Paper No: 11 Solid and Hazardous Waste Management

Module: 22-23 Biomedical wastes: Definition, sources, classification, collection, segregation, Treatment and disposal

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Description of Module	
Subject Name	**Environmental Sciences**
Paper Name	Solid and Hazardous Waste Management
Module Name/Title	Biomedical wastes: Definition, sources, classification, collection, segregation, Treatment and disposal
Module Id	EVS/SHWM-XI/22-23
Pre-requisites	Knowledge in basic science and interest to learn about biomedical waste and its management
Objectives	• To know what is biomedical waste and its source of generation • To be knowledgeable about the different types of biomedical waste. • To explain the steps of biomedical waste management • To describe the proper mode of collecting and segregating the biomedical waste • To understand the risks of biomedical waste, its method of treatment and disposal
Keywords	Biomedical wastes, hazardous wastes, incineration, autoclaving, infectious waste, biomedical waste symbols

Module 22-23: Biomedical wastes: Definition, sources, classification, collection, segregation, Treatment and disposal

1. Objectives:

- To know what is biomedical waste and its source of generation
- To gain knowledge about the different types of biomedical waste.
- To explain the steps of biomedical waste management
- To describe the proper mode of collecting and segregating the biomedical waste
- To understand the risks of biomedical waste, its method of treatment and disposal

2. Biomedical Waste: Definition:

Bio-medical waste means "any solid and/or liquid waste produced during diagnosis, treatment or vaccination of human beings or animals. Biomedical waste creates hazard due to two principal reasons: infectivity and toxicity. Figure 1 shows some of the biomedical waste

Waste sharps

Discarded medicines

Human anatomical waste

Solid waste

Figure 1.Biomedical waste

3. Sources:

The source of biomedical waste is the place or the location at which biomedical waste has been generated. The source of biomedical waste is classified into two types based on the quantity of waste generated. They include major and minor source. Major source generates more amount of biomedical waste compared to minor source and also there is regular generation of biomedical waste in the major source which includes government hospitals, private hospitals, nursing home and dispensaries. Minor source includes physicians and dental clinics. Figure 2 shows the details of the various source of biomedical waste generation

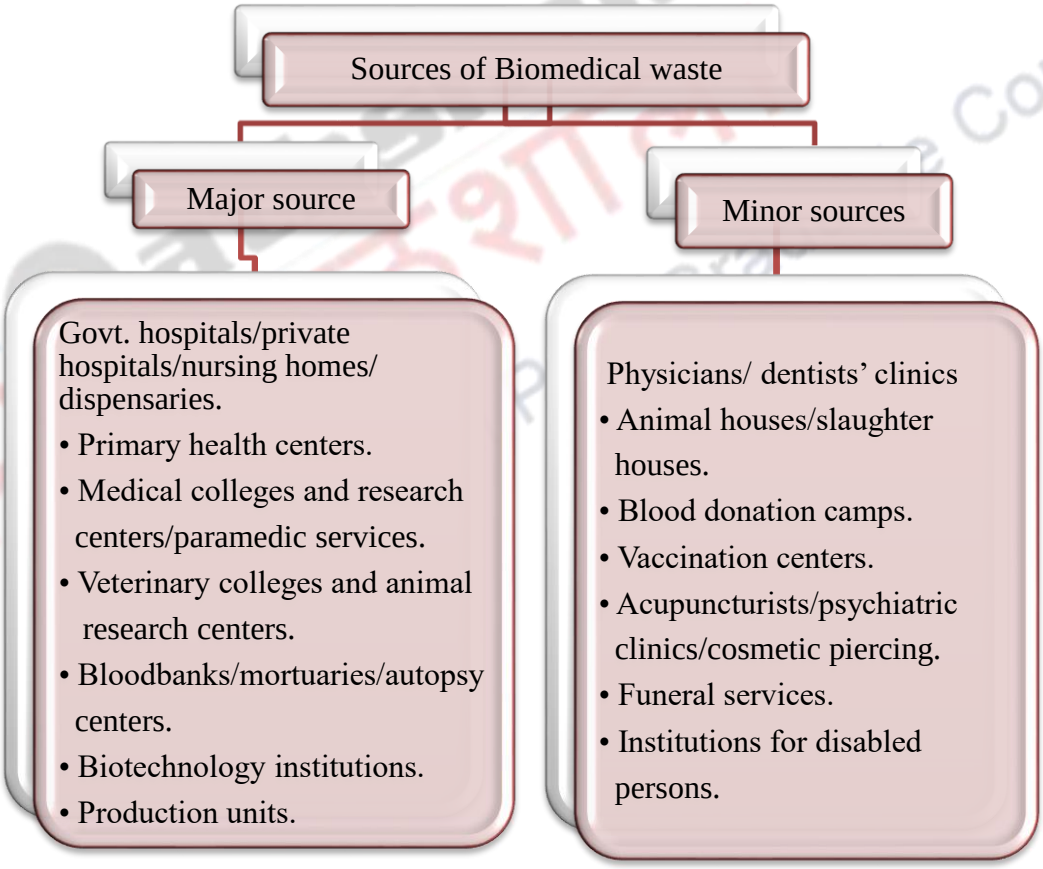

Figure 2 Sources of biomedical waste

4. Classification:

The classification of the biomedical waste is carried out based on its characteristics, source of generation and the level of hazard to the environment. The biomedical waste is classified into two types:

1. Non hazardous waste
2. Hazardous waste

4.1 Non-hazardous waste:

About 75% to 90 % of biomedical waste characteristics were similar to that of domestic waste and are non-risky in nature. This waste is generated mainly from the organization and maintenance of hospital and health care centers.

4.2 Hazardous waste:

The remaining 10 – 25% of biomedical waste falls under the hazardous waste categories. The hazardous waste contains infectious characteristics of about 15% - 18 % and toxicity characteristics of about 5% - 7%. The various hazardous wastes includes,

- **Infectious waste:** Waste containing pathogens; e.g. excreta; laboratory cultures; isolation wards waste; swabs, materials, or equipments that have been in contact with infected patients.
- **Pathological waste:** Human tissues or fluids e.g. body parts; blood and other body fluids; fetuses.
- **Pharmaceutical waste:** Waste containing pharmaceuticals; e.g. pharmaceuticals that are expired or no longer needed; contaminated pharmaceuticals (bottles, boxes).
- **Genotoxic waste:** Waste containing cytostatic drugs (often used in cancer therapy)/ genotoxic chemicals.
- **Chemical waste:** Waste containing chemical substances e.g. laboratory reagents; film developer; disinfectants and solvents that are expired or no longer needed.
- **Wastes with high content of heavy metals:** Batteries, Broken thermometers, blood pressure gauges, Pressurized containers, gas cylinders, gas cartridges, aerosol cans.
- **Radioactive waste from radiotherapy:** Waste containing radioactive substances e.g. unused liquids from laboratory research; contaminated glassware, packages or absorbent paper; urine and excreta from patients treated or tested with uncapped radionuclide

5. Biomedical Waste management:

Proper management of biomedical waste is highly essential since it induces various risk to the human health and to the surrounding ecosystem that leads to the ecological hazard, professional hazard and public hazard. Steps involved in biomedical waste management was shown in Figure 3

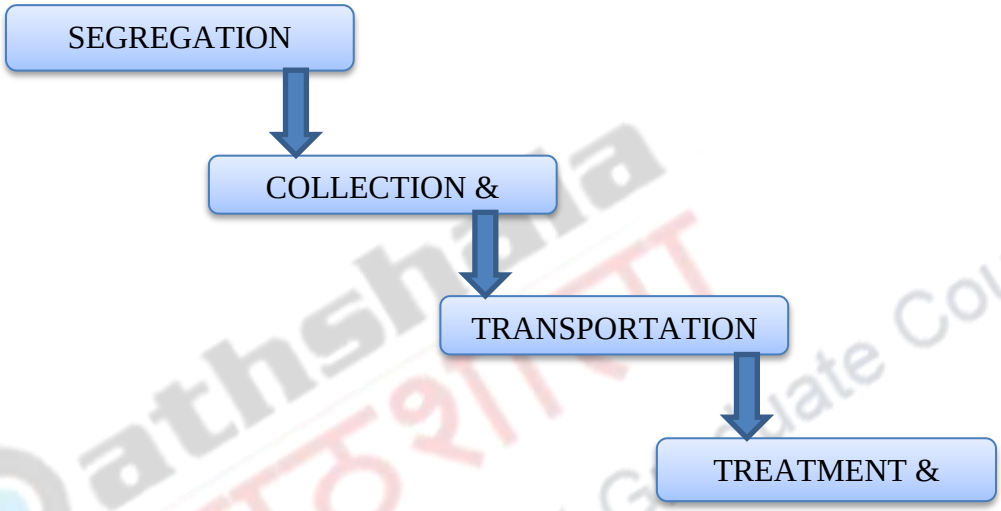

Figure 3. Steps involved in biomedical waste management

5.1 Segregation

To avoid mixing of the biomedical waste with other, a container should be set to the side with colour coding bags at the point of generation. The sorting or separation of waste into different categories is referred as segregation. Segregation will decrease or minimize the risks in addition to rate of managing and disposal. Segregation is the most important and critical step in bio-medical waste management. Only, effective segregation can confirm the effective bio-medical waste management.

5.1.1 How does segregation help?

Segregation plays an effective role in handling and treatment of waste. It reduces the quantity of waste and if done effectively, it can avoid the mixing of biomedical waste with any other type of waste especially municipal waste. Segregation will avoid the reuse of certain biomedical waste like used

syringes, needles and other plastics. Some materials like plastics can be recycled after proper disinfection and these can be reused for non-food grade products.

During segregation process, the biomedical waste must be separated under the following categories shown in Table 1. Category no.1 includes the Human anatomical waste in which the human tissues, organs, body parts are considered. Animal waste falls under the Category No. 2. It includes Animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals and colleges, discharges from hospitals, animal houses. Category No. 3 is the Microbiology & Biotechnology waste which contain Wastes from laboratory cultures, stocks or specimen of live microorganisms or attenuated vaccines; human and animal cell cultures used in research; infectious agents from research and industrial laboratories; wastes from production of biologicals, toxins and devices used for transfer of cultures. The Category No. 4 includes waste Sharps in which Needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps. Discarded Medicine and Cytotoxic drugs falls under the Category No 5 which consists of wastes comprising of outdated, contaminated and discarded medicines. The soiled waste is included in the Category No. 6 containing items contaminated with body fluids including cotton, dressings, soiled plaster casts, lines, bedding and other materials contaminated with blood.

Table 1. Categories of Waste (Source: Biomedical Waste (Handling and management Rules 1998)

WASTE CATEGORY	**TYPE OF WASTE**
Category No. 1	Human Anatomical Waste
Category No. 2	Animal Waste
Category No. 3	Microbiology & Biotechnology Waste
Category No. 4	Waste Sharps
Category No. 5	Discarded Medicine and Cytotoxic drugs
Category No. 6	Soiled Waste

Category No. 7	Solid Waste
Category No. 8	Liquid Waste
Category No. 9	Incineration Ash
Category No.10	Chemical Waste

Category No 7 is the solid waste which includes waste generated from disposable items other than the waste sharps such as tubing, catheters, intravenous sets, etc. Liquid waste falls under the category no. 8, it consists of waste generated from the laboratory and washing, cleaning, housekeeping and disinfecting activities. Category No 9 includes incineration ash i.e., ash from incineration of any biomedical waste. Chemical Waste falls under Category No 10 and consists of Chemicals used in production of biologicals, chemicals used in disinfection and as insecticides etc.

5.2 Collection and storage

The collection of biomedical waste involves the installation of different colour coded containers for biomedical wastes obtained from varying sources. The containers/ bins should be placed in a location so that 100 % collection is achieved. The bins and bags that hold the biohazard symbol as shown in Figure 4 represents the nature of waste. The symbols in biomedical waste management is generally used as a warning to take precautions while exposing to those substances. The biohazard symbol was developed by the Dow Chemical Company in 1966 for their containment products.

Subsequent to collection, the biomedical waste is stored in specific containers and stored in a proper place. The extent of storage should not exceed beyond 8-10 h in big hospitals containing more than 250 bedded and 24 h in nursing homes. Each container must be clearly labelled with the location being mentioned in them. The purpose of labelling is to trace the waste at the source. Storage spot must be clear with a warning sign.

Figure 4 Symbols

Collection of the biomedical waste was carried out in its specific coloured bags. In the yellow colour bags, the categories 1,2,3 and 6 waste will be collected and this bags are made up of plastic materials. The Red bags are made up of disinfected container or plastic in which Category 3, 6 & 7 waste will be collected. The Blue/ White Translucent bags collect Category 4 & 7 waste which is made up of Plastic/ puncture proof container. The black coloured plastic bags are used for the collection of waste under category 5, 9 & 10. Figure 5 shows the collection of biomedical waste in the colour coded boxes

5.3 Transportation

The collected wastes are transported in trolleys or in enclosed wheelbarrow for treatment. The operator should ensure to avoid manual loading. The bags / Container containing biomedical wastes must be tied/ lidded before hauling for treatment. Vehicles used for transporting should be special to avoid contact to, and direct contact with the operator, scavengers and the public. While transporting the containers, it must be properly enclosed. The effects of traffic accidents should be incorporated in the design, and the driver must be trained in the actions which must be followed in case of an accidental spillage. The interior of the containers should also be rinsed thoroughly.

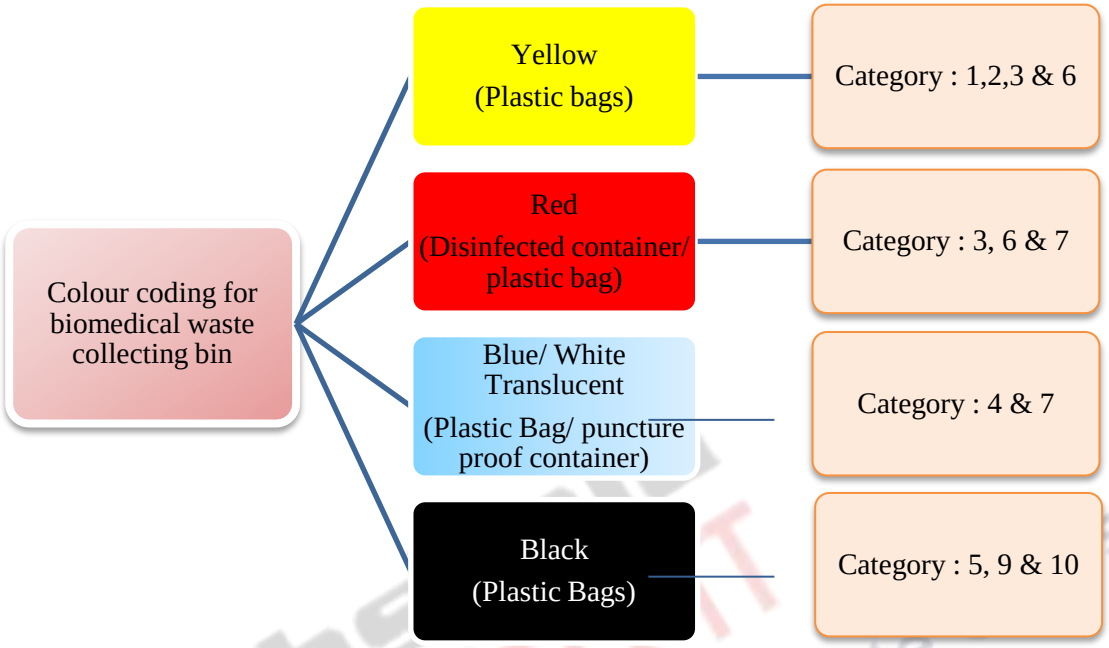

Figure 5. Collection of biomedical waste in a colour coded boxes (Source: Biomedical Waste Handling and management Rules 1998)

5.3.1 Trolleys

The use of trolleys will make the elimination of infectious waste possible at the source itself, instead of accumulation a new category of waste.

5.3.2 Wheelbarrows

Wheelbarrows are used to transfer the waste from the point source to the collection centres. There are two types of wheelbarrow – covered and open. Wheelbarrows are made of steel and provided with two wheels and a handle. Open dumping should not be done. Only packed waste (in plastic bags) should be carried. To prevent corrosion, care should be taken to prevent the liquid waste from spilling into the wheelbarrow. Wheelbarrows also come in various sizes depending on the utility.

5.3.3 Chutes

Chutes are vertical conduits provided for easy transportation of biomedical waste vertically in case of establishment with more than two floors. Chutes should be produced from stainless steel. It should have a self-closing lid. These chutes have to be sterilized on a daily basis with formaldehyde vapours. The linen that are contaminated with blood or other body fluids from each floor must be bundled in soiled linen or in plastic bags before expelling into the chute.

Alternately, elevators with mechanical winches or electrical winches can be used to bring down waste containers from each floor. Chutes are essential to keep away from horizontal transport of waste thereby diminishing the routing of the waste within the premises and hence reducing the risk of secondary contamination.

5.3.4 Dustbins

It is very important to calculate the amount of waste generated at each point. Dustbins should be of such capacity so that it can be placed at this specific site and that they do not overflow between each cycle of waste collection. Dustbins have to be cleaned subsequently at each cycle of clearance of waste with disinfectants. Dustbins can be wrinkled with plastic bags, which are chlorine-free, and colour coded as per the law.

5.4 Treatment and disposal

Before its final disposal of biomedical waste, it must be disinfected. Anatomical waste can be disposed by deep burial. Syringes to be cut (with hub cutters) and chemically disinfected with1% bleaching powder solution at source of generation before final disposal into sharps pit. Infected plastics to be chemically disinfected or autoclaved, shredded and recycled and sent for final disposal into municipal dumps.

5.4.1Incineration

Most of the hazardous biomedical wastes was treated by the method of incineration to reduce organic and combustible waste to inorganic incombustible matter. Incineration is a high temperature, dry oxidation process that results in significant reduction of waste volume and weight. Wastes that cannot be reused, recycled or pose problem in disposing in landfills are treated by incineration. Examples of

wastes that cannot be incinerated are chemical wastes, wastes containing high mercury or cadmium (broken thermometers, second-hand batteries, and lead lined wooden panels, sealed ampules or ampules containing heavy metals), silver salts, pressurized gas containers, photographic or radiographic wastes, halogenated plastics such as PVC.

The advantages of incinerator include high reduction of waste volume in addition to good disinfection competence. It helps to save the space in the landfill. The ash generated can be disposed of safely in the landfills. The major disadvantage of incineration includes high operating cost as they are energy intensive process. Also it releases a huge amount of atmospheric pollutants. The need for cyclic removal of slag and dirt, inadequacy in demolishing anti-thermal chemicals and drugs such as cyto toxic are its other disadvantages.

5.4.2 Autoclaving of Biomedical Waste

Autoclave treats the bio-medical waste through the mechanism of disinfection. The biomedical waste was subjected to following temperature and pressure based on its residence time:

i. If the autoclave residence time is not less than 60 minutes, the temperature should not be less than 121^{o}C with the pressure of 15 pounds per square inch (psi); or
ii. If the autoclave residence time is not less than 45 minutes, the temperature should not be less than 135^{o}C with the pressure of 31 pounds per square inch (psi); or
iii. If the autoclave residence time is not less than 30 minutes, the temperature should not be less than 149^{o}C with the pressure of 52 pounds per square inch (psi);

While operating a gravity flow autoclave, biomedical waste is subjected to all three condition, whereas in vacuum autoclave, the biomedical waste is first subjected to one pre-vacuum autoclave (minimum) to purge the autoclave of all air. Succeeding this first and second conditions are applied. *Bacillus stearothermophilus* spore dials or spore strips with at least 1 × 104 spores per ml.is used as biological indicator of autoclave. The operating conditions of autoclave include a residence time less than of 30 minutes, temperature less than 121^{o}C or a pressure must be less than 15 psi. On reaching certain temperature, the chemical indicator strip/tape changes colour that indicates the attainment of specific

temperature. It may be essential to use more than one strip at various locations on the waste package to ensure the effectively autoclaving of inner content of the waste in the package.

5.4.3 Biomedical Liquid Waste

Before disposing the liquid form of biomedical waste into the sewer, it must be treated. Pathological waste after being treated with chemical disinfectants are flushed into the sewage system. Likewise, the chemical waste is neutralized with suitable reagents and then either flushed or treated in the sewage treatment plant. Mostly they are neutralized and dumped in sewer network. Highly skilled operators are required for this technique as it involves handling of hazardous substances. The biomedical waste effluent generated from the various source should conform to the following limits shown in Table 2. Environment (Protection) Act, 1986 prescribes the discharge limits of these waste into public sewers.

Table 2. Disposal standard for biomedical waste

Parameters Permissible limits	
pH	6.5-9.0
Suspended solids	100 mg/L
Oil and grease	10 mg/L
Biochemical Oxygen Demand (BOD)	30 mg/L
Chemical Oxygen Demand (COD)	250 mg/L

5.4.4 Microwave Treatment

Microwave treatment uses a frequency and wavelength of 2450 MHz and 12.24 cm, respectively for the destruction of microorganisms. The infectious contaminants in water with biomedical waste are destroyed by heat conduction when it is rapidly heated by the microwaves. By bacteriological and

biological tests, the efficiency of the microwave disinfection was ensured regularly. The biomedical waste is evenly heated to a temperature of 97-100°C by means of microwaves in treatment chamber. Treatment of biomedical waste by microwaving can be carried out in the source itself. No shredding is required for microwave treatment of waste.

Most infectious wastes except body parts, human organs, infected animals carcasses and metal objects are suitable for treatment by microwave technique. This method shows good disinfection competence with good waste shrinking capacity. Similar to incineration this method also involves high operating costs. It is an eco-friendly process with potential operation and maintenance problems.

5.4.5 Deep Burial

Deep burial process is done in pits or trench of about 2 meters deep. The pits are half filled with waste, 50 cm soil and then with waste. The pits are covered with galvanized iron / wire meshes. When wastes are added to the pit, a layer of 10 cm of soil shall be added to enclose the waste. The deep burial site should be impermeable with no shallow well in the nearby area. The pits should be away from the habitation to avoid infection to surface or ground water. The site selected should not be a flooding or eroding zone and should be approved by the authority.

5.4.6 Inertization

Assimilation of waste with cement and other substances before disposal is called inertization process. This decreases the risk of entry of toxic substances into the surface or groundwater. A typical percentage of the mixture is 65% pharmaceutical waste, 15 % cement and 5 %water. A homogenous mass is created and cubes or pellets are produced and then stored. This process is economical and not suitable for infectious waste.

Table 3 shows the treatment and disposal method of the different categories of biomedical waste. The process such as incineration, deep burial, disinfecting process and municipal landfill disposal will be carried out. Category 1, 2, 3, 5 & 6 can be incinerated. Disinfecting process includes chemical treatment, autoclaving, microwaving and mutilation shredding was carried for waste under category 3, 4, 6, 7, 8 and 10. Category 1 and 2 can be disposed off by deep burial. Category 9 waste was disposed by municipal landfill.

Table 3. Treatment and disposal of biomedical waste (Source: Biomedical Waste (Handling and management Rules 1998)

WASTE CATEGORY	TREATMENT AND DISPOSAL OPTION
Category No. 1	Incineration / deep burial
Category No. 2	Incineration / deep burial
Category No. 3	Local autoclaving/ microwaving / incineration
Category No. 4	Disinfecting (chemical treatment / autoclaving / microwaving and mutilation / shredding)
Category No. 5	Incineration / destruction and drugs disposal in secured landfills
Category No. 6	Incineration/ autoclaving / microwaving
Category No. 7	Disinfecting by chemical treatment / autoclaving / microwaving and mutilation / shredding)
Category No. 8	Disinfecting by chemical treatment and discarding it into drains
Category No. 9	Disposal in municipal landfill
Category No.10	Chemical treatment and release into drains for liquids and protected landfill for solids.

6 Summary

In this lecture, we have learn about:

- The biomedical medical waste and its impact on environment
- The classification of biomedical waste and its level of toxicity.
- Method of segregation, collection, storage and transportation.

- Various disposal method and treatment techniques.

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