VOLUME 8 ISSUE 2 2022

ISSN 2454-3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, No. 2, 546-559 (2022)

International Journal of Zoological Investigations

Contents available at Journals Home Page: www.ijzi.net

Editor-in-Chief: Prof. Ajai Kumar Srivastav

Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Management of Biomedical Waste - A Review

Meshram Leena N.*, Mhatre Kirti J. and Koparkar Aruna D.

Mahatma Phule Arts, Science and Commerce College, Panvel, Raigad, Navi Mumbai 410206, India

**Corresponding Author*

Received: 26th August , 2022; **Accepted:** 3rd October, 2022; **Published online:** 15th October, 2022

https://doi.org/10.33745/ijzi.2022.v08i02.069

Abstract: Medical waste can be infectious, contain toxic chemicals and pose contamination risks to both people and the environment. The management of the waste from health services is complex and it must be understood and addressed by everyone working in health services. This review focuses on management of BMW with respect to: (1) waste segregation (sorting, receptacles and handling); (2) waste collection and storage; (3) waste transportation; and (4) treatment and disposal. This study recommends actions to be implemented at the local level such as quantitative and qualitative assessment of waste production; evaluation of local treatment and disposal options; segregation of BMW from general waste; establishment of internal rules for waste handling; assignment of responsibilities within the health-care establishment and choice of better treatment and disposal options for BMW.

Keywords: Biomedical waste, Disinfection, Encapsulation, Incineration, Irradiation, Sanitary landfills, Shredding, Thermal processes

Citation: Meshram Leena N., Mhatre Kirti J. and Koparkar Aruna D.: Management of biomedical waste - A review. Intern. J. Zool. Invest. 8(2): 546-559, 2022.

https://doi.org/10.33745/ijzi.2022.v08i02.069

Introduction

Waste generated in hospitals is referred to as Biomedical waste (BMW) (Chandrappa and Das, 2012), or medical waste (Aymen and Bajari, 2018) or health-care waste (HCW) (Ansari *et al.*, 2019). BMW management (BMWM) in a health care setup is an alarming human and environmental health concern. Despite the implementation of Biomedical Waste management and Handling Rules by the Government of India, the BMWM still remains a serious issue due to the lack of awareness and knowledge about the health hazards from BMW, improper practices of waste disposal and poor control of waste disposal which are the most critical problems associated with health care waste disposal (Hasan *et al.*, 2015).

The safe and sustainable management of BMW is social and legal responsibility of all people supporting and financing health-care activities. Effective BMWM is mandatory for healthy humans and cleaner environment. BMW is any waste produced during the diagnosis, treatment, or immunization of human or animal research activities pertaining thereto or in the production or testing of biological or in health camps. It follows the cradle to grave approach which is characterization, quantification, segregation, storage, transport, and treatment of BMW (Datta *et al*., 2018).

Since beginning, the hospitals are known for the treatment of sick persons but the hospital waste is a potential health hazard to the health care workers, public and flora and fauna of the area. BMWM is influenced by social, cultural and economic circumstances. About 10–15% of waste from hospitals are considered infectious and consists of infectious/toxic/radioactive substances which can contaminate the non-risky wastes (Chandrappa and Das, 2012).

According to (ICRC, 2011), the proper management of medical waste depends on good organization, sufficient funding and the active participation of informed and trained personnel. The BMWM is relegated to the rank of a menial task, whereas it ought to be valued and all persons in a hospital made to realize their share of responsibility. Therefore in the present study, an overview of management of BMW with respect to: waste segregation (sorting, receptacles and handling), waste collection and storage, waste transportation and treatment and disposal is considered. Emphasis is also given on methods of sustainable management and recommendations for minimization of BMW.

The present paper provides an overview on the major issues and debate, gaps in knowledge and way to bridge the gap related to management of BMW with respect to: waste segregation (sorting, receptacles and handling), waste collection and storage, waste transportation and treatment and disposal.

Research methodology:

Review method adopted was based on the scientific literature survey from databases such as Medline, Embase, PubMed Central, ScienceDirect, Proquest and Medscape. The keywords used for reviewing the literature were the ones that refer to the issues concerning the BMW. For literature search, keyword "biomedical waste" is combined with: waste segregation, waste collection and storage, waste transportation and treatment and disposal.

Management of Biomedical Waste:

Elements of biomedical waste management include: waste segregation, waste collection and storage, waste transportation and treatment and disposal.

Waste Segregation (*Sorting*, *Receptacles and Handling*):

❖ *Definition*:

Segregation refers to the basic separation of different categories of waste generated at source and thereby reducing the risks as well as cost of handling and disposal (ICRC, 2011).

- Segregation is carried out at the site of waste generation, e.g. wards, operation theatres, ICUs, stores, pharmacy, autopsy room, etc. (Raj, 2009).
- Segregation is the most crucial step in the BMW management.
- Effective segregation alone can ensure effective BMW management.
- BMW must be segregated in accordance to guidelines laid down under Schedule 1 of BMW Rules, 2016 (ICRC, 2011).

❖ *Benefits of Segregation* (*Source*: *Chandrappa and Das*, *2012*):

- Avoid contamination of non-infectious waste by infection.
- Avoid entry of toxic waste like lead, mercury and radioactive substance.
- Avoid entry of chlorinated waste to prevent generation of dioxins and furans.

❖ *Segregation of BMW in Colour Coded Bags* (*Source: Bhatia and Paul*, *2017*):

Table 1: Segregation of BMW in Colour Coded Bags

Colour coded bags	Type of BMW
Yellow	Human anatomical waste, Animal anatomical waste, Soiled waste, Expired or discarded medicines, Chemical waste, Microbiology, biotechnology and other clinical laboratory waste.
Red	Plastic waste such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes) and vacutainers (with their needles cut) and gloves.
White	Sharp waste including metals like needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, etc.
Blue	Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes and metallic body implants.

Table 1 illustrates the segregation of BMW on colour coded bags.

Waste Collection and Storage (*Source*: *ICRC*, *2011*)**:**

❖ *Collection:*

- Collection of BMW involves use of different types of container.
- Containers should be placed in such a way that 100% collection is achieved.
- Sharps must be kept in puncture-proof containers to avoid injuries and infection to the workers handling them.
- Waste must be collected regularly, at least once a day.
- Waste must not be allowed to accumulate where it is produced.
- Daily collection programme and collection round must be planned.
- Each type of waste must be collected and stored separately.
- Only closed yellow bags and sharps containers were collected by wearing gloves.

❖ *Storage:*

A specific area must be designated for storing medical waste. Until adequate quantity accumulates, the waste needs to be stored at the site where it is generated (Raj, 2017). The medical staff must ensure that the waste bags are tightly closed up to three quarters and they are closed and marked before transferring them (Aymen and Bajari, 2018).

The storage area must meet the following criteria:

- Closed and access must be restricted to authorized persons only.
- Separate from any food store and covered and sheltered from the sun.
- Flooring must be waterproof with good drainage.
- Easy to clean and protected from rodents, birds and other animals.
- Easy access for on-site and off-site means of transport.
- Well aired, well lit and compartmented to store various types of waste.
- Entrance must be marked with a sign (“No unauthorized access”, “Toxic”, or “Risk of infection”).
- Wastes can be stored for a week in a refrigerated area (3° to 8°C).

- No untreated bio-medical waste shall be kept stored beyond a period of 48 h.
- If no refrigerated area, the limit of storage time for infectious BMW is:
  - ✓ Temperate climates: 72 h in winter and 48 h in summer.
  - ✓ Hot climates: 48 h in the cool season and 24 h in the hot season.

Waste Transportation (Source: *Aymen and Bajari, 2018*):

The transportation of the BMW can be within the hospital (internal) and from the hospital to the final disposal site (external) (Raj, 2009).

❖ *Internal transport:*

- Transport of segregated bags of BMW from different areas of the hospital to the dumping place of the hospital.
- Trolleys/carts can be used for internal transport.
- Persons carrying BMW should wear disposable plastic gloves.
- Spillage must be avoided.

❖ *External transport:*

- Transport of BMW from the hospital site to the final site of disposal.
- Vehicles carrying BMW should not carry general municipal garbage.

❖ *General Guidelines for BMW Transportation* (*Source: Bhatia and Paul, 2017*)*:*

- BMW should be transported for treatment in trolleys/covered wheel barrow.
- Bags/containers containing BMWs should be tied/lidded before transportation.
- Bag containing BMWs should be accompanied with a signed document by Nurse/Doctor mentioning date, shift, quantity and destination.
- Final transport of BMW must be only in authorized vehicle with appropriate documentation for further record.
- Vehicles used for transport of BMW must have the "Bio-Hazard" symbol and these vehicles should not be used for any other purpose.
- Care should be taken to avoid contact with the operator, scavengers and the public.
- Containers must be properly enclosed during transportation.
- Effects of traffic accidents should be incorporated in the design.
- Driver must be trained in the actions in case of an accidental spillage.
- Trolleys: Eliminate infectious waste possible at the source itself, instead of accumulation a new category of waste.
- Wheelbarrows: Used to transfer the waste from the point source to the collection centres.
- Dustbins: Proper size, placed at the specific site and do not overflow between each cycle of waste collection. Cleaned with disinfectants and wrinkled with plastic bags (chlorine-free and colour coded as per the law) (Fig. 1).

*Treatment and Disposal of BMW***:**

❖ *Definition of Waste treatment:*

Any method, technique, or process designed to change the biological character or composition of any medical waste to reduce and/or eliminate its potential for causing disease is referred to as 'Waste Treatment' (Odumosu, 2015).

Selection of Treatment and Disposal methods (Source: ICRC, 2011):

According to ICRC (2011), there is no universal solution for waste treatment. The method for treatment and disposal of BMW can be chosen by considering the local circumstances and with minimum negative impacts on health and the environment. Selection of technique for treatment and disposal of BMW depends on parameters such as:

- Quantity and type of wastes produced.

•

Trolleys

Wheelbarrows

Dust bins used for collection of BMW

Fig. 1: Trolleys, Wheelbarrows, Dustbins and Vehicles used for transportation of BMW.

Table 2: Techniques for Treatment and Disposal of BMW

Technique	Type	Method	Examples
Disinfection	Chemical	Addition of disinfectants	Alkaline hydrolysis, ammonium salts, chlorine dioxide, dry inorganic chemicals, hydrogen peroxide, lime, ozone, peracetic acid and sodium hypochlorite.
	Thermal (Incineration)	Low temperatures (100° to 180°C)	Vapour (autoclave, micro-waves), Hot air (convection, combustion, infrared heat)
		High temperatures (200° to >1000°C)	Incineration (combustion, pyrolysis, gasification)
	By irradiation	UV rays, Electron beams	
	Biological	Enzymes	
Mechanical processes	Shredding	Process which does not decontaminate the waste	
Encapsulation	Solidification of sharps		
Burial	Sanitary landfills, Trenches, Pits		

- Availability of waste treatment site near the hospital.
- Cultural acceptance of treatment methods.
- Availability of reliable means of transport.
- Provision of enough space around the hospital.
- Availability of financial, material and human resources.
- Availability of a regular supply of electricity.
- National legislation on the subject, the climate, groundwater level, etc.

❖ *Techniques for Treatment and Disposal of BMW*:
Table 2 and Figures 2, 3 depict techniques for treatment and disposal of BMW.

Incineration Technology (Table 3):

❖ *Definition of Incineration:*

Incineration can be defined as -- A process of dry oxidation of incinerators to reduce the volume and weight of organic and burnt materials into inorganic and non-incinerated materials (ash) (Aymen and Bajari, 2018).

❖ *Features of Incineration* (*Odumosu, 2015*):

- High-temperature thermal process (between 900°C and 1200°C).
- Combustion of waste under controlled conditions into inert material and gases.
  - Most widely used method of treating BMW in many parts of the world.
  - Recommended for treatment of human anatomical waste, animal waste, cytotoxic drugs, discarded medicines and soiled waste.
  - All types of incinerators have both primary and secondary combustion.
  - Secondary combustion chamber is used to completely combust all non-combusted gases leaving the primary incinerator chamber to ensure optimal combustion.

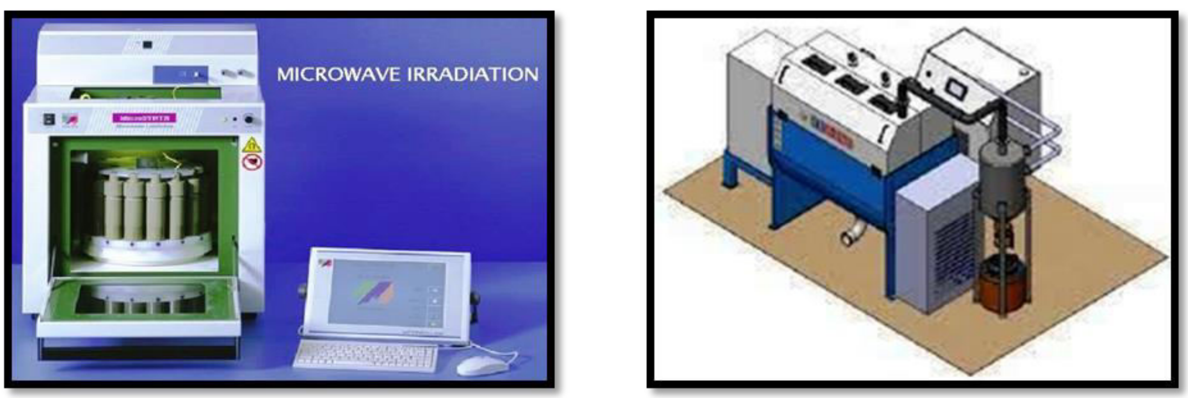
❖ *Types of Incineration Technology* (*ICRC, 2011*; *Aymen and Bajari, 2018*):

❖ *Characteristics of waste suitable for incineration*:

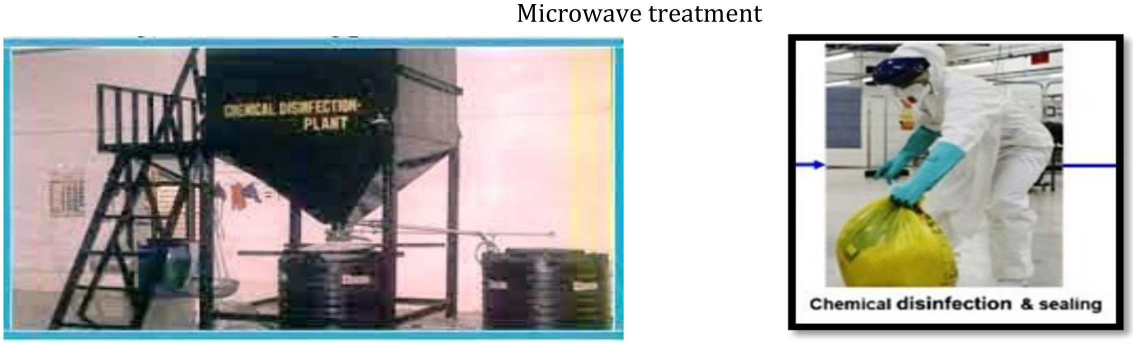
- Low heating volume

Incinerator

Autoclave

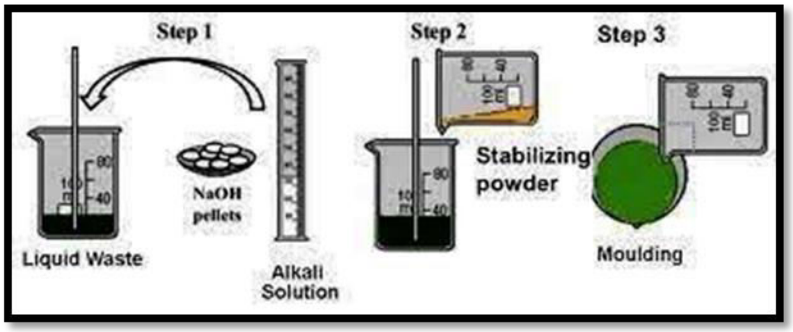


Microwave treatment



Chemical disinfection

Fig. 2: Techniques for Treatment and Disposal of BMW.



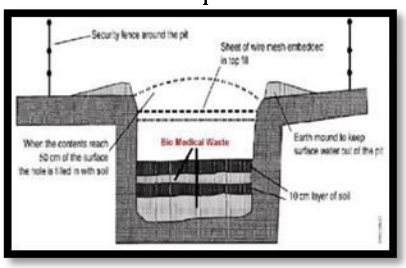
Inertization of BMW

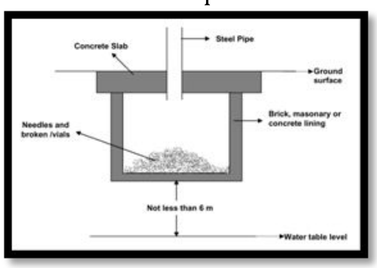
Needle cutter/Destroyer

Land disposal

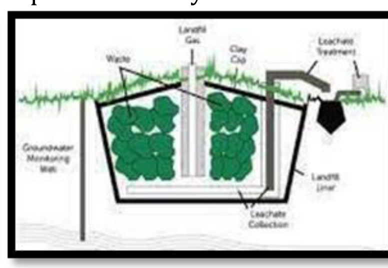
Concrete Sharp Pit

Deep Burial facility





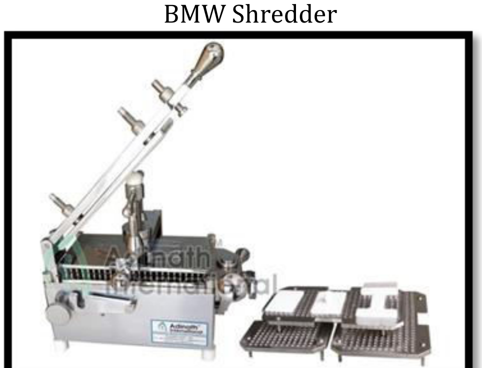
Layout of Sharp Pit for disposal for Sharp waste



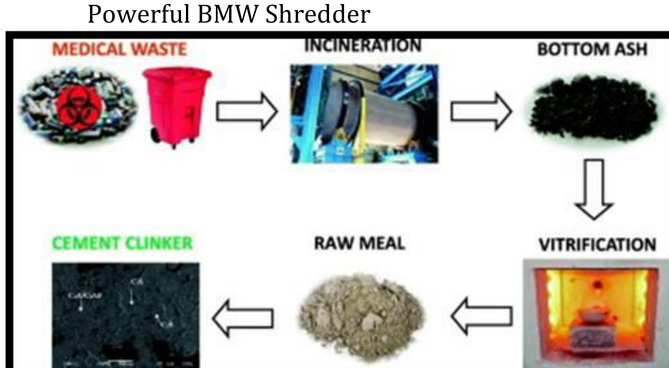
Modern Landfill

BMW Shredder

Powerful BMW Shredder



Encapsulation/Solidification



Vitrification of BMW

Fig. 3: Techniques for Treatment and Disposal of BMW.

Table 3: Types of Incineration Technology

Incineration	Example	Advantages	Drawbacks
High-temperature incinerator (>1000°C)	Rotary kiln (>1200°C)	• Waste is completely destroyed. • Waste is not recognizable. • Waste volume and weight are significantly reduced. • Large quantities of waste can be treated. • Toxic emissions are reduced. • Suitable for all types of waste.	• High construction cost. • High operating and maintenance costs. • Requires electricity, highly skilled staff and fuel. • Ash contains leached metals, dioxins and furans.
Dual-chamber incinerator (800°- 900°C)	Household refuse incineration plant	• Micro-organisms are completely destroyed. • Waste volume and weight are significantly reduced (>95%). • All types of organic waste (liquid and solid) are destroyed. • Large quantities of waste can be treated.	• High investment cost. • Needs fuel. • Requires skilled staff and permanent monitoring. • Emission of toxic flue gas (dioxins and furans). • Sharps are not destroyed. • Unsuitable for chemical and pharmaceutical wastes. • Ash contains leached metals, dioxins and furans.
Single-chamber incinerator (300°-400°C)	Single-chamber incinerator (300°-400°C)	• Relatively effective disinfection. • Waste volume and weight are significantly reduced. • Simple and cheap.	• Needs fuel. • Wastes are only partially burnt. • Risk of incomplete sterilization. • Emission of atmospheric pollutants. • Soot needs to be removed periodically. • Ineffective for destroying heat-resistant chemicals or pharmaceuticals. • Sharps are not destroyed. • Ash contains leached metals, dioxins and furans.

✓ above 2000 Kcal/Kg for single chamber incinerators

✓ above 3500 Kcal/Kg for pyrolytic double chamber incinerators.

- Content of combustible matter above 60%.
- Content of non-combustible matter below 50%.
- Content of non combustible fines below 20%.
- Moisture content below 30%.

❖ *Waste types not to be incinerated:*

- Pressurized gas containers.
- Large amount of reactive chemical wastes.
- Silver salts and photographic or radiographic wastes.
- Halogenated plastics such as PVC.
- Waste with high mercury or cadmium content such as broken thermometers,

used batteries.

- Sealed ampoules or ampoules containing heavy metals.

Non-Incineration Technology:

Non-incineration technology treatment is an alternative method to burning of BMW and it includes four basic processes: thermal, chemical, irradiative and biological.

❖ *Thermal Processes:*

These methods depend on thermal energy (heat) for the decontamination of pathogens in waste. This process is further subdivided into low-heat, medium-heat, and high-heat thermal processes.

➢ *Low-Heat Thermal Processes:*

- Pathogens from the BMW are destroyed at temperatures without chemical breakdown, combustion or pyrolysis.
- Heat range is of 93-177°C (200-350°F).
- Cause a size reduction up to 60%–70%.
- Consist of two basic categories: wet heat (steam) and dry heat (hot air) treatment method.
- Examples of Wet heat treatment: Autoclaving and Microwave treatment
- Autoclaving (Steam disinfection):

✓ Thermal process at low temperatures where waste is subjected to pressurized saturated steam for a sufficient length of time to be disinfected (60 min at 121°C).

✓ Allows for the treatment of limited quantities of highly infectious waste.

✓ Recommended for BMW like microbial cultures and other infectious matter.

✓ Advantages of steam disinfection

  - Autoclaved waste becomes safe household refuse.
  - Health facilities are familiar with this processing method.
  - Ecologically sound technology.
  - Facilitates the recycling of plastics.
  - Low operating costs.

✓ *Drawbacks of steam disinfection*

  - Moderate to high installation costs.
  - Requires electricity.
  - Produces contaminated effluents, which need to undergo special treatment.
  - In some cases a boiler is needed with emission control.
  - Unsuitable for chemical or pharmaceutical wastes.
  - Appearance of the waste does not change.
  - Shredding is essential in order to avoid re-use.
  - Weight of the waste does not change.
  - Unpleasant odours.
  - Presence of chemicals which can generate toxic fumes.
  - Slow and time-consuming

- Microwave treatment:

✓ Uses the action of moist heat and steam generated by microwave energy to disinfect the waste.

✓ Should not be used for cytotoxic, hazardous or radioactive wastes, contaminated animal carcasses, body parts and large metal items.

✓ Presence of metal leads to sparkling and possibly health hazards.

✓ The microwaving demands comparatively higher investment and proper segregation of waste.

➢ *Medium-Heat Thermal Processes:*

- Temperature range is 177–370°C (350–700°F).
- Involves the chemical breakdown of organic material.

- Operates on reverse polymerization using high-intensity microwave energy and thermal de-polymerization using heat and high pressure.

➢ *High-Heat Thermal Processes:*

- Temperature range is from 540°C to 8300°C (1000–15,000°F) or more.
- High heat produced involves both chemical and physical changes resulting in total destruction of the waste.
- Significant reduction in the total mass and volume of the waste.
- Cause a size reduction up to 90%–95%.

❖ *Chemical disinfection* (*Source: ICRC, 2011*; *Odumosu, 2015*):

- Involves addition of disinfectants to treat liquid waste such as blood, urine, stools, or hospital sewage.
- Disinfectants used: Alkaline hydrolysis, ammonium salts, chlorine dioxide, dry inorganic chemicals, hydrogen peroxide, lime, ozone, peracetic acid and sodium hypochlorite.
- Appropriate for liquid BMW although it can be used to treat solid wastes.
- Shredding or grinding of waste to enhance the exposure of the waste to chemical agents.
- Chemical waste is neutralized with suitable reagents and then either flushed or treated in the sewage treatment plant.

➢ *Advantages of chemical disinfection*:

- Simple.
- Relatively cheap.
- Wide availability of disinfectants.

➢ *Drawbacks of chemical disinfection:*

- Chemicals must be handled with caution.
- Prescribed contact time and concentrations must be complied with.
- Waste volume is not reduced.
- Wastes have to be shredded /mixed before being treated with chemicals.
- Final disposal method must be the same as for untreated medical waste.
- Generates dangerous effluents, which need to be treated.
- Creates toxic substances.
- Highly skilled operators are required to handle hazardous *substances.*

❖ *Disinfection by Irradiation:*

- Involves the use of electron beams (gamma radiation, UV irradiation, Cobalt 60) that uses a shower high-energy electron to destroy microorganisms in the waste by causing chemical dissociation and rupturing of their cell walls.
  - Radiation sterilizing effect is by penetration and inactivation of microbial contaminants.
  - Requires safety precautions such as the use of protective covering, etc., to prevent occupational hazards.
  - Pathogen destruction efficacy relies on the amount of the dose absorbed by the mass of waste, waste density and electron energy.
  - Alternative method of decontamination of all types of waste except pathological wastes.

❖ *Biological Processes:*

- Involves the use of enzymes to degrade organic waste.
- Rarely used method in hospital waste management.

Mechanical processes (*Shredding*) (*Source*: *ICRC, 2011; Odumosu, 2015*):

❖ *Definition of Shredding:*

Shredding is a mechanical process by which waste are deshaped or cut into smaller pieces so as to make the wastes unrecognizable.

❖ *Characteristics of Shredding:*

- Shredder is used for shredding in BMW with minimum requirements.
- Shredders cut the waste into small pieces.
- Shredding provides a means of recycling plastics and needles.
- Considered whenever needles and syringes are available in large quantities.
- Involves a centralized system for collecting and transporting wastes from the various facilities.
- Shredded plastic and glass can be reprocessed for manufacture of new items.

❖ *Advantages of Shredding:*

- Makes the waste unrecognizable.
- Prevents the re-use of needles and syringes.
- Reduces volume.
- Facilitates the recycling of plastics.
- Enhances the effectiveness of chemical or thermal treatment in closed and integrated systems.

❖ *Drawbacks of Shredding:*

- Requires electricity.
- Some facilities are very expensive.
- Shredder can be damaged by large pieces of metal.
- The waste is not disinfected.
- Staff are exposed to air-borne pathogens when untreated waste is shredded.
- Requires skilled staff and permanent monitoring.

Encapsulation/Solidification (*Source: ICRC, 2011*; *Odumosu*, *2015*):

❖ *Definition of Encapsulation/Solidification :*

Encapsulation/solidification consists of containing a small number of hazardous items or materials in a mass of inert material. The purpose of the treatment is to prevent humans and the environment from any risk of contact (Chandrappa and Das, 2012).

❖ *Characteristics of Encapsulation:*

- Used for the disposal of sharps in a leak proof and puncture-proof containers.
- Involve filling of containers with waste and an immobilizing/ binding material (bituminous sand, plastic foam, cement mortar or clay) and containers are sealed.
- Cubic boxes made of high-density polyethylene or metallic drums, are three-quarters filled with sharps, chemical or pharmaceutical residues or incinerator ash.
- Containers are then filled up with immobilizing material.
- Once the medium has dried, containers are sealed and disposed of in a sanitary landfill or waste burial pit.

❖ *Advantages of Encapsulation :*

- Simple, inexpensive and safe.
- Best solution for the disposal of sharps and pharmaceutical wastes.
- Risks for scavengers are reduced.

❖ *Drawbacks of Encapsulation :*

- To be regarded as a temporary solution.
- The quantities of waste treated are small.
- The weight and volume of the waste is increased.

Burial (*Disposal in sanitary landfills, trenches or pits*) (*Source*: *ICRC*, *2011*):

Deep burial pits are recommended and used in rural and isolated areas where it is not prudent to invest huge amount of money (Chandrappa and Das, 2012). In some developing countries, where hospitals lack the required means to treat wastes before disposal, direct landfilling is likely to be necessary for much of the produced materials (Ansari *et al*., 2019).

❖ *Characteristics of deep burial:*

- Not recommended and must only be used as a last resort.
- BMW can be disposed of in a sanitary landfill and be covered rapidly.
- Dig a trench down to the level of old municipal refuse and immediately bury the discarded BMW at the level under a 2 metre of fresh municipal refuse.
- *Conditions for design and use of a sanitary landfill:*
    - ✓ Access must be restricted and controlled.
    - ✓ Competent staff must be available.
    - ✓ Discarding areas must be planned.
    - ✓ Bottom of the landfill must be waterproofed.
    - ✓ Water table must be more than 2 metres below the bottom of the landfill.
    - ✓ No drinking water sources or wells in the vicinity of the site.
    - ✓ Chemicals must not be disposed of on these sites.
    - ✓ Waste must be covered daily.
    - ✓ Vectors (insects, rodents, etc.) must be controlled.
    - ✓ Landfill must be equipped with a final cover to prevent rainwater infiltration.
    - ✓ Leachates must be collected and treated.

❖ *Advantages of disposal by burial in sanitary landfill and trench:*

- Simple and inexpensive operating costs.
- Carried out using an existing municipal waste management system.
- Scavengers cannot access the BMW if the landfill is well managed.

❖ *Drawbacks of disposal by burial in sanitary landfill and trench :*

- BMW are not treated and remain hazardous.
- Landfill must be secure, fenced in and guarded.
- Scavengers and animals need to be controlled.
- High degree of coordination is needed between collectors and landfill operators.
- Makes health workers less aware of the need to sort the various types of waste.
- Transport to the landfill can be a lengthy and costly operation.

Risk of water pollution.

Strategies for Sustainable Management of BMW:

- Keep hospitals clean and safe by identifying hazards and risks of biomedical waste.
- Place the waste in designated colour coded bins.
- Give BMW to the Common Biomedical Waste Treatment and Disposal Facility (CBWTF) for complete treatment and disposal.
- Segregate waste in correct coloured liners (non-chlorinated).
- Segregate waste at source and in correct

liners for suitable treatment.

- Never mix waste during collection and transportation.

- Manage spillage right away.
- Plastic waste should not be sent to landfill sites.
- Standards for treatment and transportation of BMW as per Schedule II of BMWM Rules, 2016.
- Safety first. Protective gear for healthcare workers.
- Untreated biomedical waste is a risk to environment and health.
- If injured treat your wound immediately.
- Never drag filled waste liners.
- Waste should never be handled without wearing protective gear.
- Segregate general waste from infectious BMW as mixing of these can lead to greater spread of infections and epidemics.
- Follow guidelines for handling and disposing BMW from health care facilities.

Conclusion

Management of biomedical waste is an essential component of health facilities and it must be treated and disposed on priority basis. It must be understood and addressed by everyone working in health services. Waste Management Hierarchy provided by United States Environment Protection Agency (EPA) with a preference for Source reduction and reuse, Recycling/composting, Energy recovery and Treatment and Disposal is recommended to minimize the quantities of biomedical waste. New innovative technologies should be developed for sustainable management of biomedical waste for environmental protection and to minimize health risk to human.

Acknowledgements

Encouragement and support provided by Dr. Ganesh A. Thakur, Principal, Mahatma Phule Arts, Science and Commerce College, Panvel, Raigad, Navi Mumbai, India is gratefully acknowledged.

References

Ansari M, Mohammad HE, Mahdi F and Ehsan A. (2019) Dynamic assessment of economic and environmental performance index and generation, composition, environmental and human health risks of hospital solid waste in developing countries; A state of the art of review. Environ Int. 132(2019): 105073.

Aymen Abd-Ul Salam Awad and Firas Al B. (2018) Environmental impacts of medical waste treatment and management by burning inside health facilities. International J Civil Engineer Technol. 9(5): 41-53.

Bhatia D and Dibyendu P. (2017) Biomedical Waste Management (BMW) and it's Awareness in India (In accordance with BMW Rules, 2016). ENVIS RP Centre, North Eastern Hill University, Shillong, Meghalaya, pp. 27.

Chandrappa R and Das DB. (2012) Solid Waste Management. Chapter 6: Biomedical Waste. Environmental Science and Engineering. Springer-Verlag Berlin Heidelberg, pp. 147-175.

Datta P, Gursimran KM and Jagdish C. (2018). Biomedical waste management in India: Critical appraisal. J Lab Physicians 10: 6-14.

Hasan S, Shazina S and Priyadarshini C. (2015) Biomedical waste management - a public health hazard: an overview of literature. Malaya J Bioscie. 2(2): 143-148.

ICRC. (2011) Medical Waste Management. International Committee of the Red Cross, 19, avenue de la Paix 1202 Geneva, Switzerland, pp. 164.

Odumosu BT. (2015) Biomedical Waste: Its Effects and Safe Disposal. Chapter 4: In: Environmental Waste Management, (ed.) Ram Chandra, CRC Press, Boca Raton, pp. 81-93.,

Raj Mahendra RR. (2009) Biomedical waste management: An overview. J Indian Acad Oral Med Radiology 21(3): 139-142.