), unless: 1) they have been approved for this use by the FDA, or 2) there is documentation available to show that the addition is safe and does not adversely affect the blood or blood component.

8. Lactated Ringer's Injection (USP) or other solutions containing calcium should never be added to or infused through the same tubing with blood or blood components containing citrate.

9. Blood components should be warmed if clinically indicated for situations such as exchange or massive transfusions, or for patients with cold-reactive antibodies. Warming must be accomplished using an FDA-cleared warming device so as not to cause hemolysis.

10. Some life-threatening reactions occur after the infusion of only a small volume of blood or blood components. Therefore, unless otherwise indicated by the patient's clinical condition, the rate of infusion should initially be slow.

11. Periodic observation and recording of vital signs should occur before, during, and after the transfusion to identify suspected adverse reactions. If a transfusion reaction occurs, the transfusion must be discontinued immediately and appropriate therapy initiated. The infusion should not be restarted unless approved by transfusion service protocol.

12. Specific instructions concerning possible adverse reactions shall be provided to the patient or a responsible caregiver when direct medical observation or monitoring of the patient will not be available after transfusion.

13. Transfusion should be started before component expiration and completed within 4 hours.

14. All adverse events related to transfusion, including possible bacterial contamination of blood or a blood component or suspected disease transmission, must be reported to the transfusion service according to its local protocol.

Side Effects and Hazards for Whole Blood and All Blood Components

Basic Infection and infectious agents on spread of infection

Immunologic Complications, Immediate

1. Hemolytic transfusion reaction, the destruction of red cells, is discussed in detail in the section on components containing red cells and in the platelet section.

2. Immune-mediated platelet destruction, one of the causes of refractoriness to platelet transfusion, is the result of alloantibodies in the recipient to HLA or platelet-specific antigens on transfused platelets. This is described in more detail in the section on platelets.

3. Febrile nonhemolytic reaction is typically manifested by a temperature elevation of ≥1 C or 2 F occurring during or shortly after a transfusion and in the absence of any other pyrexic stimulus. This may reflect the action of antibodies against white cells or the action of cytokines either present in the transfused component or generated by the recipient in response to transfused elements. Febrile reactions may occur in less than 1% of transfusions of leukocyte-reduced red cell components and about 5% of leukocytereduced apheresis platelet components. Febrile reactions occur more frequently in patients receiving non-leukocyte-reduced components and those previously alloimmunized by transfusion or pregnancy. No routinely available pre- or posttransfusion tests are helpful in predicting or preventing these reactions. Antipyretics usually provide effective symptomatic relief. Patients who experience repeated, severe febrile reactions may benefit from receiving leukocyte-reduced components. If these reactions are caused by cytokines in the component, prestorage leukocyte reduction may be beneficial.

4. Allergic reactions frequently occur (ie,1-3% of plasma-containing components) as mild or self-limiting urticaria or wheezing that usually respond to antihistamines. More severe manifestations, including respiratory and cardiovascular symptoms, are more consistent with anaphylactoid/anaphylactic reactions and may require more

aggressive therapy (see below). No laboratory procedures are available to predict these reactions.

5. Anaphylactoid/anaphylactic reactions, characterized by hypotension, tachycardia, nausea, vomiting and/or diarrhea, abdominal pain, severe dyspnea, pulmonary and/or laryngeal edema, and bronchospasm and/or laryngospasm, are rare but dangerous complications requiring immediate treatment with epinephrine. These reactions have been reported in IgA-deficient patients who develop antibodies to IgA antibodies. Such patients may not have been previously transfused and may develop symptoms after infusion of very small amounts of IgA-containing plasma, in any blood component. Similar reactions have also been described in patients with haptoglobin deficiency. In certain circumstances, patients may benefit from the use of washed cellular components to prevent or reduce the severity of allergic reactions not minimized by treatment with medication alone.

6. Transfusion-related acute lung injury (TRALI) is characterized by the acute onset of hypoxemia and noncardiogenic pulmonary edema within 6 hours of a blood or blood component transfusion in the absence of other causes of acute lung injury or circulatory overload. Various stimuli in blood components, most commonly white blood cell (WBC) antibodies from donors sensitized during pregnancy or prior transfusion or transplantation, or proinflammatory molecules that accumulate in stored blood components, may cause TRALI. These mechanisms may not be mutually exclusive and may act synergistically with underlying patient factors to lead to a final common pathway of acute lung injury. These stimuli may trigger an inflammatory response, granulocyte activation and degranulation, and injury to the alveolar capillary membrane, and the development of permeability pulmonary edema. Although most TRALI cases are associated with donor antileukocyte antibodies, rare cases have implicated recipient antileukocyte antibodies that reacted with donor leukocytes. Widespread leukoreduction of blood components has likely mitigated this latter risk. Laboratory testing of blood donors for antileukocyte antibodies or blood components for biologic mediators does not alter management of this reaction, which is diagnosed on clinical and radiographic findings. Treatment of TRALI involves aggressive respiratory support, and often mechanical ventilation. The preferential use of plasma collected from male donors has been associated with a significant reduction

in the number of reported TRALI cases and associated fatalities. Transfusion services should immediately report suspected TRALI to the blood collection facility to facilitate the retrieval of other components associated with the involved donation(s) or prior donations.

Immunologic Complications, Delayed

1. Delayed hemolytic reaction is described in detail in the section on components containing red cells.

2. Alloimmunization to antigens of red cells, white cells, platelets, or plasma proteins may occur unpredictably after transfusion. Blood components may contain certain immunizing substances other than those indicated on the label. For example, platelet components may also contain red cells and white cells. Primary immunization does not become apparent until days or weeks after the immunizing event, and does not usually cause symptoms or physiologic changes. If components that express the relevant antigen are subsequently transfused, there may be accelerated removal of cellular elements from the circulation and/or systemic symptoms. Clinically significant antibodies to red cell antigens will ordinarily be detected by pretransfusion testing. Alloimmunization to antigens of white cells, platelets, or plasma proteins can be detected only by specialized testing.

3. Posttransfusion purpura (PTP) is a rare syndrome characterized by the development of dramatic, sudden, and self-limited thrombocytopenia, typically 7 to 10 days after a blood transfusion, in a patient with a history of sensitization by either pregnancy or transfusion. Although the immune specificity may be to a platelet-specific antigen the patient lacks, both autologous and allogeneic platelets are destroyed. High-dose Immune Globulin, Intravenous (IVIG) may correct the thrombocytopenia.

4. Transfusion-associated graft-vs-host disease (TA-GVHD) is a rare but extremely dangerous condition that occurs when viable T lymphocytes in the transfused component engraft in the recipient and react against recipient tissue antigens. TA-GVHD can occur if the host does not recognize and reject the foreign transfused cells, and it can follow transfusion of any component that contains even very small numbers of viable T lymphocytes. Recipients with severe cellular immunodeficiency (except for HIV infection) are at greatest risk (eg, fetuses receiving intrauterine

transfusions, recipients of hematopoietic progenitor cell transplants, and selected patients with severe immunodeficiency conditions), but TA-GVHD has also been reported in recipients receiving purine analogues (eg, fludarabine, cladribine) for oncologic and rheumatologic diseases, and in immunologically normal recipients who are heterozygous for a tissue antigen haplotype for which the donor is homozygous. Tissue antigen haplotype sharing is most likely to occur when the transfused component is from a blood relative or has been selected for HLA compatibility. TA-GVHD remains a risk with leukocyte-reduced components because they contain sufficient residual T lymphocytes. Irradiation of the component renders T lymphocytes incapable of proliferation and is presently the only approved means to prevent TA-GVHD.

Non-immunologic Complications

1. Because Whole Blood and blood components are made from human blood, they may carry a risk of transmitting infectious agents [eg, viruses, bacteria, parasites, the variant Creutzfeldt-Jakob disease (vCJD) agent, and, theoretically, the CJD agent]. Careful donor selection and available laboratory tests do not totally eliminate these hazards. Also, septic and toxic reactions can result from transfusion of bacterially contaminated blood and blood components. Such complications are infrequent, but may be life-threatening. Infectious disease transmission may occur despite careful selection of donors and testing of blood. Donor selection criteria are designed to screen out potential donors with increased risk of infection with HIV, HTLV, hepatitis, and syphilis, as well as other agents (see section on Testing of Donor Blood). These procedures do not totally eliminate the risk of transmitting these agents. Transfusion services should immediately report infections that may be related to the blood donor or to the manufacture of the blood components to the collection facility.

2. Cytomegalovirus (CMV) may be present in white-cell-containing components from donors previously infected with this virus, which can persist for a lifetime despite the presence of serum antibodies. Up to 70% of donors may be CMV seropositive. Transmission of CMV by transfusion may be of concern in low-birthweight (≤1200 g) premature infants born to CMV-seronegative mothers and in intrauterine transfusions and/or certain other categories of immunocompromised individuals such as hematopoietic progenitor cell or solid organ transplant patients, if they are CMV

seronegative. For at-risk recipients, the risk of CMV transmission by cellular components can be reduced by transfusing CMV-seronegative or leukocyte-reduced components. For other infectious agents (eg, Babesia spp, Leishmania spp, and Plasmodia spp) there are no routinely available tests to predict or prevent disease transmission. All potential blood donors are subjected to screening procedures intended to reduce to a minimum the risk that they will transmit infectious agents.

3. Bacterial sepsis occurs rarely but can cause acute, severe, sometimes life-threatening effects. Onset of high fever (≥2 C or ≥3.5 F increase in temperature), severe chills, hypotension, or circulatory collapse during or shortly after transfusion should suggest the possibility of bacterial contamination and/or endotoxin reaction in the transfused products. Although platelet components stored at room temperature have been implicated most frequently, previously frozen components thawed by immersion in a waterbath and red cell components stored for several weeks at 1 to 6 C have also been implicated. Although most platelet components are routinely tested for bacterial contamination, this does not completely eliminate the risk. Both gram-positive and gram-negative organisms have been identified as causing septic reactions. Organisms capable of multiplying at low temperatures (eg, Yersinia enterocolitica) and those using citrate as a nutrient are most often associated with components containing red cells. A variety of pathogens, as well as skin contaminants, have been found in platelet components. Endotoxemia in recipients has resulted from multiplication of gram-negative bacteria in blood components. Prompt recognition of a possible septic reaction is essential, with immediate discontinuation of the transfusion and aggressive therapy with broad-spectrum antimicrobials and vasopressor agents, if necessary. In addition to prompt sampling of the patient's blood for cultures, investigation should include examination of material from the blood container by Gram's stain, and cultures of specimens from the container and the administration set. It is important to report all febrile transfusion reactions to the transfusion service for appropriate investigation. If posttransfusion sepsis is suspected, the transfusion service should immediately report the reaction to the blood collection facility to facilitate retrieval of other potentially contaminated components associated with the collection.

4. Transfusion-associated circulatory overload (TACO) leading to cardiogenic (hydrostatic) pulmonary edema can occur after transfusion of excessive volumes or at

excessively rapid rates. This is a particular risk in individuals with underlying cardiopulmonary or renal disease, the very young and the elderly, and in patients with chronic severe anemia in whom low red cell mass is associated with high plasma volume. Small transfusion volumes can precipitate symptoms in at-risk patients who already have a positive fluid balance. Pulmonary edema should be promptly and aggressively treated, and infusion of colloid preparations, including plasma components and the supernatant fluid in cellular components, reduced to a minimum.

5. Hypothermia carries a risk of cardiac arrhythmia or cardiac arrest and exacerbation of coagulopathy. Rapid infusion of large volumes of cold blood or blood components can depress body temperature, and the danger is compounded in patients experiencing shock or surgical or anesthetic manipulations that disrupt temperature regulation. A blood warming device should be considered if rapid infusion of blood or blood components is needed. Warming must be accomplished using an FDA-cleared blood warming device so as not to cause hemolysis.

6. Metabolic complications may accompany large-volume transfusions, especially in neonates and patients with liver or kidney disease. a. Citrate “toxicity” reflects a depression of ionized calcium caused by the presence in the circulation of large quantities of citrate anticoagulant. Because citrate is promptly metabolized by the liver, this complication is rare. Patients with severe liver disease or those with circulatory collapse that prevents adequate hepatic blood flow may have physiologically significant hypocalcemia after rapid, large-volume transfusion. Citrated blood or blood components administered rapidly through central intravenous access may reach the heart so rapidly that ventricular arrhythmias occur. Standard measurement of serum calcium does not distinguish ionized from complexes calcium. Ionized calcium testing or electrocardiogram monitoring is more helpful in detecting physiologically significant alteration in calcium levels. b. Other metabolic derangements can accompany rapid or large-volume transfusions, especially in patients with preexisting circulatory or metabolic problems. These include acidosis or alkalosis (deriving from changing concentrations of citric acid and its subsequent conversion to pyruvate and bicarbonate) and hyper- or hypokalemia. Fatal Transfusion Reactions When a fatality occurs as a result of a complication of blood or blood component transfusion, the Director, Office of Compliance and Biologics

Quality, Center for Biologics Evaluation and Research (CBER), should be notified as soon as possible. Within 7 days after the fatality, a written report must be submitted to the FDA/CBER, Director, Office of Compliance and Biologics Quality, Attn: Fatality Program Manager. A copy of the report should be sent to the collecting facility, if appropriate.

PATHOLOGICAL WASTE

1. Human Pathological Waste

Human pathological waste includes recognizable human derived tissue, organs, and body parts that must be disposed of via internment or incineration. This excludes teeth and contiguous structures of bone and gum; body fluids removed during surgery, autopsy, or other medical procedures; specimens of body fluids and their containers; and discarded materials saturated with body fluids other than urine.

2. Research Animal Pathological Waste

Research animal pathological waste includes vertebrate animal derived tissue, organs, carcasses, and body parts that must be disposed of via incineration.

3. Standard Regulated Medical Waste – "Red Bag" Waste

Standard red bag waste includes solid, non-sharps waste contaminated with biological material which are autoclaved and disposed in a landfill.

Managing Pathological Waste

1. **Animal Pathological Waste –** Animal pathological waste includes vertebrate animal derived tissue, organs, carcasses, and body parts. Animal pathological waste is managed by RARC using the approved RARC disposal procedures. RARC can be reached by phone at 212-746-1022.

2. **Human Pathological Waste –** Human pathological waste disposal is coordinated through WCM Housekeeping only in WCM Housekeeping supported areas. This service excludes whole cadavers, skulls, torsos, and fetuses. Contact EHS for assistance with these human remains and/or locations not serviced by WCM Housekeeping.

Generators Responsible for the Packaging of Pathological Waste

1. **Drain "Saturated" Pathological Waste:** Sufficiently drain all material before placement into a red bag. Certain organs can retain liquids after drainage and may need to be bagged into thicker, high-density polyethylene bags (HDPE) to prevent leakage. If red-bag material is "saturated" with blood or other fluids, double or triple-bagging or the utilization of absorbents is recommended. HDPE bags and absorbents must be purchased separately by each group.

2. **Bag the Waste into the Initial Red Bag:** Once sufficiently drained, place collected pathological waste into a red bag. Properly close all red bags when full or at the end of each day by. This includes twisting the red bag closed at the top and hand-tying into a single knot to seal. Pathological waste must be refrigerated to prevent decomposition and the development of pungent odors.

3. **Packaging and Box Setup:** Follow RARC procedures for animal pathological waste. Ensure that the following guidelines are followed when packaging the RMW fiberboard box:

    - Line the fiberboard box with a WCM labeled red bag.
    - Place initial sealed red bags into a labeled red bag lining the RMW fiberboard box.
    - Do not exceed maximum weight rating marked on package.
    - Seal closed all box flaps with 2-inch wide pressure sensitive tape or equivalent by taping all edges on the top and bottom flaps.
    - Close and seal each box according to manufacturer's specifications.
    - Each box must not be crushed, torn, saturated, or compromised.

4. **Package Labeling:** Regulated medical waste fiberboard boxes must have the following:

    - Check the box "Incineration Only" on side of box
    - Apply the yellow "Incineration Only" sticker provided by WCM Housekeeping,

- Check the box indicating “Pathological” waste on the side of the box, and
- Write the name of the group where the box was created (e.g. Autopsy, Gross Anatomy, RARC).
- Weigh each box separately, and write this weight on the side of each box.

5. **Store:** Store the box in a secured regulated medical waste storage area equipped with refrigeration, and label the box with, at a minimum, the universal biohazard symbol or the word “biohazard”. Coordinate RMW fiberboard box drop-off with WCM Housekeeping at least 2-3 days prior to shipment.

REQUEST FOR DISPOSAL

1. **WCM Housekeeping Supported Areas:** Contact WCM Housekeeping at 646-962-9912 a minimum of 2-3 days prior to the intended drop-off date with the number of correctly labeled pathological waste boxes intended for shipment. It is the generator’s responsibility to notify WCM Housekeeping and arrange for a specific drop-off time. Pathological waste is created and shipped from 3 main locations:
    - Belfer Research Building including 1300 York Avenue (Main Research Building)
    - “S” Building (Hamad Bin Khalifa Biomedical Research Building)
    - Gertrude & Louis Feil Family Research Building
2. **WCM Housekeeping Pathological Waste Acceptance Policy:** WCM Housekeeping personnel are responsible for reviewing RMW fiberboard boxes prior to acceptance into the RMW Storage Area. Housekeeping personnel will complete the Pathological Waste Acceptance Form which lists packaging, labeling, and box integrity requirements. Housekeeping reserves the right to refuse any non-compliant pathological waste boxes.
3. **Area Not Supported by WCM Housekeeping:** Contact EHS for assistance identifying and establishing pathological waste disposal services in these locations.

PRIOR TO SHIPPING

1. **Training:** Confirm only Regulated Medical Waste and Pathological Waste Shipper Training certified personnel finalize packaging and sign the Medical Waste Tracking Form.

2. **Shipping Labels:** The regulated medical waste shipping label must be adhered to each fiberboard pathological waste box being shipped. The date of shipment must be written on the RMW fiberboard box. The shipping labels are provided by the disposal contractor either before or during the time of shipment. The shipping label will also list the shipment's Medical Waste Tracking form number.

3. **Record Retention:** Retain copies of the Medical Waste Tracking Forms for a minimum of three years. Obtain disposal facility-signed copies of Medical Waste Tracking Forms within 30 days of shipment and retain with original copies.

SHARPS WASTE

Sharps waste is a form of biomedical waste composed of used sharps, which includes any device or object used to puncture or lacerate the skin. Sharps waste is classified as biohazardous waste and must be carefully handled. Common medical materials treated as sharps waste are:

- Syringes and injection devices
- Blades
- Contaminated glass and some plastics

DANGERS INVOLVED

- As a biohazardous material, injuries from sharps waste can pose a large public health concern. By penetrating the skin, it is possible for this waste to spread blood-borne pathogens. The spread of these pathogens is directly responsible for the transmission of blood-borne diseases, such as Hepatitis B (HBV), Hepatitis C (HCV), and HIV. Health care professionals expose themselves to the risk of transmission of these diseases when handling sharps waste.

- The large volume handled by health care professionals on a daily basis increases the chance that an injury may occur. Contraction of disease through such an injury will inhibit health care workers from providing their services. This is a cost incurred by society in the promotion of public health. As trained professionals, their services are not easily replaced.

- The general public can be at direct risk to injuries from sharps waste as well. If these hazardous materials are not separated from standard waste, individuals can unknowingly come in contact with them. In addition, if sharps waste is not disposed, and removed from the environment, then it can be subject to reuse and misuse, both intentional and unintentional. This is especially applicable in the areas of hypodermic needles and blades. The spread of disease through sharps waste is preventable through proper management and disposal.

MANAGEMENT AND DISPOSAL

- Extreme care must be taken in the management and disposal of sharps waste. The main goal in sharps waste management is to safely handle all materials until they can be properly disposed. The final step in the disposal of sharps waste is to dispose of them in anautoclave. A less common approach is to incinerate them; typically only chemotherapy sharps waste is incinerated. Steps must be taken along the way to minimize the risk of injury from this material, while maximizing the amount of sharps material disposed.

- From the moment sharps waste is produced, it is to be handled as little as possible. Health care workers are to minimize their interaction with sharps waste by disposing of it in a sealable container. If the sharps waste incorporates an additional part, such as a syringe, tube, or handle, the whole unit is disposed together. Attempts by health care workers to disassemble sharps waste is kept to a minimum. Stricthospital protocols and government regulations ensure that hospital workers handle sharps waste safely and dispose effectively.

- Self-locking and sealable sharps containers are made of plastic so that the sharps waste can not easily penetrate through the sides. Such units are designed so that the whole container can be disposed of with other biohazardous waste. Single use sharps containers of various sizes are sold throughout the world. They are now commonplace

in clinics and hospitals. Large medical facilities may have their own 'mini' autoclave in which these sharps containers are disposed of with other medical wastes. This minimizes the distance the containers have to travel and the number of people to come in contact with the sharps waste. Smaller clinics or offices without such facilities are required by federal regulations to hire the services of a company that specializes in transporting and properly disposing of the hazardous wastes.

- Recent legislation in France has stated that pharmaceutical companies supplying self injection medications are responsible for the disposal of spent needles. Previously popular needle clippers and caps are no longer acceptable as safety devices and either sharps box or needle destruction devices are required.

- Disposal methods vary by country and locale, but common methods of disposal are either by truck service or, in the United States, by disposal of sharps through the mail. Truck service involves trained personnel collecting sharps waste, and often medical waste, at the point of generation and hauling it away by truck to a destruction facility. Similarly, the mail-back sharps disposal method allows generators to ship sharps waste to the disposal facility directly through the U.S. mail in specially designed and approved shipping containers. Mail-back sharps disposal allows waste generators to dispose of smaller amounts of sharps more economically than if they were to hire out a truck service.

HOSPITAL ACQUIRED INFECTION

Hospital-acquired infections are caused by viral, bacterial, and fungal pathogens; the most common types are bloodstream infection (BSI), pneumonia (eg, ventilator-associated pneumonia [VAP]), urinary tract infection (UTI), and surgical site infection (SSI).

Study reports falling VAP and BSI rates in critically ill children

The incidence of central line-associated BSI and VAP declined significantly between 2007 and 2012 in critically ill pediatric patients, according to a national cohort study of patients admitted to 173 neonatal intensive care units (NICUs) and 64 pediatric intensive care units (PICUs).[1, 2] No change was observed, however, in the rate of catheter-associated UTI.

In the NICUs, the rate of central line-associated BSI decreased from 4.9 to 1.5 per 1000 central-line days during the study period; in the PICUs, the rate fell from 4.7 to 1.0 per 1000 central-line days.[2] The rate of VAP decreased from 1.6 to 0.6 per 1000 ventilator days in the NICUs and from 1.9 to 0.7 per 1000 ventilator days in the PICUs.

Signs and symptoms

Risk factors for catheter-associated BSI in neonates include the following :

- Catheter hub or exit-site colonization
- Catheter insertion after the first week of life
- Duration of parenteral nutrition
- Extremely low birth weight (< 1000 g) at catheter insertion
- Disruption of catheter dressings Pediatric ICU: Neutropenia, prolonged catheter dwell time (>7 days), percutaneously placed central venous lines, frequent manipulation of lines

Risk factors for candidemia in neonates include the following :

- Gestational age of less than 32 weeks
- 5-minute Apgar scores below 5
- Shock, disseminated intravascular coagulation
- Prior intralipid use
- Parenteral nutrition, central venous line placement
- H2 blocker administration
- Intubation
- Hospital stay longer than 7 days

Risk factors for VAP in pediatric patients include the following:

- Reintubation
- Genetic syndromes
- Immunodeficiency, immunosuppression
- Prior BSI

Risk factors for hospital-acquired UTI in pediatric patients include the following :

- Bladder catheterization
- Prior antibiotic therapy
- Cerebral palsy

The source of infection may be suggested by the instrumentation, as follows:

- Endotracheal tube: Sinusitis, tracheitis, pneumonia
- Intravascular catheter: Phlebitis, line infection
- Foley catheter: UTI

Patients with pneumonia may have the following:

- Fever, cough, purulent sputum
- Abnormal chest auscultatory findings (eg, decreased breath sounds, crackles, wheezes)

Patients with UTI may have the following:

- Fever or normal temperature
- Tenderness, suprapubic (cystitis) or costovertebral (pyelonephritis)
- Cloudy, foul-smelling urine

Diagnosis

Because not all bacterial or fungal growth on a culture is pathogenic and because such growth may reflect simple microbial colonization, interpretation of cultures should take into account the following:

- Clinical presentation of the patient
- Reason for obtaining the test
- Process by which the specimen was obtained
- Presence or absence of other supporting evidence of infection

Methods used to diagnose and characterize BSIs include the following:

- Suspected catheter-associated BSI: Differential time to positivity of paired blood cultures (simplest) [11] ; quantitative culture of blood obtained from the catheter and peripheral vein; quantitative culture of catheter segment
- Suspected fungal infection: Fungal cultures
- Possible thrombosis or vegetations: Imaging studies such as echocardiography
- Immunocompromised patients: Occasional special studies (eg, cultures for*Nocardia*, atypical mycobacteria, cytomegalovirus [CMV], and CMV antigenemia)

Tests used to identify pneumonia include the following:

- Acute-phase reactants
- Oxygen saturation and hemodynamic studies
- Chest radiography
- Sputum Gram stain and culture (if necessary, samples can also be obtained through bronchoalveolar lavage or thoracocentesis)
- Rapid diagnostic tests, in specific cases
- Urinalysis and urine culture, along with clinical findings, are essential for differentiating between asymptomatic bacteriuria, cystitis, and pyelonephritis.

The following factors should be kept in mind in the interpretation of urine cultures:

- Number of colonies and species isolated
- Method of sample collection
- Time from collection to laboratory processing
- Sex of the patient
- Previous antibiotic use
- Although imaging studies are controversial, they are recommended by most experts in evaluating children with first-time UTI.

Management

Medical care includes symptomatic treatment of shock, hypoventilation, and other complications, along with empiric broad-spectrum antimicrobial therapy.

Management of BSI may include the following:

- Line removal as appropriate
- Antibiotic therapy covering gram-positive and gram-negative organisms, started empirically and then tailored according to specific susceptibility patterns
- Antifungal therapy as appropriate
- Antiviral therapy as appropriate
- Prevention through use of catheter disinfection caps

Management of pneumonia includes the following:

- Initial empiric broad-spectrum antibiotic therapy, later streamlined on the basis of identified organisms and susceptibilities, with attention to the risk of multidrug-resistant (MDR) pathogens
- Antiviral medications against influenza for symptomatic patients and patients with immunodeficiency or chronic lung diseases to limit morbidity and mortality

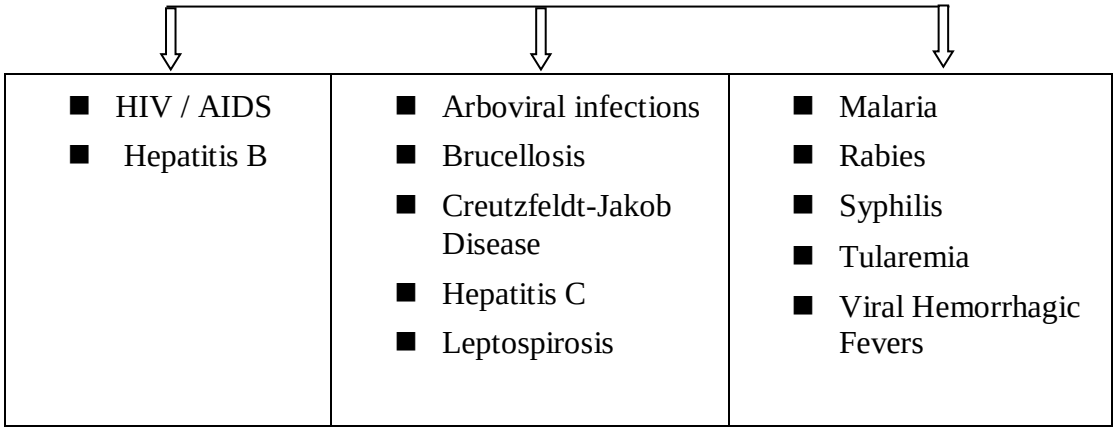
Management of UTI includes the following:

- Removal of indwelling catheters if possible
- Empiric antibiotic and antifungal therapy

Management of SSI includes the following:

- Surgical debridement
- Antibiotic therapy

Diseases Caused by Bloodborne Pathogens



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UNIT 3:

2mks:

1. What are the diseases caused by blood borne pathogens?

2. List the risk factors for catheter associated BSI in neonates.

3. Define sharp wastes.

4. What are the types of pathological wastes?

5. List the generators responsible for packaging pathological wastes.

6. Write the causes of hospital acquired infections.

7. What are the tests used to identify pneumonia.

8. Who are donors?

9. What is hospital acquired diseases?

10. Define management of BSI.

12 mks:

1. Explain about blood and component labelling.

2. Explain the instructions used in blood and component labelling.

3. Explain in detail about pathological wastes.

4. Write in detail about management and disposal of sharp wastes.

5. Explain the methods used to diagnose BSI and pneumonia.

6. Brief on hospital acquired infections, its signs and symptoms for candidemia in neonates.

7. Explain the risk factors for: (a) VAP in paediatric patients

   (b) BSI in neonates.

   (c) UTI in paediatric patients.

8. Discuss about the management of hospital acquired infections.

9. Briefly explain about the immediate and delayed immunological complications regarding the side effects and hazards for whole blood and blood components.

10. Explain briefly about the non-immunological complications regarding the basic infections and infectious agents on spread of infection.

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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – 4 – Medical Waste Management – SBM1608

UNIT 4

AUTOCLAVING

DEFINITIONS

Decontamination – the application of microbiocidal steam, gas, solid (granular) or liquid chemical agents in situations in which microbes may be protected from contact by extraneous matter. Decontamination implies the destruction of or removal of microorganisms to some lower level, but not necessarily total destruction. Sterilization, disinfection and antisepsis are forms of decontamination

Sterilization – the total destruction of all living organisms (including spores) by processing in steam sterilizers (autoclaves), with ethylene oxide autoclaves or by chemical (high level) sterilization.

Disinfection – to destroy all nonspore forming organisms that could pose a potential hazard to humans or compromise the integrity of the equipment. Disinfection implies the use of antimicrobial agents on inanimate objects (floors, bench tops, equipment).

Antisepsis – the application of a liquid antimicrobial chemical to living tissue either human or animal. The objective is to prevent sepsis by either destroying potentially infectious organism or inhibiting their growth and multiplication.

Disinfections unit container for Autoclaving

Sterilization Methods

Wet Heat (Steam)

This method requires approximately 15psi pressure with a chamber temperature of at least 250 C). The cycle time begins when the materials being sterilized reach the predetermine (121 temperature. Then the length of time is dependent upon the volume size of the load (usually 30-60 minutes). Monitor steam sterilization effectiveness with a biological indicator, Geobacillus stearo thermophilus.

Dry Heat

This is less effective than steam, and requires more time (two to four hours) and a higher temperature C). Monitor dry heat sterilization with a Bacillus subtilis biological or 160-170µ (320-338 indicator. Biological Test Packs EHS monitors autoclaves used for waste decontamination. This process utilizes spores of Geobacillus stearothermophilus.

Ethylene Oxide Gas (EO)

By using Ethylene oxide gas sterilization can be done.

Autoclaving procedure for biological waste

All biological waste that requires autoclaving should always be placed in a secondary container when being transported to and from the autoclave for decontamination. Waste bag that require autoclaving shall be double bagged and placed in a container for autoclaving. This will prevent spills in the autoclave. Bottles with liquids will also be placed in a secondary container prior to being autoclaved. Autoclave tape should be placed on the bottle to verify proper sterilization. Waste contained in trays will be placed in a secondary container labeled and autoclaved. DO NOT over fill trays with waste. The tray must be closed and all material should be immersed in disinfecting liquid. Use caution when removing items from autoclave. Steam and hot liquids may seriously burn you. Autoclave gloves face shields, and rubber aprons are available for added protection. Before disposing of the autoclave waste read the printout of the run to assure proper sterilization time, temperature, pressure. If an error is noted the waste must be re-autoclaved and facility maintenance should be notified.

Procedures for Decontamination by Autoclaving

Purpose

Biohazardous waste material and sharps containers generated within research and teaching facilities are required to be decontaminated in laboratory (or departmental) autoclaves and disposed of using the appropriate waste streams. The procedures below serve as guidelines to help autoclave users ensure safe and effective processing.

1. Select appropriate containers or bags for collecting materials to be autoclaved.

For biohazardous dry solid materials

a. Collect in polypropylene AUTOCLAVE bags:

BSL-1 waste Clear bags, no symbol

BSL-2 waste Orange bags, symbol

BSL-3 waste Red bags, symbol

b. DO NOT use the red bags that come with the Regulated Medical Waste (RMW) boxes for initial waste collection. They are not meant to be autoclaved

c. Ensure that bags are free of sharp objects that may puncture bags. Autoclave bags are tear resistant, but can be punctured or burst in the autoclave.

d. Fill bags only 2/3 full.

e. Ensure adequate steam penetration by creating an opening of at least one inch in the bag's closed top.

f. On autoclaves which have no Prevacuum cycle, water can be carefully added to bags of waste run on Solids/Gravity cycle if needed to achieve effective decontamination. (Steam created inside the bag during processing aids in reaching appropriate temperature.

For biohazardous sharps

a. Collect in commercially available Sharps containers with lids or closures. Containers must not be tightly sealed shut AND MUST NOT BE OVERFILLED.

For biohazardous liquids

a. Never autoclave plastic materials of uncertain heat stability. Collect liquid in glassware or plasticware that is suitable for autoclaving.

b. Do not fill containers more than 2/3 full.

c. Make sure that caps are loose or use vented closures.

d. Never put sealed containers in an autoclave. They can explode. Large bottles with narrow necks may also explode or boil over if filled too full of liquid.

e. Never put materials containing solvents, corrosives or radioactive materials in the autoclave (e.g., phenol, chloroform, pyridine, or bleach)

2. Place waste bags or containers with liquids in a secondary container.

a. Make sure your plastic secondary container is suitable for autoclaving. Polyethylene or HDPE cannot be autoclaved.

b. Polypropylene, polycarbonate or stainless steel pans are typically used for secondary containment. See Nalgene Labware's Autoclaving Web page for additional plastic considerations.

c. Select a container with the lowest sides possible for the autoclave. This will promote penetration of steam and will collect any leakage or overflow of liquids.

d. Make sure pan contains the entire volume of waste—no spilling over sides.

e. Leave space between items/bags to allow steam circulation.

f. Safely transport the material to the autoclave.

3. Place a Class 5 Chemical Indicator (CI) in the waste load to check operating parameters.

a. If you are using a challenge test pack containing the CI, place it with the waste.

b. If you are using a CI with no pack, place it WITHIN the load of waste in a position where it will encounter the greatest challenge to steam penetration.

c. Avoid direct exposure to waste by using CIs with extenders, or make one yourself by straightening and trimming a coat hanger, and attach the CI to one end with autoclave tape. Place carefully to avoid puncture of bags.

d. Not every container of waste per load must receive a CI. Place CI in the container which occupies the most challenged position in the load (i.e., if running 3 bags, put CI in center bag).

4. Load the autoclave

a. Review the Standard Operating Procedures (SOP) for the autoclave unit. Training must be provided for any new autoclave operators.

b. Check the drain screen at the bottom of the chamber before loading the autoclave.

c. Place a piece of autoclave tape (Class I Chemical Indicator) on the outside of the container or bag. Black stripes appearing on the tape give a visual verification that the material has been processed.

d. If an autoclave is available, place the load + its secondary container in the autoclave chamber for processing.

• DO NOT OVERFILL THE CHAMBER!

• Load should not touch chamber walls

• DOOR should be clear of obstructions before closing

e. Whenever possible, autoclave the load immediately after preparation. Do not leave unprocessed items in the autoclave overnight.

f. If the autoclave is in use, store waste, in a secondary container, in a designated holding area, and decontaminate at the earliest possible time.

5. Choose an appropriate cycle.

CYCLE TYPE & TYPICAL PARAMETERS	RECOMMENDED FOR:
LIQUIDS STERILIZE TEMP = 121º C STERILIZE TIME = 30-60 min. COOL TIME =40 min. RUN TIME = 70-100 min.	Type I borosilicate glass containers with vented closures; 2/3 full only • Liquid Media • Nonflammable liquids • Aqueous solutions • Liquid biowaste
	NOT RECOMMENDED FOR DRY ITEMS THAT DON'T REQUIRE A SLOW EXHAUST
SOLIDS / GRAVITY S TERILIZE TEMP = 121º C STERILIZE TIME = 30 to 40 min. DRY TIME =0 to 30 min. RUN TIME =45 to 80 min.	• Glassware: -Type I borosilicate - empty & inverted - no tight or impermeable closures • Dry hard items, either unwrapped or in porous wrap • Metal items with porous parts • Other porous materials
	NOT RECOMMENDED FOR LIQUIDS OR MEDIA THAT REQUIRE A SLOW EXHAUST
PRE-VACUUM STERILIZE TEMP121º C STERILIZE TIME = 30 to 45 min. COOL TIME = 2 to 5 min. RUN TIME 40 to 55 min.	• Glassware that must be sterilized upright &/or can trap air • Wrapped dry items that can trap air • Pipette tip boxes • Sharps decontamination (in collection containers) • Biohazard waste decontamination (in autoclave bags; can be wet & dry tubes, plates, etc.)
	NOT RECOMMENDED FOR LIQUIDS OR MEDIA, LIGHTER WEIGHT PLASTIC CONTAINERS OR DRY ITEMS WHICH WILL COLLAPSE IN A VACUUM

6. Please note this important information

a. For both DRY and LIQUID biohazardous waste materials, cycle times must be set for a minimum of 30 minutes @ 1210C, 15 PSI.

b. LARGER VOLUMES OF LIQUIDS AND LARGER LOADS OF SOLIDS REQUIRE LONGER STERILIZATION TIMES.

c. LIQUIDS MUST BE AUTOCLAVED WITH SLOW EXHAUST.

Recommended Sterilization Times Per Volume For Liquid Cycles

Volume of Liquid in One Container	Minimum Recommended Sterilize Time at 121º C
75 ml	25 minutes
250 ml	30 minutes
500 ml	40 minutes
1000 ml	45 minutes
1500 ml	50 minutes
2000 ml	55 minutes
>2000 ml	55 + 10 min. / L

7. Fill out the autoclave use log (link) and be aware of required cycle times. Record your name, date, time, cycle to be run, etc. The results of the load verification results must also be recorded

8. Always employ the following safety guidelines when the autoclave cycle is finished:

a. Wear personal protection equipment:

- Lab coat
- Eye protection (when removing load)
- Closed-toe shoes
- Heat-resistant gloves to remove items, especially hot glassware

b. Never open an autoclave unless the chamber pressure = 0.

c. Open the door cautiously. Stand behind the door or beside the unit and slowly crack it open no more than ½". Allow all steam to escape by waiting at least 10 minutes before unloading the material. CAUTION: Material will still be HOT!

d. Let liquids stand 10–20 minutes after the autoclave is opened. Superheated liquids can boil over and damage the autoclave and cause personal injury.

e. Do not override autoclave's built-in safety control features under any circumstances. If a problem occurs, contact the responsible technician.

9. Verify operating parameters by checking for color change on Chemical Indicator strip.

- See example on right for 3M™ Comply Chemical Indicators.
- See EHSS website to download SOP for Chemical Indicators (CI).

10. Properly dispose of materials that have been successfully decontaminated as verified by Chemical Indicator strip.

a. Discard BSL-1 decontaminated waste (contained in clear bags with no biohazard symbol) into the regular trash.

b. Place BSL-2 or BSL-3 decontaminated waste (contained in orange bags or bags with biohazard symbol) and ALL Sharps containers into Regulated Medical Waste boxes lined with red biohazard bags.

c. Decontaminated biohazardous liquids may be poured down the drain.

d. Loads that do not pass verification must autoclaved again and shown to be successfully decontaminated by CI verification before disposal.

e. Causes of all CI verification failures must be determined and corrected, or reported to the responsible technician who will initiate corrective action.

NOTE: The stripes on autoclave indicator tape changing from light to dark does not ensure that decontamination conditions were successfully met, but serves only as a visual indicator of processed (heat-exposed) versus non-processed items.

11. Perform required verification testing for your autoclave.

a. Use Biological Indicator (BI) testing for:

- Verifying proper function of newly installed autoclaves
- A monthly check on proper function for all other autoclaves used to decontaminate waste

b. When the heat-resistant bacterial spores (Geobacillus stearothermophilus) in the BI vial are killed, definitive verification for decontamination was achieved by the autoclave.

c. Each specific cycle (type, time, temperature, etc.) used to decontaminate biohazardous waste must be verified with B.I. testing.

d. Label the BI with pertinent information (date, autoclave tested, location in chamber, etc.)

e. Place BI in the waste load in one of the following ways:

- Challenge test packs are placed with a waste load (such as between 2 bags of waste).
- BI vials (no packs) are positioned within a load, such as inside a Sharps container or bag of waste, to encounter the greatest challenge to steam penetration.
- For more thorough testing, additional vials can be placed in critical loads.

f. BI vials used alone can be taped to the same extenders used for CI strips to facilitate placement and avoid direct exposure to waste.

g. Upon completion of the cycle, follow BI manufacturer's instructions for activating and incubating test vials and positive control. Observe vials at specified intervals (such as 24 to 48 hours) for a color change indicating bacterial growth. If growth occurs, the autoclave tested has not met appropriate operating parameters.

h. Results must be recorded on the Biological Indicator Testing log. g. See the EHSS website to download SOP for Biological Indicators (BI).

i. BI Failures:

- All BI testing failures must be reported immediately to the technician responsible for the autoclave, who will investigate and take corrective action.
- Users of the autoclave also must be informed of any failure that may have affected runs processed in the autoclave at or near the time of testing.
- The autoclave in question must be taken out of service for decontamination of waste until the problem is found and proper function is restored as verified by repeat BI testing.

j. BI verification testing should also be performed:

- After a sterilizer has been repaired
- As required for research needs

12. Keep autoclaves in good repair with preventive maintenance.

a. The responsible technician, the autoclave's manufacturer, or the autoclave's sales /service representative can provide more information.

b. If you suspect there is a problem with your autoclave's performance, contact the responsible technician for assistance.

SHARPS WASTE

Sharps waste is a form of biomedical waste composed of used *sharps*, which includes any device or object used to puncture or lacerate the skin. Sharps waste is classified as biohazardous waste and must be carefully handled. Common medical materials treated as sharps waste are:

- Syringes and injection devices
- Blades
- Contaminated glass and some plastics

SHARP WASTE DISPOSAL AND TRANSPORT

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- Self-locking and sealable sharps containers are made of plastic so that the sharps waste can not easily penetrate through the sides. Such units are designed so that the whole container can be disposed of with other biohazardous waste. Single use sharps containers of various sizes are sold throughout the world. They are now commonplace in clinics and hospitals. Large medical facilities may have their own 'mini' autoclave in which these sharps containers are disposed of with other medical wastes. This minimizes the distance the containers have to travel and the number of people to come in contact with the sharps waste. Smaller clinics or offices without such facilities are required by federal regulations to hire the services of a company that specializes in transporting and properly disposing of the hazardous wastes.

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PLASMA PYROLYSIS/GASIFICATION SYSTEMS, COMPOSTING

Plasma refers to every gas of which at least a percentage of its atoms or molecules is partially or totally ionized. In a plasma state of matter, the free electrons occur at reasonably high concentrations and the charges of electrons are balanced by positive ions. As a result, plasma is quasi-neutral. It is generated from electric discharges, e.g. from the passage of current (continuous, alternate or high frequency) through the gas and from the use of the dissipation of resistive energy in order to make the gas sufficiently hot. Plasma is characterized as the fourth state of matter and differs from the ideal gases, because it is characterized by 'collective phenomena'. 'Collective phenomena' originate from the wide range of Coulomb forces. As a result, the charged particles do not interact only with neighboring particles through collisions, but they also bear the influence of an average electromagnetic field, which is generated by the rest charges. In a large number of phenomena, collisions do not play important role, as 'collective phenomena' take place much faster than the characteristic collision time (Blachos, 2000).

Plasma Technology can be used as a tool for green chemistry and waste management (Mollah et al., 2000). Thermal plasmas have the potential to play an important role in a variety of chemical processes. They are characterized by high electron density and low electron energy. Compared to most gases even at elevated temperatures and pressures, the chemical reactivity and quenching rates that are characteristic of these plasmas is far greater. Plasma technology is very drastic due to the presence of highly reactive atomic and ionic species and the achievement of higher temperatures in comparison with other thermal methods. In fact, the extremely high temperatures (several thousands degrees in Celsius scale) occur only in the core of the plasma, while the temperature decreases substantially in the marginal zones (Gomez et al., 2009).

Five distinct categories of processes are used as the basis for the plasma systems catering for waste management (Juniper, 2006). These are:

- Plasma pyrolysis (Huang & Tang, 2007; Sheng et al., 2008)
- Plasma combustion (also called plasma incineration or plasma oxidation)
- Plasma vitrification
- Plasma gasification in two different variants (Malkow, 2004)
- Plasma polishing using plasma to clean off-gases

Plasma gasification is the most common plasma process. It is an advanced gasification process which is performed in an oxygen-starved environment to decompose organic solid waste into its basic molecular structure. Plasma gasification does not combust the waste as incinerators do. It converts the organic waste into a fuel gas that still contains all the chemical and heat energy from the waste. Also, it converts the inorganic waste into an inert vitrified glass (Moustakas et al., 2005; Moustakas et al., 2008).

Mixed solid waste is shredded and fed into a reactor where an electric discharge similar to a lightning (the plasma) converts the organic fraction into synthesis gas and the inorganic fraction into molten slag. Typically temperatures are greater than 7,000°F achieving complete conversion of carbon-based materials, including tars, oils, and char, to syngas composed primarily of H_2 and CO, while the inorganic materials are converted to a solid, vitreous slag. The syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity while the slag is inert and can be used as gravel.

Figure 1: Plasma gasification process flow chart

The advantages of the process include: Good environmental performance, production of about 400 KWh net of electricity per tonne of waste treated, no by-products going to landfill.

PLASMA GASIFICATION

The application potential of gasification and plasma gasification is also considered high, since these methods have recently proved that they are effective and flexible, since they can also be used for the treatment of other waste streams (e.g. sludge, hospital waste, etc.) apart from municipal waste. That is why the gasification practices are considered as suitable alternative especially in the case of isolated areas, such as islands. The relevant cost is similar to that of other thermal management practices, higher than that of biological options, the relevant land demand is limited and the energy yield is also considered of vital importance. The experience from the operation of such plants is less than that from incineration units.

The first attempt to apply gasification process in the target region and more specifically in Greece was made he National Technical University of Athens, with a unit that was installed in Mykonos in order to treat all types of waste generated on the island with emphasis on municipal solid waste. The unit had been initially designed and developed in the framework of the LIFE project entitled: “Development of a demonstration plasma gasification / vitrification unit for the treatment of hazardous wastes” and later was modified in order to cater for the treatment of municipal solid waste, too. The scope was to investigate the use of this innovative technique in an isolated area like an island in order to provide a solution to the overall management of waste. General views of the whole demonstration facility are available below:

Figure 2: General view of the demonstration gasification / vitrification unit

Figure 3: Another General view of the demonstration gasification / vitrification unit

The primary waste feeding system consists of a hopper intended for feed of solid material having maximum moisture content of 50% and a maximum particle size of 2.5 cm. The screw conveyor solid feeder has a maximum capacity of about 85 kg/h of waste and the feeding capacity varies depending on the feed waste bulk density. The feed rate is adjustable by varying the speed of the screw conveyor. Waste is manually loaded into the hopper connected to the screw conveyor. The feed rate is continuous and very steady, compared to a hydraulic feeder.

Waste is fed from a hopper through a screw feeder to the top of the furnace and dropping down is passing through the very hot and free of oxygen region between the two electrodes.

Figure 4: Feeding system

The furnace is comprised of a crucible, with approximately 130 litters capacity. It also includes a start-up natural gas burner for preheating and idle operation, a port for gasification

air injection, a water-cooling mechanism for the graphite electrodes, an external surface water-cooling for the furnace walls and a tapping hole for periodical or continuous slag removal. During the operation of the plasma unit, the bottom part of the furnace contains the molten slag, while the upper section of it contains the process gases and is lined with a suitable high-temperature refractory. The required gasification air fed to the furnace is supplied by a compressed air system. Adjusting the valves on the compressed air line can control the flow rate.

Figure 5: Gasification / vitrification furnace

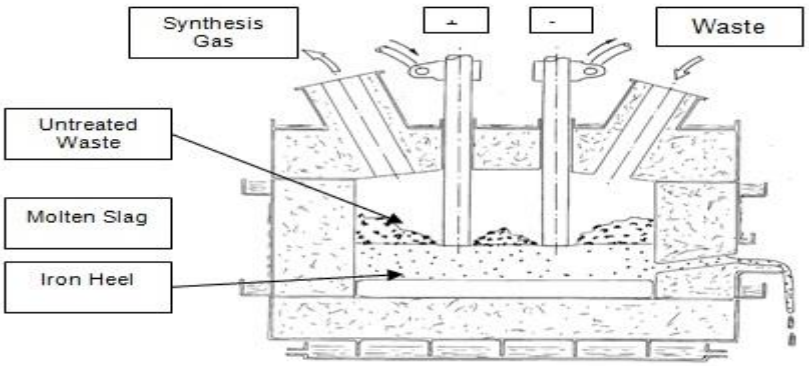

Figure 6: Plasma Gasification / Vitrification Process

In the pilot unit the furnace in which waste gasification is taking place is preheated at 600-800°C by burning propane in its interior. After preheating, two cylindrical graphite electrodes are inserted in the furnace and their ends are approached to a close distance. Two graphite electrodes are used to supply an electrical arc to the furnace. The current flows from the anode (+) to the molten bath and from the bath to the cathode (-). The cathode is grounded at zero (0) potential.

Graphite electrodes with male/female threads are used. The electrode dimensions were 7.6 cm in diameter and 106.7 in length. Electrodes are installed with the female end down, in order to avoid dust accumulation in the threads. Two electrodes were screwed together on each side (anode and cathode) and are mounted on flexible joints, which allow them to be moved over the slag pool and improve mixing. The mechanism also permits the electrodes' extension into the furnace to be adjusted during operation (Carabin & Holcroft, 2005; Carabin et al., 2004; Gagnon & Carabin, 2006).

The DC power supply for the electrodes has a maximum power output of 200 KVA (Plasma arc power supply, input: 600 VAC-3f-60HZ, 3 X 200A fuses).

Then, a high voltage is applied between them producing an electrical arc which is raising locally the temperature up to values as high as 5,000°C and creating a plasma atmosphere. Air is not permitted to enter the furnace. Under these conditions it is ensured that from the volatile part of the waste syngas is produced consisting mainly of H_2, CO, CO_2 and H_2O and containing in very low proportions H_2S and HCl, but without significant presence of NOx. A camera is installed in front of a window on the top of the furnace, connected with a laptop, by which we can watch or make video recording of the electrical arc and the decomposition of the organic matter taking place in the interior of the furnace.

The slag could be tapped out periodically from the tap hole located on the front side of the crucible, close to the bottom of the furnace. The slag was either poured in a slag mold to form ingots or quenched in a water tank to produce granulated slag.

The inorganic part of the waste used is melted, drops to the bottom of the furnace and from time to time is removed through a hole in the lower part of the furnace, is collected to a fire resistant pan and is taken to the laboratory for analysis and investigation of its toxicity.

The hot cyclone was designed to remove dust in the synthesis gas. The produced gases, while entering the cyclone, are put in circular movement and the centrifugal force makes particulate matter contained in the gases to be removed to a high degree.

The result of its operation is the oxidation of the components of the furnace gases. The secondary combustion chamber was designed to combust H_2 and CO in the synthesis gas. In order to combust CO and H_2 into CO_2 and H_2O, air is added into the secondary combustion chamber. Propane burners are used to maintain the chamber temperature at

1,100^{o}C. The operator can check local regulations to determine the required temperature in secondary combustion chamber. This temperature is required to fully combust CO and H_2 in a region where no hazardous by-products are created. In normal operation, the gas residence time in the secondary combustion chamber is about two seconds. A single blower provides the combustion air for the burners and the combustion air for the synthesis gas.

It is located at the outlet of the secondary combustion chamber. Its role is to cool the combustion gases quickly to approximately 75^{o}C so as to minimize any production of dioxins, furans or other organic compounds. The shock-like cooling avoids the formation of the aforementioned compounds from elementary molecules in the synthesis gas due to the de novo Synthesis back reactions (Calaminus & Stahlberg, 1998). These reactions are known to occur in waste heat boilers where a slow cooling in the range from 400^{o}C to 250^{o}C of flue gases with chlorine compounds, non combusted organic molecules and catalysts such as dust will result in dioxin formation. The quench vessel uses two atomizing nozzles to quench the gas from the secondary combustion chamber. These nozzles are capable of providing 2 litters per minute of flow. Regulating the amount of the quenching water can control the gas temperature exiting the vessel.

It removes water-soluble components of the off-gas including hydrochloric acid and most oxides of sulphur, prior to discharge. Since the synthesis gas may contain acid gases (such as HCl or SO_2), a packed tower type wet scrubber uses caustic soda to neutralize the acid gas from the quench vessel. The pH of the scrubbing solution is controlled at 9.0. The scrubber liquor is re-circulated through a wet bagfilter in order to remove suspended particles. The bagfilter is a cartridge unit having series of cylindrical filters that are cleaned periodically by an automatic sequence using pulses of compressed gas.

The pilot unit has a maximum hourly capacity of only 50 kg of waste and the quantity of the syngas produced is too low for a gas engine to convert it in electrical energy; therefore, the syngas has to be released in the atmosphere but in a safe way. Hence, CO and H_2 have to be transformed to CO_2 and H_2O and for this purpose a Secondary Combustion Chamber (SCC) has been added in the installation, which is maintained at high temperature (around 700-800°C) by combusting propane with air and in which CO and H_2 are burnt to CO_2 and H_2O. The SCC in our installation is situated after the furnace and between the two units is interceded a cyclone to remove the solid particles. After the SCC the flue gases are objected to quenching by coming in contact with a big quantity of cold water and this takes place in a

pipe where flue gases and cooling water are moving opposite each other. After quenching, the flue gases are passing for cleaning through a scrubber with NaOH solution, then through a filter and finally before they are released to the atmosphere via a stack are cooled in a heat exchanger to condense and recirculate the maximum quantity of water vapors. The results of the pilot application were positive and encouraging for future applications using this technology. It is hoped that a full scale unit will operate soon in Mykonos and other Greek islands using gasification or plasma gasification technology. However, it is true that the existing severe economic crisis in Greece will cause significant delays is these management plans.

LAND APPLICATION OF WASTEAND COMPOSTING

Type of Facility / Activity & link to more information	**Do I Need a Permit, Registration or License?**	**How Do I Apply?**
Land Application under Part 360-4 - Permit Composting under Part 360-5 - Permit	A permit is required for: • Land application of biosolids; • Large septage haulers; • Land application of industrial waste; • Storage of biosolids at land application sites; • Composting more than 10K cubic yards of yard waste/yr; • Composting more than 1K cubic yards of source separated organics/year • Composting or other processing of biosolids, septage, or mixed solid waste.	For all land application and composting permits, please contact your DEC regional permit administrator
Land Application under Part 360-4 - Registration Composting under Part 360-5 - Registration	A registration is required for: • Land application of non-recognizable food processing waste (NFPW); • Storage of NFPW and manure; • Land application of septage; • Storage and transfer of septage; • Composting 3K-10K cubic yards of yard waste/year; • Composting up to 1K cubic yards of source separated organic waste per year; • Composting of food processing waste.	

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UNIT 4:

2 marks:

1. What is autoclaving?
2. Define Antisepsis.
3. Differentiate b/w wet heat sterilization and dry heat sterilization.
4. What is Sharp Waste? Give examples for sharp wastes.
5. Give the applications of plasma gasification.
6. Define Decontamination.
7. State the categories of plasma system catering.
8. Define Plasma Gasification.
9. What was the initial title of LIFE project?
10. What are the merits of plasma gasification?

12 marks:

1. Explain the procedure for biological waste.
2. All biological wastes require autoclaving. Examine.
3. Discuss about the plasma pyrolysis gasification systems and its components.
4. Examine in detail about plasma gasification.
5. Brief about the sharp waste disposal and its transport.
6. Summarize on the various methods of sterilization.
7. What is the purpose of decontamination? Discuss about the different ways in which biological wastes can be decontaminated.
8. Explain the protocol of autoclaving.
9. What is plasma gasification? Explain the various processes involved in it.
10. Write the land application for waste land composting.

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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – 5 – Medical Waste Management – SBM1608

UNIT-V

MODERN TECHNOLOGY FOR MEDICAL WASTES

INTRODUCTION

Inadequate and inappropriate handling of health care waste may have serious public health consequences and a significant impact on the environment (Pruss et al., 1999). Dwivedi et al (2009)has studied that all the waste materials which is generated by hospitals are not hazardous in nature but only a part of these wastes are infectious which is laden with fatal microorganisms of many serious contagious diseases, which easily spread into water bodies and air. Proper management and handling of hazardous waste is of prime importance today. To minimize these problems many efforts have be end one or are being done at the international level. For safe and scientific management of biomedical waste, handling, segregation, mutilation, disinfection, storage, transportation and finally disposal are vital steps for any health care institution. In developed countries all the institutions related to the health problem are adopting these vital steps. Katoch and Kumar (2008) have reported that a mathematical model can assist waste management planners to optimize existing waste management systems, to set guidelines and regulations, and to evaluate prevailing strategies for the handling of waste. The total process by which the medical waste is treated will influence the selection of biological and physical indicators used in the testing and validation processes and will influence the protocols in which they are used. The development of new medical waste treatment methods utilizing heat, chemicals, heat/chemicals, or irradiation has provided potential alternate solutions to the medical waste treatment/disposal problem (EPRI, 2000). The usual practice of disposal of health care waste in the different regions of the world is gradually increasing.

DISINFECTION EFFICACY OF THE TREATMENT PROCESSES

The establishment of specific criteria that define medical waste treatment efficacy is required to consistently evaluate new or modified medical waste treatment technologies.

There are four levels of treatment (EPRI, 2000 and HCWH, 2001):

Level 1

–

Low Level Disinfection:

Inactivation of most vegetative bacteria, fungi, and some viruses but does not inactivate mycobacterial and bacterial spores and thus is inadequate for biomedical waste treatment.

Level 2

–

Intermediate Level Disinfection:

Inactivation of all mycobacteria, viruses, fungi and vegetative bacteria but that of bacterial spores is not included. Tests for this level disinfection must show that a 6 log reduction of microorganism most resistant to the treatment is attained.

Level 3

–

High Level Disinfection:

A minimum of 4 log reduction of spores of either B. stearothermophilus or B. subtilis is accepted as indicating high level disinfection. A 4 log 10 reduction is equivalent to a 99.99% reduction in spores.

Level 4

–

Sterilization:

Sterilization is evidenced by a minimum 6 log reduction in spores of B. stearothermophilus.

3. LOW HEAT TREATMENT SYSTEMS

The environmental regulations actually mandate the treatment of infectious medical waste on a daily basis if it is stored at room temperature. A number of treatment methods are available. The final choice of suitable treatment method is made carefully, on the basis of various factors, many of which depend on local conditions including the amount and

composition of waste generated, available space, regulatory approval, public acceptance, cost etc. However, incineration used to be the method of choice for most hazardous health care wastes and still widely used. Low heat treatment systems popularly known as non-incineration treatment include four basic processes: thermal, chemical, irradiative, and biological. The majority of non-incineration technologies employ the thermal and chemical processes. The main purpose of the treatment technology is to decontaminate waste by destroying pathogens. Facilities should make certain that the technology could meet state criteria for disinfection.

3.1 Autoclaving

Autoclaving is a low-heat thermal process where steam is brought into direct contact with waste in a controlled manner for sufficient duration to disinfect the waste. For ease and safety in operation, the system should be horizontal type and exclusively designed for the treatment of bio-medical waste. For optimum results pre-vacuum based system is preferred against the gravity type system. It shall have tamper proof control panel with efficient display and recording devices for critical parameters such as time, pressure, date and batch number etc. Typically, autoclaves are used in hospitals for the sterilization of reusable medical equipment. They allow for the treatment of only limited quantities of waste and are therefore commonly used only for highly infectious waste, such as microbial cultures or sharps. Research has shown that effective inactivation of all vegetative microorganisms and most bacterial spores in a small amount of waste (about 5-8 kg) require a 60 mine cycle at 121°C (minimum) and 1 bar (100 kPa); this allows for full steam penetration of the waste material. About99.9999 % inactivation of microorganisms is achievable with autoclave sterilization (Pruss et al., 1999).

3.2 Microwave Irradiation

In microwaving, microbial inactivation occurs as a result of the thermal effect of electromagnetic radiation spectrum lying between the frequencies 300 and 300,000 MHz. Microwave heating is an inter-molecular heating process. The heating occurs inside the waste material in the presence of steam. Most microorganisms are destroyed by the action of microwaves of a frequency of about 2450MHz and a wavelength of 12.24 cm. The microwaves rapidly heat the water contained within the waves and the infectious components are destroyed by heat conduction (Hoffman and Hanley, 1994).

3.3 Chemical Methods

Chemical disinfection, used routinely in health care to kill microorganisms on medical equipment and on floors and walls, is now being extended to the treatment of health-care waste. Chemicals are added to waste to kill or inactivate the pathogens it contains; this treatment usually results in disinfection rather than sterilization. Chemical disinfection is most suitable for treating liquid waste such as blood, urine, stools, or hospital sewage. Several self-contained waste treatment systems, based on chemical disinfection, have been developed specifically for health care waste and are available commercially. Most commonly used chemicals for disinfection of bio medical waste are sodium hypochlorite (NaClO,5 %) hydrogen peroxide (H_2O_2, 30 %), and Fenton reagent ($FeCl_2.2H_2O$; 0.3 g in 10 ml H_2O_2, 30 %) (Chitnis et al., 2003 and HCWH, 2001).

3.4 Solar Disinfection

Solar heating as an alternative technology to cook up medical waste is being used in poor developing countries that cannot afford other expensive technologies. Chitnis et al in 2003 reported a 7 log reduction in the amount of viable bacteria when they used a box – type solar cooker to disinfect medical waste. A hybrid solar steam sterilizer with a capacity to run 76 L autoclave four times a day built in cooperation with Solar Bruke (Germany) and Solar Alternative (India) was at first installed in Holy Family Hospital in Mandar (150 beds) in winter 2004

4. CASE STUDY

The efficacy testing is only one factor in the safe and effective treatment of medical waste by conventional or new technologies. The facilities generating medical waste must evaluate their current waste streams in order to minimize the medical waste components of their solid wastes, more effectively manage the processing and transport of the medical waste within their facilities and in sure that all medical waste is appropriately packaged for internal and/or external transport. The establishment of qualitative and quantitative parameters that ensure effective and safe medical waste treatment are required in defining treatment technology efficacy criteria and delineating the components necessary to establish an effective state medical waste treatment technology approval process (EPRI, 2000).The total amount of medical waste generated from a health care facility is associated with the type or the size of the institution (Cheng et al., 2009). Biomedical waste management rules were

formulated in response to the worldwide public concern over medical waste. The practice of separation into different types of waste in health care institutes should be evaluated more scientifically. This study strongly suggests that waste should be removed from the hospital within24 hours of its generation to prevent environmental contamination caused by any accidental spillage of waste. General waste generated in the hospital should be treated similar to infectious waste, as it can be equally hazardous (Saini et al., 2004).Modeling of waste management system is rater less developed, perhaps due to the fact that the process invokes a large number of parameters having unknown behavior. However, need of some predictive tool is clearly visualized by many researchers (Katoch and Kumar 2008). MoEF, GoI (1998)had earlier described ten categories which are reduced to eight in the draft rule of 2011. Many regulatory definitions of regulated medical waste are based on ten broad categories defined in a 1986EPA guide on infectious waste management. The ten categories are: Cultures and Stocks; Anatomical Wastes (or Human Pathological Wastes); Human Blood, Blood Products, and Other Bodily Fluids; Sharps; Animal Wastes; Isolation Wastes; Contaminated Medical Equipment; Surgery Wastes; Laboratory Wastes; and Dialysis Wastes (HCWH, 2001).In compliance to Biomedical Waste (Management and Handling) Rules, Municipal Corporation Shimla had established zonal treatment facility for incineration of yellow bag waste since August 2002. In addition an autoclave facility within the campus of IGMCH which had been operating since September 2003 along with a shredder for the purpose of disinfection, recycling and resale of red bag waste. There are around one hundred clinics and health care facilities in the limits of Municipal Corporation. It was formerly the summer capital during the British Rule. Its altitude is about 2,100 m and surrounded by pine, deodar, oak, and rhododendron forests. The area of town is about 25 km 2. All the seasons of nature visit Shimla during the year.

INFECTION PREVENTION AND CONTROL

The Infection Control team are doing to prevent hospital infections at Great Ormond Street Hospital (GOSH) and what you can do to help us minimise the risk of infections during your child's stay.

Children and young people can be at a higher risk of getting an infection when they are ill. The body has natural defence mechanisms to fight off infections, but these may be affected for a variety of reasons when someone is ill. For example, when a child has an operation, the surgical wound means that the natural skin barrier is broken, which could allow

bacteria (germs) to enter the body. Bacteria and viruses (germs) may come from other patients, staff, visitors (including siblings), equipment or the environment.

This page explains the key principles that will help to prevent infections:

HAND HYGIENE

Hand washing or using alcohol gel is the most effective way of stopping infections passing from person to person.

What we can do

- All our staff have been trained in hand hygiene.
- We expect all staff to wash or gel their hands before and after having contact with your child.
- Every month, we audit compliance with our hand hygiene protocol.

What you can do

- If you are not sure if a staff member has cleaned their hands, it is ok for you to ask.
- Make sure that your child washes their hands before meals and after using the toilet.
- Make sure that you wash your hands before and after visiting your child, before meals or feeding your child, after visiting the toilet and after changing your child's nappy.
- Ask your visitors to do the same.

MONITORING

What we can do

- We test all patients before or on admission if they carry germs that are resistant to common antibiotics, such as MRSA (meticillin resistant staphylococcus). The test is done by taking a swab from the nose and the throat, as well as sending a faeces (poo) sample.
- If your child is carrying a germ that is resistant to the common antibiotics, we will nurse them in a single room and alert this on your child's computer record.

What you can do

- If your child has been in contact with someone who has an infectious disease, such as chickenpox, shingles or measles, or has developed a rash, let us know before you come to GOSH. This will help us to prevent it spreading to other children and their families.
- If one of your other children (siblings of the patient) has been in contact with someone who has an infectious disease, such as chickenpox, shingles or measles, or has developed a rash, check first with the ward if it is ok for them to visit.
- Do not visit or bring in your other children if any of you have symptoms including diarrhoea and vomiting, a cough or a cold.
- Tell your visitors that should not visit if they have symptoms like diarrhoea and vomiting, a cough or a cold.

ENVIRONMENT

What we can do

- Cleanliness of the environment is very important to us and we are making sure that our wards and departments are clean and tidy.

What you can do

- You can help us by telling us if you think an area or a piece of equipment is not clean enough – please let the nurse in charge know.
- Please keep your child's room or bed area tidy and free from clutter to help our domestic staff to clean the area.

ISOLATION

What we can do

- If your child has an infection we may need to nurse them in isolation in a single room. The aim of isolation is to prevent the transfer of infection from infected patients to other patients, staff and visitors.

Infections can be passed on in different ways:

- They may be spread by direct contact with another person, usually by the hands.
- They can be passed on indirectly from one person to another via contaminated equipment, toys or the environment.
- They may be airborne from someone coughing or sneezing and can be passed on through the inhalation of airborne droplets.

If we need to look after your child in an isolation room, we will explain to you and your child why this is necessary. Depending on what type of infection your child has, staff may need to wear gloves, aprons or face masks when looking after your child.

What you can do

- Make sure that everyone cleans their hands before and after leaving the room with soap and water or alcohol gel.
- Make sure that the door of the room is kept closed.
- Make sure that all toys and equipment used for your child are kept in their room and until they are better and no longer need to be isolated.
- Do not visit other children and parents on the ward and make sure that they do not come to visit you.
- Check with the nurse in charge if you can use the parent's room and kitchen on the ward.
- Check with the nurse in charge if your other children can come to visit.

PERSONAL PROTECTIVE EQUIPMENT

This section discusses the evidence and associated recommendations for the use of personal protective equipment by healthcare workers in general care settings, including aprons, gowns, gloves, eye protection and face masks. Where appropriate, in addition to the grade of the evidence underpinning the recommendations, there is an indication of a Health and Safety requirement.

The primary role of personal protective equipment is to protect staff and reduce opportunities for transmission of microorganisms in hospitals. Over the past 20 years there has been a trend to eliminate the inappropriate wearing of aprons, gowns and masks in general care settings because of a lack of evidence that they are effective in preventing healthcare acquired infection (HCAI).

The decision to use or wear personal protective equipment must be based upon an assessment of the level of risk associated with a specific patient care activity or intervention and take account of current health and safety legislation. However, several studies have identified that both a lack of knowledge of guidelines and non-adherence to guideline recommendations are widespread and that on going in-service education and training is required.

Many agencies, including the Department of Health and NHS employers encourage healthcare providers and their employees to pursue safer methods of working through considering the benefits of new safety devices. The incidence of sharps injuries has led to the development of needlestick-prevention devices in many different product groups . These are designed to minimise the risk of operator injury during needle use as well as so-called 'downstream' injuries that occur after disposal, often involving the housekeeping or porters responsible for the collection of sharps disposal units.

More recent studies have shown significant reductions in injuries associated with the use of safety devices in cannulation.

It would seem logical that where needle-free or other protective devices are used there should be a reduction in sharps injuries. Some studies identify a range of barriers to the expected reduction in injuries, including staff resistance to using new devices, complexity of device operation or improper use, and poor training. A comprehensive report and product review conducted in the United States provides background information and guidance on the need for and use of needlestick-prevention devices but also gives advice on establishing and evaluating a sharps injury prevention program (ECRI, 2003). The report found that all devices have limitations in relation to cost, applicability and/or effectiveness. Some of the devices available are more expensive than standard devices, may not be compatible with existing equipment, and may be associated with an increase in bloodstream infection rates.

In the US, the Occupational Safety Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) suggest that a thorough evaluation of any device is essential before purchasing decisions are made. Similarly in the UK, the NHS Purchasing and Supply Agency recognises that meaningful evaluations are paramount in assessing user acceptability and clinical applicability of any needle safety devices. The evaluation should ensure that the safety feature works effectively and reliably, that the device is acceptable to healthcare practitioners and that it does not adversely affect patient care.

THE SAFE USE AND DISPOSAL OF SHARPS

This section discusses the evidence and associated recommendations for the safe use and disposal of sharps in general care settings, including minimising the risks associated with sharps use and disposal and the use of needle protection devices. Where appropriate, in addition to the grade of evidence underpinning the recommendations, there is an indication of a Health and Safety legislation requirement.

Sharps injuries – what's the problem?

The safe handling and disposal of needles and other sharp instruments forms part of an overall strategy of clinical waste disposal to protect staff, patients and visitors from exposure to bloodborne pathogens (Health Services Advisory Committee, 1999). In 2003 the National Audit Office found that needlestick injuries ranked alongside moving and handling, falls, trips and exposure to hazardous substances as the main types of accidents experienced by NHS staff (National Audit Office, 2003). In 2001 the Royal College of Nursing (RCN) launched its *Be Sharp Be Safe* campaign aimed at reducing sharps injuries. A component of the campaign is surveillance using the software EPINet™. Fifteen sites contributed to the RCN 2002 survey and reported a total of 1,445 injuries (Watterson, 2004). Although many injuries (52.6%) were superficial, 44.6% (n = 626) ranked moderate, including some bleeding, and 2.8% (n=39) were severe. Nurses were the group with the highest proportion of sharps injuries, accounting for 41.2% of all reported injuries.

A report in 2006 from the Health Protection Agency confirms that healthcare workers are still being exposed to bloodborne virus infections, even though such exposures are largely preventable. The number of reported occupational exposures increased by 49% in three years, from 206 in 2002 to 306 in 2005, with almost half of all exposures occurring in nurses (Health Protection Agency, 2006). The report draws attention to the need for NHS Trusts to

provide local protocols and information on the risk of bloodborne viruses in the work place and to ensure that healthcare workers are adequately trained on how to prevent injuries.

The average risk of transmission of bloodborne viruses following a single percutaneous exposure from an infected person, in the absence of appropriate post-exposure prophylaxis has been estimated (Health Protection Agency, 2006; Center for Disease Control and Prevention, 2006):

- hepatitis B virus (HBV) 33.3% (1 in 3)
- hepatitis C virus (HCV) 1.8 -1.9% (1 in 50)
- human immunodeficiency virus (HIV) 0.3 % (1 in 300)

National and international guidelines are consistent in their recommendations for the safe use and disposal of sharp instruments and needles (Expert Advisory Group on AIDS and the Advisory Group on Hepatitis, 1998; Ward et al, 1997; Centers for Disease Control, 1988; Occupational Safety and Health Administration, 1999). As with many infection prevention and control policies, the assessment and management of the risks associated with the use of sharps is paramount and safe systems of work and engineering controls must be in place to minimise any identified risks, such as positioning the sharps bin as close as possible to the site of the intended clinical procedure (Health and Safety Commission, 1999).Any healthcare worker experiencing an occupational exposure to blood or body fluids needs to be assessed for the potential risk of infection by a specialist practitioner, such as a physician or occupational health nurse, and offered testing, immunisation and post-exposure prophylaxis if appropriate (Expert Advisory Group on AIDS, 2000).

BIOETHICS AND HANDLING OF WASTE MANAGEMENT

Principles of Globalization and Public Health

- Increase in technological and economic interdependence allows disease to spread rapidly, ignoring borders;
- The free movement of capital and labor makes it difficult for countries to protect their citizens from global disease;
- Industrialized, as well as developing countries, face decreased spending on public health infrastructure.

- National governance challenged by globalization
- Global trade expansion opens markets to all legal products
- Transnational approaches needed on global health issues
- Both temporal and spatial dimensions

Key Ethical Principles Related to Global Public Health

- Autonomy- individual choice
  - requires resolution of information asymmetry and voluntary choice
- Beneficence- do no harm and also prevent harm
- Justice- esp. distributive justice

  fair, equitable and appropriate distribution of social goods including political rights
- Cognitive globalization of risks (social learning through trans-border marketing, promotion, & movies); middle classes in particular;
- Treaties are necessary to solve issues that extend beyond national laws;*

  The rights of nations to protect public health are circumvented by global trade.

International Regulation

Cross Border Management of Public Health Threats

- Infectious Disease
- Hazardous Waste
- Tobacco?

Emerging Infectious Disease

- "Diseases of infectious origin whose incidence in humans has increased within the past two decades or threatens to increase in the near future" (1)
- Emerging infections "represent a global threat that will require a coordinated, global response" (2)
- Ethical implications of disease eradication?
- Single disease politics?

Current International Efforts at Infectious Disease Control

1) Improve surveillance efforts;

2) Develop international standards and guidelines for disease reporting and control;

3) Strengthen international research;

   Disproportional concern with techno fix

4) Encourage national governments to improve public health systems.

International Health Regulations

- Regulation function of WHO, currently under revision (infectious diseases);
- Interaction with World Trade Organization on health: little to none (Sanitary and Phytosanitary Measures);
- Doha Round of trade negotiations (2001) recognized need to respect public health emergencies in trade actions.

Why International Health Regulations are Needed

- International Regulations on hazardous waste trade are required to protect populations from disease posed by trading across international borders.
- International Regulations on Infectious Disease are required because vectors do not respect geographically determined borders.

Hazardous Waste

- Basel Convention on the Control of Transboundary Movements of Hazardous Waste and its Disposal.
- Requires
- Signatory countries to minimize their generation of hazardous waste
- Ensure that adequate disposal facilities are available
- Prevention of Illegal Traffic

Why Should Tobacco be Viewed as a Bioethical Issue?

- Information asymmetry and nicotine addiction contradict ideas of autonomy;
- Principle of beneficence requires global health governance to prevent harm;
- Social justice violated when only market forces control tobacco use (market failure requires global governance to correct).

International Cooperation

- First intended to protect industrialized world commercial investments and armies
- Global infectious disease spread through mobility, war, etc
- Major effort to protect economies through control of ID and bad publicity.

Donor Influences

- Health policies
- 25% of public health expenditures globally
- Technical assistance
- Multinational alliance
- Private-public partnerships

Dealing with Trade Issues

- WTO: Existing international trade agreements do not adequately address public health concerns;
- Trade liberalization has significant potential for spread of hazardous products;
- Trade trumps health in WTO agreements;
- Trade liberalization reduces national sovereignty.

Dealing with Ethics in Foreign Policy

- Human rights enshrined at Nuremberg trials;
- Morality, values, ethics, and universal principles part of every foreign policy discussion, including war in Iraq;
- Humanitarian intervention part of morality of international affairs.

Social Justice

- National social minimums?
- Distributive justice for all?
- Access to health and education
- Conflict of state sovereignty and global governance
- Legitimate authority to exercise public policy for a common purpose.

Health Industry

- Health care reform—structural adjustment leading to privatization and "efficiency"
- Fragmentation due to so many international organizations
- Growth area for private sector—channeling of public money to private pockets.
- Rise of civil society, NGOs

Global Ethical Needs

- New form of global governance
- Moral foreign policy
- Attention to equity of individuals
- Attention to accountability of industrialized nations
- Public interest maintained
- Enlightened self interest of corporate world
- Global alliances

TEXT / REFERENCE BOOKS

1. V.J. Landrum, Medical Waste Management and disposal, Elsevier, 1991, ISBN:978-0-8155-1264-6

2. SATabish, Principles of Hospital Management, OUP, Jaypee Publishers. 6th Edition 2000.

3. SL Goel, Dr. R. Kumar, Encyclopedia of Hospital Management-Text and Case Studies Hospitals in Community Health Care, ISBN (Hardbound): 8184502273, 9788184502275. 2010.

4. J. Glyn Hendry & Gary W Heinke, Environmental Science and Engineering, Prentice Hall India, 2004

5. Shyam Divan, Environment all a wand policy in India, Oxford India Press, 2004.

6. Charles A Wentz, Hazardous Waste Management, McGraw Hill Inc, Newyork, 1995

UNIT 5:

2marks:

1. Mention the different methods of autoclaving.

2. What are the different ways in which the infections spread?

3. What are the steps taken to prevent infections?

4. Mention the primary role of personal protective equipment.

5. Tobacco is viewed as a bioethical issue. Why?

6. What are the Global Ethical Needs?

7. Mention the principles of Globalization and Public health risk.

8. Define microwave irradiation.

9. What are the key ethical principles related to Global Public health?

10. What is Solar Disinfection?

12 marks:

1. Explain in detail about the safe use and disposal of sharps.
2. What is bioethics? List the methods in which the waste management is handled.
3. Explain in detail about the requirement of personal protective equipment.
4. Brief about a case study on infectious waste management.
5. Illustrate the methods of sterilization.
6. Explain the different methods of low heat treatment systems.
7. Discuss the key principles that will help to prevent infections.
8. Use of personal protective equipment is recommended among healthcare workers. Examine
9. Summarize the management of sharp wastes and its safe use.
10. Discuss the disinfection efficacy of the treatment processes.