4.4 Characteristics of Bio-Medical Waste

The characteristics of bio-medical waste is non infectious, infectious, hazardous and cytotoxic. The non infectious waste is the waste which is similar to household waste like wrapper, eatables, food etc. The infectious waste includes pathological waste, surgical waste (body parts), sharps waste, items contaminated with blood and body fluids etc. Cytotoxic and hazardous waste includes chemical waste, pharmaceutical waste and discarded medicines.

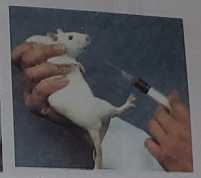
4.5 Categorization of Bio-Medical Waste

As per Bio-Medical Waste (Management and Handling) Rules, 1998, the bio-medical waste has been categorized into ten categories, they are as follows.

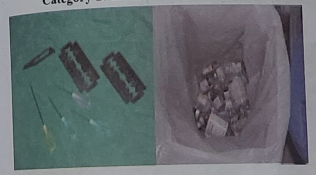
- *Category 1:* Human Anatomical Waste (body parts, organs, human tissues etc.).
- *Category 2:* Animal Waste (animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses).
- *Category 3:* Microbiology & Biotechnology Waste (Wastes from laboratory cultures, stocks or micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures).
- *Category 4:* Waste Sharps (needles, syringes, scalpels, blade, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps).
- *Category 5:* Discarded Medicines and Cytotoxic drugs (Waste comprising of outdated, contaminated and discarded medicines).
- *Category 6:* Soiled Waste (items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood).
- *Category 7:* Solid Waste (Waste generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc.).
- *Category 8:* Liquid Waste (Waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities).
- *Category 9:* Incineration Ash (Ash from incineration of any bio-medical waste).
- *Category 10:* Chemical Waste (Chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.).

Categorization of Bio-Medical Waste

Category 1: Human Anatomical Waste

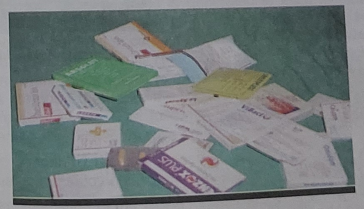


Category 2: Animal Waste



Category 4: Waste Sharps

Category 3: Microbiology & Biotechnology Waste

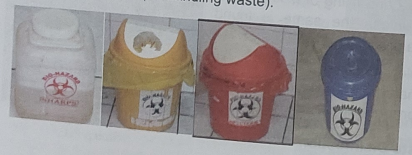


Category 5: Discarded Medicine & Cytotoxic Drugs

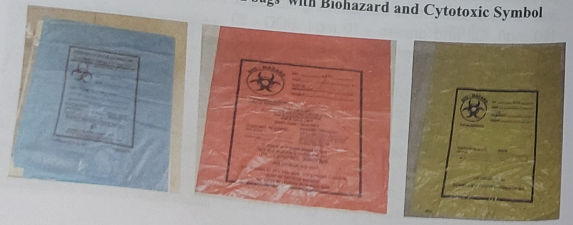
4.10 Tools and Equipments Required for Bio-Medical Waste Management

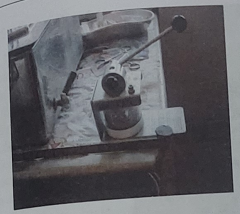
The tools and equipments required for managing the bio medical waste are as follows.

- Colored bins/bags (yellow, red, blue & white translucent puncture proof and black) having Bio Hazard and Cytotoxic symbol (for segregation of waste).
- Big plastic container (for storing mutilated and disinfected plastic waste).
- Needle cutter/Needle burner (for destroying needle and Syringe).
- Autoclave/Microwave (for disinfection).
- Sodium hypo Chlorite solution (for disinfecting mutilated material).
- Shredder (for cutting into pieces).
- Incinerator (for incinerating waste).
- Deep burial pit (for burial of waste).
- Sharp pit (for keeping disinfected and mutilated sharps).
- Scissors & knife (for destroying plastic waste).
- Protective aids (for handling waste).

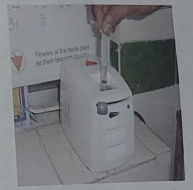


Specific Coloured Bins and bags with Biohazard and Cytotoxic Symbol

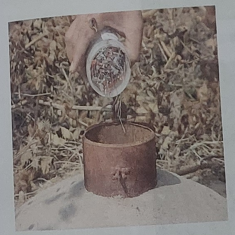




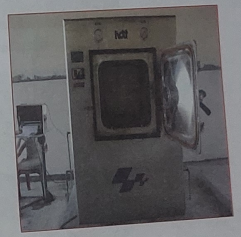
Manual needle cutter



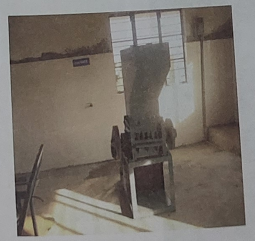
Electrical needle burner



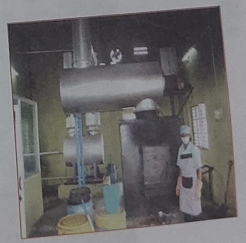
Sharp pit



Autoclave



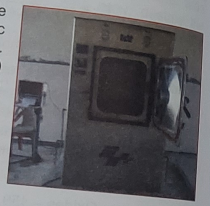
Shredder



Incinerator

may be used. On each occasion, when wastes are added to pit, layer of 10 cm of soil shall be added to cover the wastes. Burial must be performed under close and dedicated supervision. Pits should be distant from habitation so as to ensure that no contamination of ground water occurs. The area should not be prone to flooding or erosion. The institution shall maintain record of all the pits for deep burial. Fencing of the deep burial pit has to be maintained. The deep burial site should be relatively impermeable and no shallow well should be close to the site. The location of the deep burial site will be authorized by the prescribed authorities.

4.9.3 Autoclave



The microbiology and biotechnology waste, waste sharps, soiled waste and solid waste (plastic waste) are subjected to autoclave for disinfection. Temperature- 121^{0}C and pressure 15 pounds (psi) RT 60 m or 135^{0}C and pressure 31 psi RT 45 minutes or 149 ^{0}C and pressure of 52 psi RT 30 minutes. When operating a vacuum autoclave, medical waste shall be subjected to a minimum of one pre-vacuum pulse to purge the autoclave of all air. The waste shall be subjected to Temperature: 121^{0}C and pressure of 15 psi RT 45 minutes; or 135^{0}C and pressure of 31 psi RT 30 minutes.

Routine Test

A chemical indicator strip/tape the changes colour when a certain temperature is reached can be used to verify that a specific temperature has been achieved. It may be necessary to use more than one strip over the waste package at different location to ensure that the inner content of the package has been adequately autoclaved.

Validation Test (Spore testing)

Bacillus stearothermophilus spores using vials or spore Strips; with at least 1 × 10^4 spores per milliliter.

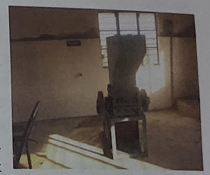
Sharp Pit

4.9.4 Sharp Pit

The sharp waste finds its way into sharp pit. The detail of sharp pit is as follows.

A pit is to be dug according to the requirement of the hospital. All the sides of the pit should be plastered with cement. A cylindrical metal pipe of 4 inches diameter or more is fixed at the ceiling of the pit. The opening of the metal pipe should have locking facility. The sharps are deposited in this pit through the pipe from the puncture proof translucent container after mutilating.

4.9.5 Shredder



After autoclave the plastic waste is subjected to shredding, where plastic waste is shredded into pieces.

Shredder

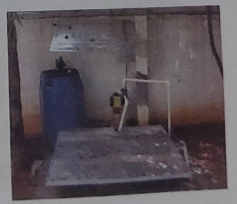
4.9.6 Secured Landfill

Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for incinerate biological processing. Land filling shall also be carried out for residues of waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing.

Under unavoidable circumstances or till installation of alternate facilities, land filling shall be done following proper norms.

Sharp Pit

4.9.7 Liquid Waste Disinfection



Liquid waste needs to be disinfected/treated and should conform to the following standards PH - 63-9.0, Suspended solids - 100 mg/l, Oil and grease - 10 mg/l, BOD - 30 mg/l, COD - 250 mg/l, Bio-assay test - 90% survival of fish after 96 hours in 100% effluent. These limits are applicable to those, hospitals which are either connected with sewers without terminal sewage treatment plant or not connected to public sewers. For discharge into public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act, 1986 shall be applicable.

introduced into a vessel, forcing out the air in the chamber by its heavier mass (gravity displacement) or the steam is pulled into the vessel after the air has been exhausted by a vacuum system (vacuum displacement). As the steam accumulates, the pressure and temperature within the chamber increases until the minimum temperature and pressure requirements for treatment of the waste have been met. Table 4.7 gives the standards on autoclaving the BMW for the purposes of disinfecting and treating.

Table 4.7 Standards for biomedical waste autoclaving, MoEF, GoI

Option	Operating, monitoring, and validation parameters
I	*Gravity flow autoclave:* When operating a gravity flow autoclave, medical waste shall be subjected to: a temperature of not less than 121°C and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 60 minutes; or a temperature of not less than 135°C and pressure of 31 psi for an autoclave residence time of not less than 45 minutes; or a temperature of not less than 149°C and pressure of 52 psi for an autoclave residence time of not less than 30 minutes.
II	*Vacuum autoclave:* When using a vacuum autoclave, the BMW should be subjected to a least of pre-vacuum pulse to purge the autoclave of all air. The BMW should be subjected to the conditions as specified in the manufacturers operating manual.
III	*Time, temperature and pressure indicators:* BMW should not be considered as suitably treated unless the time, temperature and pressure indicators indicate that these parameters have reached sufficiently during the autoclave process.
IV	*Recording of operational parameters:* Each autoclave shall have graphic or computer recording devices which will automatically and continuously monitor and record date, time of day, load identification number and operating parameters throughout the entire length of the autoclave cycle.
V	*Validation test spore testing:* The autoclave should completely and consistently kill the approved biological indicator at the maximum design capacity of each autoclave unit.
VI	*Routine test:* A chemical indicator strip changes colour when a certain temperature is reached can be used to verify that the desired temperature has been reached and the BMW has been adequately autoclaved.

Source: MoEF, GoI (2011).

4.7 CHEMICAL DISINFECTION

Chemical disinfection is used to kill pathogens present in medical equipments. Chemical disinfection is most suitable for treating liquid waste such as blood, urine, stools, or hospital sewage. Chemical processes employ disinfectants such as dissolved chlorine dioxide, bleach (sodium hypochlorite), acetic acid, or dry inorganic chemicals. In liquid systems, the waste may go through a dewatering section to remove and recycle the disinfectant. The disinfected waste should be carefully disposed off.

4.7.1 Standard for Liquid BMW

The effluent generated or treated from the hospitals should conform to the following limits (Table 4.8):

Table 4.8 Standard for liquid BMW

S. No.	Parameters	Permissible limits
1.	pH	6.5–9.0
2.	Suspended solids	100 mg/l
3.	Oil and grease	10 mg/l
4.	BOD	30 mg/l
5.	COD	250 mg/l
6.	Bioassay test	90% survival of fish after 96 h in 100% effluent

4.8 MICROWAVING

Microwaves are electromagnetic waves with a frequency between radio waves and infrared waves on the electromagnetic scale. When applied to the treatment of waste, the mechanism of microbial inactivation is thermal. The waste should either be wet or made to wet by addition of moisture in the form of steam. The microwaves and moisture create thermal turbulence. Some treatment processes utilise microwaves to heat water to form steam which is then applied to the clinical waste stream. A dry microwave system is also used. It uses direct microwave energy in a nitrogen atmosphere to treat the waste and produce higher treatment temperatures than those used by wet microwave technologies. The microwaves swiftly heat water contained in between the waves and the infectious part is destroyed by heat conduction.

4.8.1 Standards of Microwaving

1. Microwave treatment should not be used for hazardous or radioactive wastes, contaminated body parts, animal carcass or metal items.
2. The microwave system should be made to perform efficacy test/routine tests and a performance guarantee may be provided by the supplier before operation of the limit.
3. The microwave should completely and consistently kill the bacteria and other pathogenic organisms at the maximum design capacity of each microwave unit.

4.9 PYROLYSIS

Plasma pyrolysis is an environment-friendly technology which converts organic waste into commercially useful by-products. The extreme heat generated by the plasma enables it to dispose all types of BMW and hazardous waste in a safe manner. BMW is converted into CO, H_2, and hydrocarbons when it comes in contact with the plasma arc. The gases are burnt to produce a temperature of 1200°C which hinder the formation of dioxin and furans.

In a plasma system, an electric current is discharged through an inert gas (e.g., argon) to ionise it and in turn causes an electric arc to create temperatures as high as 6000°C. The BMW inside the system is brought to temperatures between 1300 to 1700°C, destroying pathogenic microorganisms and converting the waste into slag, ferrous metal, and inert gases. In a plasma torch, an arc is established between two electrodes. A carrier gas, which may be inert or have

Category	Waste category (Type)	Treatment and disposal option
3.	*Microbiology and biotechnology waste and other laboratory waste* (Wastes from clinical samples, pathology, biochemistry, haematology, blood bank, laboratory cultures, stocks or specimens of microorganisms vaccines, human and animal cultures in research and infectious agents from research and industrial labs, wastes from production of toxins and equipment used for transfer of cultures)	Disinfection at source by chemical treatment. Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection or by autoclaving/microwaving followed by mutilation/ shredding. Mutilation/shredding must be such that so as to prevent unauthorised reuse, and after treatment final disposal in secured landfill or disposal of recyclable wastes (plastic or glass) through registered or authorised recyclers.
4.	*Waste sharps* (Needles, syringes, scalpels, blades, glass, etc. that may cause cuts. These include both used and unused instruments)	Disinfection. Chemical treatment using 1% hypochlorite solution or any other reagent. Chemical treatment should ensure disinfection or destruction by needle and tip cutters. Autoclaving or microwaving followed by mutilation/shredding. Mutilation/shredding must be such that so as to prevent unauthorised reuse, whichever is applicable and final disposal through authorised Common Biomedical Waste Treatment Facility (CBWTF) or disposal in secured landfill or designated concrete waste sharp pit.
5.	*Discarded medicines and toxic drugs* (Wastes comprising of outdated, contaminated and discarded medicines)	Disposal in secured landfill or incineration. There will be no chemical pre-treatment before incineration. Chlorinated plastics/bags shall not be incinerated.
6.	*Soiled waste* (Items contaminated with blood, body fluids, used cotton, dressings, plaster casts, beddings or other material contaminated with blood)	Incineration. There will be no chemical pre-treatment before incineration. Chlorinated plastics/bags shall not be incinerated.
7.	*Infectious solid waste* (Wastes generated from disposable items other than the waste sharps such as tubing, hand gloves, saline bottles with IV tubes, catheters, glass, intravenous sets, etc.)	Disinfection. Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection or autoclaving or microwaving followed by mutilation or shredding. Mutilation/shredding must be such that so as to prevent unauthorised reuse, and after treatment final disposal through registered or authorised recyclers.
8.	*Chemical waste* (Chemicals used in the production of chemical or biological material used in disinfection such as insecticide)	Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent and discharge into drains meeting the norms notified under these rules and solids disposal in secured landfill.

Disposal of BMW by deep burial is prohibited in towns and cities. Disposal by deep burial is permitted only in rural areas where there is no access to CBWTF, with prior approval from the prescribed authority. The deep burial facility is to be located as per the provisions and guidelines issued by CPCB from time to time.

4.3 COLOUR CODED SEGREGATION SYSTEM

The BMW should be segregated in containers/bags at the point of generation in specified colour coding schedule and with requisite labels prior to its storage, transportation, treatment and disposal as provided in Table 4.3.

Table 4.3 Colour coding and type of container for disposal of BMW

S. No.	Colour coding	Type of container to be used	Waste category number
1.	Yellow	Non-chlorinated plastic bags	Category: 1, 2, 5 and 6
2.	Red	Non-chlorinated plastic bags/puncture proof container for sharps	Category: 3, 4 and 7
3.	Blue	Non-chlorinated plastic bag	Category: 8
4.	Black	Non-chlorinated plastic bag	Municipal waste

The labels should be non-washable and clearly visible. The colour coding is selected depending on the BMW treatment option.

4.4 STANDARDS FOR TREATMENT AND DISPOSAL OF BMW

A Common Biomedical Waste Treatment Facility (CBWTF) is a system where biomedical waste, generated from a number of health care facilities, has necessary treatment set up to reduce adverse effects that the BMW may pose. The treated waste is finally sent for disposal in landfill or for recycling. Setting up of small or individual BMW treatment facility by health care facilities will require high capital investment besides separate manpower and infrastructure for proper running and maintenance of the BMW treatment system. The CBWTF incorporates these problems and also prevents setting up of a large number of BMW treatment equipments. It also reduces the monitoring difficulties by regulatory bodies. Further the cost of BMW treatment per ton is drastically reduced.

In order to set up a CBWTF, care should be taken in selecting appropriate technology, development of area, and proper designing of transportation system to achieve optimum results. The key features and guidelines for the establishment of CBWTF are given in Table 4.4.

Table 4.4 Key features and guidelines for the establishment of CBWTF

Component	Description
Location	A CBWTF shall be located at a place reasonably far away from residential and sensitive area so that it has minimal impact on these areas. The CBWTF shall be located as near to its area of operation as possible in order to minimise the movement in waste handling and to increase the efficiency of the operation. The location shall be approved by the SPCB/PCC.
Land requirement	Sufficient land shall be allocated for CBWTF to provide all requisite systems. It is felt that a central treatment facility will require minimum of 1 acre land area.
Coverage area	In any area, only one central treatment facility may be allowed to handle up to 10,000 beds at the rate approved by the concerned authority. A CBWTF shall not handle the waste of health care facilities located outside a radius of 150 km. In case an area where 10,000 beds are not available in a radius of 150 km, an additional CBWTF may be permitted to handle the health care facilities situated outside 150 km radius.

CHAPTER 4

Bio-Medical Waste

4.1 Introduction to Bio-Medical Waste

Bio-medical waste means any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals, and including, human anatomical waste, animal waste, microbiology and biotechnology waste, waste sharps, discarded medicines and cytotoxic drugs, soiled waste, solid waste (catheter, saline bottle etc.), incineration ash and chemical waste.

Waste is produced from all hospitals irrespective of the size of them. The waste from hospitals carries a higher potential for infection due to infectious waste and injury due to accidental needle prick. It is a risk to medical staff, in and out patients, visitors, workers in support services, workers in waste disposal facilities and the general public of getting infected. Around 20 blood born diseases can be transmitted if the waste is not managed properly. Staff of health care establishments, who are either in contact with the patient or the infectious waste generated, are continuously at risk during their working hours. The following types of occupational hazards occur/can occur.

- Accidental cut or punctures from infected sharps such as, hypodermic needles, scalpels, knives etc.
- Contact with infected material like pathological waste, used gloves, tubing etc., especially from the operation theatre, bedding and dress material of the patient or from the doctors (used during check up/surgery etc.)
- Contact with stool, urine, blood, pus etc of the patients, especially during cleaning job.

Therefore it is essential that adequate protection measures are to be provided against occupational health hazards. The administration of the health care establishment (Infection Control Officer in case of large ones) should have a detailed deliberation on this subject.

As a safety measure for the medical and para-medical staff the following instructions need to be notified and strictly adhered to:

- Clear directives in the form of a notice to be displayed in all concerned areas.
- Issuance of all protective clothes such as, gloves, aprons, masks etc. without fail.
- Sterilization of all equipment and issue of only properly sterilized equipment and tools, such as, surgical tools to the medical personnel and maintenance of registers for this purpose.
- Provision of disinfectant, soap etc of the right quality and clean towels/tissue paper.
- Immunization to all medical care workers.
- Provision of a wash area, where they can take bath, if needed/desired.
- Washing and disinfecting facility for the cleaning equipment and tools.
- Regular medical check-up (at least half-yearly).

Environmentally sound management of bio-medical waste is very much important to protect health and environment. The proper bio-medical waste management will help to:

- Control hospital acquired infections
- Reduce HIV/AIDS, sepsis, and hepatitis transmission from dirty needles and other improperly cleaned or disposed medical items
- Control diseases passed to humans through insects, birds, rats and other animals
- Prevent illegal repackaging and resale of contaminated needles
- Cut cycles of infection and avoid negative long term health effects like cancer, from the environmental release of toxic substances.

As per *WHO norms* the health-care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it includes the waste originating from minor or scattered sources such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.).

4.2 Evolution of Bio-Medical Waste Management

Establishment of a sustainable bio-medical waste management system benefit from a national legal framework that regulates and organizes the different

elements of a waste management system. Legislation usually places obligations and controls on what is permitted and prescribes sanctions on those that deviate from accepted practice. In reality, a law will remain ineffective if sources (finance, material and knowledge) are not available in the health care sector to implement it and or if enforcement is weak.

The five guiding principles governing in waste-related laws are:

(i) ***Polluter Pays Principle:*** This requires any waste producer to be made legally and financially responsible for the safe and environmentally sound disposal of their waste. The responsibility to ensure that the disposal of waste causes no environmental damage is placed upon each waste generator.

(ii) ***Precautionary Principle:*** The rationale of the principle is that if the outcome of a potential risk is suspected to be serious, but may not be accurately known, it should be assumed that this risk is high. This has the effect of obliging health care waste generators to operate a good standard of waste collection and disposal, as well as provide health and safety training, protective equipment and clothing for their staff.

(iii) ***Duty of Care Principle:*** This recognizes that any person managing or handling health care waste, or waste-related equipment, is morally responsible to take good care of the waste while it is under their responsibility.

(iv) ***Proximity Principle:*** The philosophy behind this principle is that treatment and disposal of hazardous waste (including health care waste) should take place at the nearest convenient location to its place of generation, in order to minimize the risks to the general population. This does not necessarily mean treatment or disposal has to take place at each health care establishment, instead it could be done at a facility shared locally or at a regional or national location.

(v) ***An Extension to Proximity Principle:*** This is the expectation that every country should make arrangements to dispose of all wastes in an acceptable manner inside its own national borders and prior informed consent principle also known as "cradle to grave" control, this principle introduces the concept that all parties involved in the generation, storage, transport, treatment and disposal of hazardous wastes (including health care waste) should be licensed or registered to receive and handle named categories of waste. In addition, only licensed organizations and sites are allowed to receive and handle these wastes. No hazardous wastes (including health care waste) should leave a place of waste generation until the subsequent parties (e.g. transport, treatment and disposal operators and regulators) are informed that a waste consignment is ready to be moved.

The national legislation is the basis for bio-medical waste management practices in India. It establishes control and permits for the disposal. The regulatory frame work which governs the management of waste is as follows.

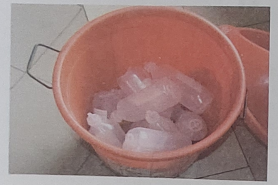
1. The Water (Prevention and Control of Pollution) Act, 1974 (for waste water quality)
2. The Air (Prevention and Control of Pollution) Act, 1981(for air quality)
3. The Environment (Protection) Act, 1986
4. Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008 (for hazardous waste).
5. The Bio-Medical Wastes (Management and Handling) Rules 1998 (for health care waste)
6. The Municipal Solid Wastes (Management and Handling) Rules, 2000 (for domestic municipal waste)
7. Battery (Management and Handling) Rules, 2001 (for used batteries waste).

4.3 Organization and Management of Bio-Medical Waste

The bio-medical waste management is a crucial one which starts from point of generation and ends at point of disposal. Policy on bio-medical waste management needs to be evolved on the feasibility option and optimal sustainable treatment technologies in each individual hospital. The final disposal of bio-medical waste in individual hospitals is discouraged as the hospitals are very much within the vicinity of residential areas, disposal of waste by incineration will lead to ambient air pollution. It is encouraged to have Common Bio-Medical Waste Treatment Facilities (CBMWTF) to treat all regional hospitals in one place away from the residential places.

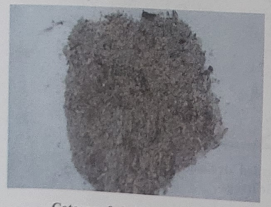
The Central Government has given guidelines for Common Bio-Medical Waste Treatment Facilities to come up in each district of India to treat and dispose bio-medical waste scientifically. Establishment of such facilities has reduced the burden of disposal for the bio-medical waste generators. However the generators have to segregate the waste properly as per bio-medical waste management and handling Rules in specific color coded bins/bags and store in the central temporary storage room so that the common bio-medical waste treatment facilitator can lift the waste from individual hospital with in 48 hours in dedicated vehicles and carry to their facilities away from residential areas to treat and dispose. The path between the two points (cradle to grave) can be segmented schematically as categorization, quantification, segregation, handling, storage, treatment, destruction and disposal of bio-medical waste.

Category 6: Soiled Waste

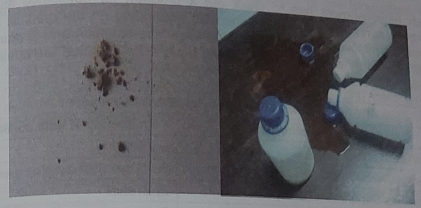


Category 7: Solid Waste

Category 8: Liquid Waste



Category 9: Incineration Ash



Category 10: Chemical Waste (Liquid & Solid)

4.6 Quantification of Bio-Medical Waste

A survey of all units in hospitals/health care establishments will help to identify and quantify bio-medical waste generation. In almost all the units (out patient, wards, operation theater, labour room, laboratory, intensive care units etc.), waste is generated, only difference will be in category and quantity. As regards to the category wise percentage of waste generation in any hospital, non infectious waste is 80%, pathological and infectious waste 15%, sharps waste 1% , chemical or pharmaceutical waste 3 % and others 1 %. To quantify the bio-medical waste generation, waste audit is to be undertaken. The audit will give the clear picture of what type of waste, how much and from where it is generated. This information will be helpful to do waste minimization, items and equipments required for segregation and treatment of waste and their placement. To know how much and what type of waste is generated in each medical area, as a precursor to actual bio-medical waste management planning, segregate the waste at the point of generation category wise in specific color codes as per Bio-Medical Waste (Management and Handling) Rules. Measure each category of bag by weighing them daily for one week and then average it to one month. If the segregation is not good then take the total weight, approximately 10 % to 25% will be the infectious waste. The following steps will help in finding the waste generated quantity wise, category wise and unit wise.

- Ascertain how many medical areas produce health care waste. List all the departments and study on its activities, production of waste and quantity.
- Find the composition of the waste in each place. Segregate waste category wise, weigh it daily at least for one week and then average to monthly. The waste generated is not same in all the areas producing waste.
- Along with the solid waste generation assessment, liquid waste assessment is also necessary.

CHAPTER 4

Technologies for Biomedical Waste Management

4.1 INTRODUCTION

Biomedical waste includes waste generated in hospitals and clinics, and veterinary hospitals. It contains infectious materials and has the potential to spread disease in cities and rural communities if not properly managed. With increasing awareness of the dangers of biomedical waste, strict laws have been passed to remove it from municipal waste streams and manage it in a manner that will render it safe (see Chapter 2). This chapter covers the composition and characteristics of Biomedical Waste (BMW) and technologies to manage them safely.

4.2 BIOMEDICAL WASTE (BMW) COMPOSITION AND CHARACTERISTICS

India has established regulations defining and setting standards for the handling, treatment and disposal of BMW. The waste classification is a mix of BMW categories based on type (e.g., microbiologic, pathologic, etc.), origin (e.g., isolation waste, surgery waste, laboratory waste, dialysis waste, etc.), and physical characteristics (e.g., soft wastes, hard metals, glass, plastics, liquid, etc.). The BMW composition varies considerably as shown in Table 4.1.

Table 4.1 Typical composition and characteristics of BMW

Composition and characteristics	Percent
Celluloid material (paper and cloth)	50–70%
Plastics	20–60%
Glassware	10–20%
Fluids	1–10%
Moisture	8.5–17%
Incombustibles	8%
Heating value	7,500 BTU/lb

Source: HCWH (2001)

BMW handling, treatment and disposal methods are shown in Figure 4.1.

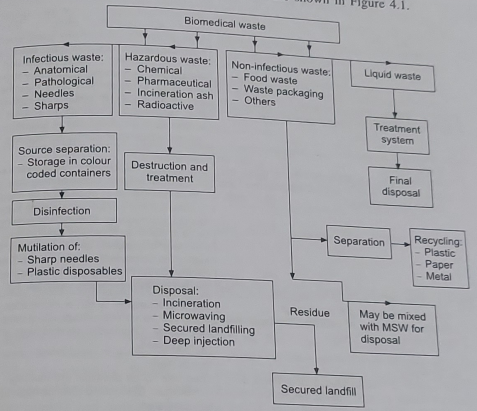
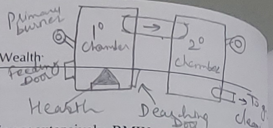


Figure 4.1 Management of BMW.

The Ministry of Environment and Forests (MoEF), Government of India (GoI), has issued the draft notification on the Biomedical Waste (Management and Handling) Rules, 2011. BMW is to be treated and disposed of in accordance with the rules. The categories of wastes defined in the proposed rules are given in Table 4.2.

Table 4.2 Categories of biomedical waste

Category	Waste category (Type)	Treatment and disposal option
1.	*Human anatomical waste* (Human tissues, organs, body parts)	Incineration. There will be no chemical pre-treatment prior to incineration. Chlorinated plastics are not be incinerated.
2.	*Animal waste* (Animal tissues, organs, body parts bleeding parts, blood, fluids, carcasses, and animals used in research, waste generated by veterinary hospitals/colleges, discharge from hospitals and animal houses)	Incineration. There will be no chemical pre-treatment before incineration. Chlorinated plastics shall not be incinerated.



- Non-combustible fines below 20%.
- Moisture content below 30%.

The chemical and physical characteristics of BMW vary extensively. BMW vary considerably in composition, bulk density as well as in heat and moisture content. The energy content of BMW can vary from 3,400 to 45,000 kJ/kg. Because of varying waste characteristics and the impact on incinerator output, large volume of BMW with low or high energy or moisture content may be known so that incinerator operating system and charging rates can be adjusted accordingly.

Incineration of certain types of BMW, such as those containing chlorine or heavy metals, may under certain conditions (such as insufficiently high incineration temperatures, inadequate control of emissions) release toxic material into the atmosphere.

4.5.3 Types of BMW Incinerators

Three basic kinds of incineration technology are of interest for treating BMW:

(i) Double-chamber incinerators, which are specially designed to burn infectious BMW.
(ii) Single-chamber furnaces, which should be used only if double chamber incinerators are not affordable.
(iii) Multiple chamber pathological waste incinerators are often designed and used specifically for pathological wastes which have high moisture content and may contain bulk liquids.

4.5.4 Standards for Incinerators

The incinerators should meet the following operational and emission standards.

Operating Standards

Operating standards of incinerators are as follows:

1. Combustion efficiency (CE) at least 99%.
2. The combustion efficiency is computed as follows:

$$CE = \frac{\%CO_2}{\%CO_2 + \%CO} \times 100$$

3. The temperature of the primary chamber should be 800 ± 50°C.
4. The secondary chamber gas residence time should be at least one second at 1050 ± 50°C, with minimum 3% oxygen in the stack gas.

Emission Standards

Emission standards of incinerators are shown in Table 4.6.

Fixed Health Incinerator: Applicable for waste: Hospitals, Research labs, Canteens, Hotels, offices and banks, Automobile/White Goods Industries, chemical industries, Workshops

Table 4.6 Emission standards

S. No.	Parameters	Concentration mg/Nm³ at (12% CO_2 correction)
1.	Particulate matter	150
2.	Nitrogen oxides	450
3.	HCl	50
4.	Minimum stack height shall be 30 m above ground	–
5.	Volatile organic compounds in ash shall not be more than 0.01%	–

Note:
- Suitably designed pollution control equipment should be installed/retrofitted with the incinerator to achieve the required emission limits.
- Wastes to be incinerated should not be chemically treated with any chlorinated disinfectants.
- Chlorinated plastics should not be incinerated.
- Toxic metals in incineration ash should be limited within the regulatory quantities as defined under the Hazardous Waste (Management and Handling and Transboundary Movement Rules) 2008.
- Only low sulphur fuel or diesel should be used as fuel in the incinerator.

The main disadvantage of BMW incineration is the emission of pollutants to the atmosphere, some of them extremely toxic. Pollutants are usually emitted either in condensed (particulate matter) or in gaseous phases. Many organic and metallic compounds have known effects on human health and environment.

4.6 AUTOCLAVING

Autoclaving is a wet thermal disinfection process. Autoclaves are used in health care facilities for the sterilisation of 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. About 99.99% inactivation of microorganisms is achievable with autoclave sterilisation. Needle sharps are collected in puncture proof containers and needles autoclaved before sending to needle pit. All microbiology waste along with containers per plates per tubes is autoclaved before recycling/disposal. The discarded/infected blood units in blood bank need to be autoclaved before disposal since chemical treatments are difficult or inefficient.

4.6.1 Standards for Autoclaving

Autoclaves or steam sterilisation have been used for over a century as a means of treating specific forms of waste, such as infected samples from pathology labs. Saturated steam is

- Disinfection efficiency/Microbial inactivation efficiency
- Waste reduction
- Types of waste treated
- Capacity of the system/model
- Infrastructure/Space requirements
- Operation and maintenance issues
- Emissions and discharges to the atmosphere and the surrounding land area
- Options for final disposal
- Investment and operation cost
- Occupational safety and health
- Public acceptability
- Regulatory requirements/Acceptance

The advantages and disadvantages of various BMW treatment and disposal technologies are summarised in Table 4.9 and comparison of technologies is listed in Table 4.10.

Table 4.9 Advantages and disadvantages of treatment and disposal for BMW

Treatment/Disposal	Advantages	Disadvantages
Incineration	• High efficiency of disinfection. • Suitable for infectious and hazardous waste.	• Cytotoxic may be partially destructed. • High capital and O&M costs.
Kiln	• Suitable for infectious and hazardous waste.	• High capital and O&M costs.
Disinfection by chemical	• Disinfection is effective under suitable operational parameters. • Few disinfectants are inexpensive. • Significant waste volume reduction.	• Qualified manpower for O&M is required. • Hazardous chemicals require safety measures. • Unsuitable for selected chemicals and contagious wastes.
Single chamber incineration	• Good disinfection efficiency. • Reduced weight and volume of waste. • Residues can be disposed in landfills. • Trained manpower may not be required • Low capital and O&M costs.	• Substantial emissions to atmosphere. • Removal of air pollutants is important. • Inefficient in destruction of thermally resistant wastes.
Thermal treatment	• Significant waste volume reduction. • Low capital and O&M costs.	• Qualified manpower for O&M is required. • Not suitable for BMW.
Drum incinerator	• Significant reduction of weight/volume of waste. • Low capital and O&M costs.	• Selected chemicals do not get destructed. • Substantial emissions to atmosphere (flue gas, smoke, and odour).
Encapsulation	• Low capital and O&M costs. • Suitable for other hazardous wastes	• Not suitable for BMW
Burial	• Low capital and O&M costs.	• Suitable where site access is restricted and precautionary measures are followed.
Irradiation	• Good disinfection efficiency. • Significant waste volume reduction.	• High capital and O&M costs. • Possibility of O&M problems.

Table 4.10 Comparison of BMW treatment technologies

Treatment system	Incinerator	Autoclave	Hydroclave	Microwave	Chemical
Description	High temperature process	Direct steam heating and sterilisation	Indirect steam heating and sterilisation	Microwave heating	Pulverised BMW mixed with chemicals
Sterilisation effectiveness	High	Intermediate	Intermediate	Intermediate	Depends on dispersion of chemicals in BMW
Capital investment	High	Intermediate	Intermediate	Intermediate	Intermediate
Operational cost	High	Low	Low	Low	Low
O&M requirement	High skilled manpower	Low skilled manpower	Low skilled manpower	Automatic but requires high skilled manpower	High skilled manpower for chemicals
Air emissions	High toxicity	Non-toxic but has odour	Non-toxic but has odour	Non-toxic but has odour	Emission of chemicals
Water discharges	Negligible	Odourous	Sterile but odourous	Negligible	Low
Waste composition after treatment	Potential for toxic substance but mainly ash	Waste having moisture	Dehydrated waste	Waste having moisture	Waste having moisture and chemicals

EXERCISES

1. What is the typical composition of biomedical waste?
2. Draw a diagram showing various pathways for management of biomedical waste.
3. Classify biomedical waste in eight categories and explain any thereof them in detail.
4. Discuss the colour coding system and the type of container for handling of biomedical waste.
5. What are the salient features and guidelines for establishing a common biomedical waste treatment facility?
6. List five parameters for selection of biomedical waste treatment technologies.
7. Draw a simplified flow diagram of an incineration system for biomedical waste treatment.
8. What criterion is to be followed for incineration of biomedical waste?
9. Mention the different kinds of incinerators used for biomedical waste treatment.
10. Explain the 'operating standard' and 'emission standard' of a biomedical waste incinerator.
11. What are the prescribed standards for biomedical waste autoclaving?
12. List the parameters which are important for the discharge of effluents from hospitals.
13. Mention the criteria for the selection of biomedical waste treatment technologies.
14. Compare various biomedical waste treatment technologies.

Segregation is a very important factor in waste management system. The multiple choice of color codes for segregation mentioned above is dependant upon the treatment and disposal technology for various categories of wastes. The waste which goes for incinerator or deep burial, should be collected in yellow bag or bin. The waste which is planed for autoclaving or microwaving or chemical treatment and finally to find its way in secured landfill or for recycling, should be collected in red or blue bin or bag. The waste sharps such as needles, blades etc. which is for disinfection, destruction or shredding should be collected in white puncture proof translucent container, which will be encapsulated or can go for recycling as final disposal. The chemical waste (solid), out dated medicines and cytotoxic drugs which goes for disposal in secured land fill should be collected in black bin or bag. All the bins and bags should have biohazard label except on black colored bin or bag on which cytotoxic label is to be inserted. Maximizing segregation is very effective in reducing waste management costs, environmental impacts and also complexity of management. The details of segregation of waste into specific color coded bags or bins, as per treatment and disposal technology is presented below.

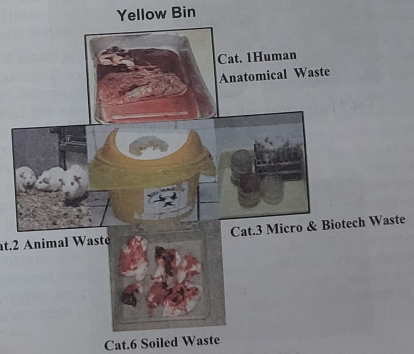
Segregation of Waste in Specific Colored Bins Depending on Treatment and Disposal Technology
Yellow Plastic Bag – Non Chlorinated- (Cat -1 Human Anatomical Waste , Cat -2 Animal Waste, Cat -3 Microbiology & Biotechnology Waste, Cat-6 Soiled Waste) Treatment & Disposal by Incineration or Deep Burial
Blue Plastic Bag- (Cat -7 Solid Waste) Treatment & Disposal by Autoclaving or Microwave or Chemical Treatment and Destruction or Shredding- Recycling
White Translucent Puncture Proof Container- (Cat – 4 Sharps Waste) Treatment & Disposal by Autoclaving or Microwave or Chemical Treatment and Destruction or Shredding- Encapsulation on Secured Landfill
Red Disinfected container/plastic bag- (Cat-3 Microbiology & Biotechnology Waste, Cat – 6 Soiled Waste, Cat-7 Solid Waste) Treatment & Disposal by Autoclaving or Microwave or Chemical Treatment – Secured Landfill and Cat. 7 Recycle
Black Plastic bag- (Cat-5 Discarded Medicine & Cytotoxic Drugs, Cat – 9 Incineration Ash, Cat – 10 Chemical Waste (solid) Treatment & Disposal- Disposal in Secured Landfill

When the bags are ¾ filled it should be tied and lifted, care should be taken that bags/containers should not be overloaded. The bio-medical waste should be handled very carefully and stored in central temporary storage room. The transport of bio-medical waste from each unit to the central storage room should be in dedicated trolleys/vehicles. The trolleys should not be over loaded. While

handling the bio-medical waste, there should be barrier between bio-medical waste and body (self). Standard protective aids should be used to cover one self.

The location of central temporary storage room should be designated inside its premises. It should be kept under lock so that no unauthorized person can enter into the room. There should not be any access to animals also. The waste in the bags or containers should be stored in central storage place in an area or room of a size appropriate to the quantities of waste produced and the frequency of collection. Recommendation for storage facilities within the hospitals is that the storage area should have an impermeable, hard-standing floor with good drainage. It should be easy to clean and disinfect. There should be a water supply for cleaning purposes. The storage area should afford easy access for staff in charge of handling the waste. It should be possible to lock the store to prevent access by unauthorized persons. Easy access for waste-collection vehicles is essential. There should be protection from the sun. The storage area should be inaccessible for animals, insects, and birds. There should be good lighting and at least passive ventilation. The storage area should not be situated in the proximity of fresh food stores or food preparation areas. A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area. The cytotoxic waste should be stored separately from other health-care waste in a designated secure location.

Segregation of Bio-Medical Waste



Component	Description
Treatment equipment	As per the provisions of BMW Rules, most of the waste classified in categories can be treated based on non-burn technologies and account for nearly 90% of the total waste in a health care facility. It is obligatory to opt for incineration/deep burial (depending upon the population of town) to anatomical and other types of waste falling under categories 1 and 2. Therefore, an incinerator of optimum capacity to cater only to categories 1 and 2 wastes should be installed. If engineered landfill is not accessible, category 5 waste may be incinerated. CBWTF shall have facilities like incineration, autoclaving, microwaving, hydroclaving, shredding, sharp pit, encapsulation, vehicle, container washing system, Effluent Treatment Plant (ETP), etc.
Infrastructure setup	The CBWTF shall have enough space within it to install required treatment equipment, incoming and outgoing waste handling/storage area, parking for vehicles, suitable area for washing, ETP, etc. A separate housing must be provided for each of the treatment equipment at the CBWTF such as incinerator chamber, autoclave chamber, microwave chamber, etc., as required. Each chamber shall be well designed and ventilated. The chamber shall be such that the probability of sticking of microorganisms are minimal. The CBWTF shall have sufficient space for waste storage, treated waste storage, administrative block, Diesel Generator (DG) set, site security, parking, suitable sign board, green belt area, washing room, etc.
Record keeping	Maintenance of records for all operations carried out at the CBWTF is very important to monitor overall operation of the CBWTF. Daily records shall be maintained for the waste accepted and treated waste removed. The record shall include at least the following details: Waste received (quantity and date), name of the health care facility, waste category as per the BMW Rules, transportation number and receiving date (at site), date on which BMW is treated, type of treated waste and it quantity, vehicle registration number and location of final disposal.

Source: CPCB (2003).

Certain treatment options may effectively reduce the infectious hazards of BMW. The selection of BMW treatment technology should be cautiously done on the basis of a range of factors most of whom will depend on the local conditions (Table 4.5).

Table 4.5 Factors in selection of BMW treatment technologies

WHO (1999)	HCWH (2001)
• Disinfection efficiency • Health, safety and environmental aspects • Volume and mass reduction • Occupational health and safety considerations • Quantity of BMW for treatment and the capacity of the treatment system • Types of waste for disposal in the landfill • Infrastructure requirements • Locally available treatment options and technologies • Options available for final disposal • Training for operation of the treatment system • Operation and maintenance of the treatment system • Location and surrounding environment of the treatment system and disposal facility • Capital and operational costs • Public acceptability • Regulatory requirements	• Throughput capacity • Types of waste treated • Microbial inactivation efficacy • Emissions and BMW residue • Regulatory acceptance • Space requirements • Utilities and ancillary requirements • Reduction of waste volume and mass • Occupational safety and health • Noise and odour • Automation • Reliability • Level of commercialisation • Technology manufacturers/vendors background • Cost • Community and staff acceptance

4.5 INCINERATION OF BMW

The objective of burning BMW is to reduce its volume since it is difficult to acquire sites for BMW disposal. Incineration of BMW reduces the volume of waste by 65–70%. Incineration

destroys infectious wastes. Incineration of waste is affordable and feasible only if the calorific value of the waste is at least 2000 kcal/kg. All types of incinerators, if operated properly, eliminate pathogens from waste and reduce waste to ashes. However, certain types of BMW, e.g., pharmaceutical or chemical wastes, require higher temperatures for complete destruction. Incinerators designed especially for treatment of BMW should operate at temperatures between 900°C and 1200°C. Treatment by incineration and disposal of the resultant ash by land filling is the most widely used treatment process for managing BMW.

4.5.1 Principles of Incineration

Incineration is a high temperature dry oxidation process that reduces organic and combustible waste into inorganics and incombustible form resulting in a significant reduction of waste volume and mass. This treatment system is selected for treating those wastes that cannot be recycled, reused or disposed in a landfill. The combustion of organic compounds produces mainly gaseous emissions, including steam, carbon dioxide, nitrogen oxides, and certain toxic substances, particulate matter, and solid residue in the form of ashes. The process flow diagram is illustrated schematically in Figure 4.2.

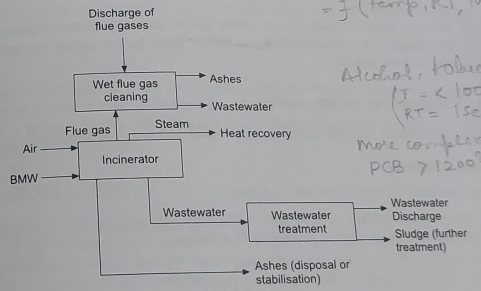


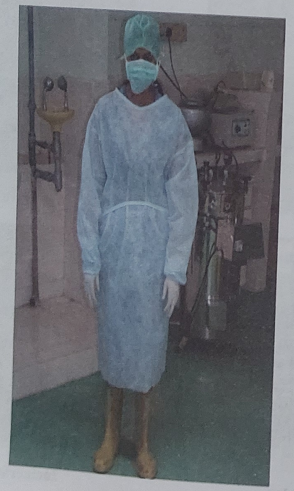
Figure 4.2 Simplified flow diagram of incineration system.

4.5.2 Waste Characteristics for Incineration

The characteristics that make BMW suitable for incineration are:

- Heating value above 2000 kcal/kg for single chamber incinerators, and above 3500 kcal/kg for double chamber incinerators.
- Combustible matter above 60%.
- Non-combustible solids below 5%.

Deep burial pit



Protective aids

4.11 Case Study

A Typical Common Bio-Medical Waste Treatment Facility: G. J. Multiclave a common Bio-Medical Waste Treatment Facility is catering to 790 hospital, 14000 bed strength. Around 5 tons per day of bio-medical waste is managed. They collect bio-medical waste from hospitals using dedicated vehicles having bio-hazard symbol on it. The waste in yellow goes for incineration, red goes for autoclave and shredding and sharps waste in white translucent bin is disinfected and encapsulated. The bio-medical waste which needs autoclaving is 1.5 tons per day. Around 2.5 to 3 tons per day goes for incineration. The various facilities available at Common Bio-Medical Waste Treatment Facility are as follows.

Autoclave, Incinerator, Shredder, encapsulation structures and waste water treatment facility.

First Bio-Medical Waste Treatment and Management Facility in Andhra Pradesh - GJ Multiclave (India) Pvt. Ltd.

GJ MULTICLAVE (INDIA) PVT LTD.

INCINERATOR

ENCAPSULATED SHARP BUNKERS

AUTOCLAVE

SHREDDER

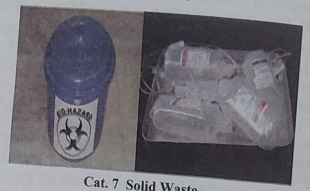
EFFLUENT TREARTMENT PLANT

DEDICATED VEHICLE To CARRY BMW FROM HCEs

4.12 Legal Provision

The Bio-Medical Waste (Management and Handling) Rules, 1998 and amendments under Environment (Protection) Act, 1986, governs the management of bio-medical waste.

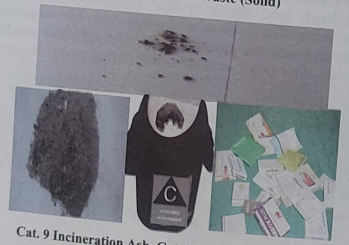
Blue Bin



Cat. 7 Solid Waste

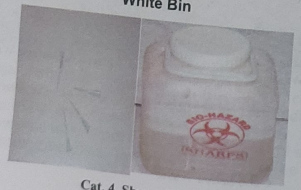
Black Bin

Cat. 10 Chemical Waste (Solid)



Cat. 9 Incineration Ash Cat. 5 Discarded Medicine

White Bin



Cat. 4 Sharps Waste

Red Bin

Cat.6 Soiled Waste

Cat.7 Solid Waste Cat.3 Micro & Biotech Waste

4.8 Treatment, Destruction and Disposal of Bio-Medical Waste

After segregation treatment of syringes, needles and plastic waste is by mutilation and disinfection to avoid reuse and infection. The various treatment, destruction and disposal methods for each category of waste are mentioned below.

As soon as category 1 human anatomical waste (human tissues, organs, body parts), category 2 animal waste (animal tissues, organs, body parts, bleeding parts etc.) and category 3 microbiology and biotechnology waste (waste from lab, cultures, stocks or specimens human and animal cells etc.) are segregated in yellow colored bin or bag, before 48 hours it should be incinerated or subject to deep burial. The deep burial option is for towns where population is less than five lakh and in rural areas. There is no need to treat the waste before disposal.

Category 4 waste sharps (needles, syringes, scalpels, blades, glass, etc., that may cause puncture and cuts, includes both used and unused sharps) should be mutilated and disinfected. As regards to needles and syringes, after the injection is administered the needles should be cut from the hub by a needle cutter, so that both the needle and the syringe become useless and can't be reused. The cut needle gets segregated in the pot which is fixed to the needle cutter. The cut syringe goes along the solid waste (plastic) stream, in the bucket with sieve, which has atleast 1% sodium hypochlorite solution or any other equivalent chemical agent. Metal needle from the pot to be transferred in to the puncture proof white translucent container having atleast 1% sodium hypochlorite solution or any other equivalent chemical agent. It must be ensured that chemical treatment ensures disinfection. The disinfected needle can be encapsulated into municipal secured landfill or can be given to authorized metal recycler. If auto disabled syringes are provided it prevents the reuse of non sterile syringes as it self locks after single use. The glass waste (vials etc.) can be given to authorized glass recyclers.

Category 5 discarded medicines and cytotoxic drugs (waste comprising of outdated, contaminated and discarded medicines.), category 9 Incineration ash and category 10 Chemical solid waste (chemical used in production of biological, chemicals used in disinfection, as insecticides, etc.), either directly incinerate or after destruction put it in secured landfill.

Category 6 soiled waste (items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood.), either incinerate or disinfect by autoclaving/ microwaving and put it in secured landfill.

Category 7 solid waste (waste generated from disposable items other than waste sharps such as tubings, catheters, intravenous sets etc.), destroy the plastic waste to ensure prevention of reuse and disinfect by keeping in atleast 1% sodium hypochlorite solution or any other equivalent chemical agent. It must be ensured that chemical treatment ensures disinfection. The solid waste (plastic waste) can be given to authorized recycler only after disinfection and shredding.

Category 8 liquid waste (waste generated from laboratory and washing, cleaning, house-keeping and disinfection activities) and category 10 Liquid chemical waste (chemical used in production of biological, chemicals used in disinfection, as insecticides, etc.), need to be treated to the standards prescribed in the Bio-Medical Waste (Management and Handling) Rules and flush in the drains. The standard for liquid waste is as follows.

The various treatment and disposal options available to properly manage the bio-medical waste is as follows.

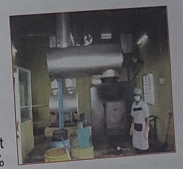
Bio-medical Waste Management- Treatment and Disposal Options		
Category of Waste	**Treatment**	**Disposal**
Soiled waste	Autoclave	Municipal Landfill
	No treatment required	Incinerate
Solid waste	Mutilate and disinfect at source of generation	Recycling Industry/Municipal Landfill
Sharps	Mutilate and disinfect at source of generation	Recycle/Encapsulate
Body parts	No treatment required	Incinerate/Deep burial
Animal waste	No treatment required	Incinerate/Deep burial
Discarded medicines	No treatment required	Dispose in secured landfill
Chemical solid waste	No treatment required	Dispose in secured landfill
Incineration ash	No treatment required	Dispose in secured landfill
General / domestic waste	-	Dispose in municipal bin

As per the guidelines issued by Central Pollution Control Board disposal of bio-medical waste by individual hospitals is discouraged and common bio-medical waste treatment facilities are encouraged. Deep burial option is in the rural area where population is less than 5 lakh.

4.9 Technologies for Bio-Medical Waste Management

Depending on the category of bio-medical waste various technologies have been evolved to treat, destruct and dispose. The human anatomical waste, animal waste, microbiology and biotechnology waste and soiled waste are either incinerated or deep buried. The deep burial option is in rural areas where population is less than five lakh.

4.9.1 Incinerator



Combustion Efficiency (CE): at least 99.00%

$$C.E. = \frac{\%CO_2}{\%CO_2 + \%CO} \times 100$$

Temperature: primary chamber- 800 ± 50 deg. C°.

Secondary chamber gas residence time - at least one second at 1050 ± 50 C°, with minimum 3% Oxygen in the stack gas.

Emission Standards are as follows. (Concentration mg /Nm^3 at 12% CO_2 correction). Minimum stack height- 30 metres above ground.

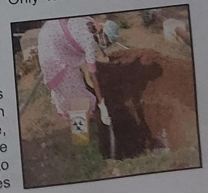
Particulate matter – 150 units

Nitrogen Oxides – 450 units

HCl- 50 and

Volatile organic compounds in ash shall not be more than 0.01%

Suitably designed pollution control devices should be installed/retrofitted with the incinerator to achieve the above emission limits, if necessary. Wastes to be incinerated shall not be chemically treated with any chlorinated disinfectants. Chlorinated plastics shall not be incinerated. Toxic metals in incineration ash shall be limited within the regulatory quantities as defined under the Hazardous Waste (Management and Handling) Rules, 2008). Only low sulphur fuel like L.D.O./LS.H.S./Diesel shall be used as fuel in the incinerator.



4.9.2 Deep Burial Pit

A pit or trench should be dug out about 2 meters deep. It should be half filled with waste, then covered with lime within 50 cm of the surface, before filling the rest of pit with soil. It must be ensured that animals do not have any access to burial site. Covers of galvanized iron/wire meshes

some heating value, passes between the electrodes and transfers the heat to the waste material. In some systems, the anode and cathode are both part of the plasma torch. Another design is to use a direct current (DC) plasma arc, wherein the arc forms between a graphite electrode directly to the metal in a molten bath formed from the waste in the treatment chamber.

Pyrolysis involves the high temperature 1000°C combustion of waste in the absence of oxygen. In achieving higher temperatures, the system treats, destroys and reduces the volume of BMW.

Biooxidiser, a commercialised technology, uses a two-step process. Firstly, the waste enters a pyrolysis chamber where it is heated from 95 to 600°C. This causes organic solids and liquids to vapourise, leaving behind an inert ash including inorganic material such as glass and metal pieces. In the second step, an induced draft fan draws the vapours from the pyrolysis chamber into a two-stage oxidation chamber operating at 1000°C to 1100°C. Controlled amounts of oxygen are added in the oxidation chamber to complete the combustion process. With the addition of pollution control devices, the output is a relatively clean exhaust stream.

4.10 LAND DISPOSAL OF BIOMEDICAL WASTE (BMW)

Landfill sites have been traditionally used for the disposal of BMW. The use of a landfill for BMW disposal poses the following increased risks:

- The possibility of harm to those handling BMW.
- The possibility of unauthorised] particularly sharps and needles.
- The disposal of unsterilised BMW may spread diseases in the nearby community.
- The discharge of pathogens in the air or water.

Land disposal may result in groundwater pollution if the landfill site is inadequately designed and/or operated. In choosing a treatment or disposal technology for BMW, particularly if there is a risk of toxic emissions or other hazardous consequences, the relative risks, should be carefully analysed. A strategy to upgrading the existing dumpsites can be:

Open dumps to controlled dump sites: It involves reduction of the working area of the site to a more manageable size, covering unused areas of the site with soil, extinguishing fires, and setting guidelines for scavengers.

Controlled dumping to engineered landfill: This involves the gradual adoption of engineering techniques to prevent surface water from entering the waste, spreading soils to cover wastes, gathering wastewater (leachate), spreading and compacting waste into thin layers, preparing new parts of the landfill with excavation equipment, and isolating the waste from the surrounding area (landfill liner).

Engineered landfill to sanitary landfill: This involves the continuing refinement, with increasing design and construction complexity, of the engineering techniques used for an engineered landfill. In addition, there should be landfill gas control measures, environmental monitoring points and boreholes (for monitoring groundwater quality), an organised and trained work force, record keeping, and onsite treatment of leachate.

4.10.1 Standards for BMW Disposal

1. A pit or trench should be deeply dug. It should be partly filled with BMW, then covered with liner, before completely filling the pit with the soil.
2. The animals should not have access to the disposal site.
3. For each fill of waste in the pit, a 10 cm soil layer should be added to cover the waste.
4. Burial must be performed under proper supervision.
5. The deep burial site should be relatively impermeable and no shallow well should be close to the site.
6. The pits should be far from habitation, and constructed to prevent contamination of surface or groundwater. The area that is sensitive to flooding or erosion should be avoided.
7. The location of the deep burial site is to be authorised by the prescribed authority.
8. Maintain a record of all pits for deep burial.
9. The groundwater table level should be at least 6 m below the lower level of deep burial pit.

4.11 CRITERIA FOR SELECTION OF BMW TREATMENT TECHNOLOGY

The identification of a suitable technology should be based on the criteria of health, environmental and economic impacts. The selection of BMW treatment options will depend on the waste volumes currently being generated and future projections. This can be achieved through a BMW audit, identification of indicators to assess and project waste generation trends and efforts to minimise BMW. The following criteria could be considered in evaluating different treatment options for BMW:

Effectiveness: BMW should be completely sterilised and rendered into a form that prevents hazards.

Cost effectiveness: The technology should be economically competitive with other available technologies. A life-cycle cost analysis takes into account all the costs such as capital, operation and maintenance, training, regulatory requirements and energy usage.

Safety: The construction, operation, and closure of the technology/facility should not present undesirable environmental and health hazard. It includes environmental risks from air emissions, wastewater effluent and hazardous waste generation.

Simple: Alternative technologies for small facilities should be easy to construct, and function should be sustainable.

Robust: The technology should consistently meet air emission norms, other health and safety criteria under a variety of operating conditions.

Following factors are needed to be considered in selecting an appropriate BMW treatment technology:

Each establishment has to chalk out a program for qualitative as well as quantitative survey of the waste generated depending on the medical activities and procedures followed by it. In order to asses the situation and to plan for bio-medical waste management, the following have to be included (as applicable) in the survey as per the time frame indicated.

Area-wise Frequency of Waste Survey	
Area/Department/Unit	**Frequency of data collection**
Wards (each one of them)	Each shift
Operation theatre (OT)	Each operation/surgical procedure
Out Patients Department (OPD)	Each shift
Intensive Care Unit (ICU)	Each shift
Emergency unit	Each shift
Dialysis unit	Each procedure
Radiation unit	Each procedure
Laboratories (pathological, biochemical)	Each shift
Pharmacy/Chemist's dispensation unit	Once a day
Kitchen	After every meal
Administrative unit and central store	Once a day
Surrounding premises and garden	Once a day

The concerned medical establishment should constitute a team of its experts and also involve personnel and workers from various departments (doctors, chemists, laboratory technicians, hospital engineers, nurses, cleaning supervisors/inspectors, cleaning staff etc.). If expertise is not available, it may take the help of external experts in the field who can help them to carry out the survey work then they can engage agencies who will carry out the whole work of bio-medical waste management on contract as a package. The medical establishment has to earmark a suitable place for storing the bio-medical waste temporarily, an enclosed space, depending upon the requirement, it can be a large room or a hall or at least a covered shade with proper fencing. Unauthorised entry to this space should be strictly restricted. It should be well lighted. The place should be washed and disinfected daily and preferably dry and clean.

The waste generated by all the departments has to be collected according to the prevailing practices of collection but due care has to be taken to see that no portion of the total waste generated is missed out from this survey. The waste so collected (except the liquid waste and incineration ash) has to be sorted out into

the different categories according to the Schedule I of the Biomedical Waste (Management and Handling) Rules, 1998.

The liquid waste may be divided into two components: (a) liquid reagents/chemicals discarded and (b) the cleaning and washing water channeled into the drain. The first component can be easily measured by a measuring cylinder or other suitable measuring device before discarding each time and keeping suitable records. The second component can be derived from the total water used in the hospital or by using appropriate flow meter.

Category-wise Survey of Waste Generation				
Item(as per Schedule I of Bio-Medical Waste (Management and Handling) Rules 1998	**Wt. (kg.) Shift I**	**Wt.(kg.) Shift II**	**Wt.(kg) Shift III**	**Total Wt.(kg.)**
Human anatomical waste				
Animal waste				
Microbiology& biotechnology				
Waste sharps				
Medicines and cyto-toxic drugs				
Soiled waste				
Solid waste				
Chemical waste (Solid)				
Incineration ash				
Liquid waste (litres)				

The survey needs to be carried out at least for 3 days a week in continuation followed by similar exercise for 4 weeks. The result is then compiled for both quantitative as well as qualitative data.

4.7 Segregation, Handling and Storage of Bio-Medical Waste

Once the bio-medical waste is generated the immediate step is segregation in specific color coded bins/bags/containers. Human anatomical waste and animal waste to be collected in yellow bin/bag, soiled waste in yellow or red bin/bag, sharp waste in white translucent puncture proof container and solid waste (plastic) in either blue or in red colored bin/bag. Bags and containers should be marked with Biohazard symbol. Out dated medicines and solid chemical waste in black colored bin/bag with cytotoxic symbol on it.