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Biomedical Waste Management: A Review

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Abstract

In developing countries, biomedical waste management is an issue of major concern. The safe and sustainable management of biomedical waste (BMW) is social and legal responsibility of all people supporting and financing health-care activities. Effective BMW management (BMWM) is mandatory for healthy humans and cleaner environment. This review explains the hospital waste management and the environmental problem in India. This study also focused on the problems associated with biomedical waste. In the past, medical waste was often mixed with municipal solid waste and disposed in nearby landfills. In recent years, many efforts have been made by environmental regulatory agencies to better manage the biomedical waste. The new rules are meant to improve the segregation, transportation, and disposal methods, to decrease environmental pollution so as to change the dynamic of BMW disposal and treatment in India. For effective disposal of BMWM, there should be a collective teamwork with committed government support in terms of finance and infrastructure development, dedicated health-care workers and health-care facilities, continuous monitoring of BMW practices, tough legislature, and strong regulatory bodies. The basic principle of BMWM is segregation at source and waste reduction. Besides, a lot of research and development need to be in the field of developing environmental friendly medical devices and BMW disposal systems for a greener and cleaner environment.

Keywords: Biomedical waste Guidelines, Biomedical waste management, WHO, Bio Medical Wastes Treatment, infectious, Bio Hazards.

INTRODUCTION

According to the Bio-medical waste rules 1998 of India, Bio – Medical Waste is defined as "Any solid, fluid or liquid waste, including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological and the animal waste from slaughter houses or any other like establishments." There are a number of hazardous medical and dental wastes that, when disposed improperly, could cause harm to the environment.[1] It also presents an occupational health hazards to the health care personnel who handle these wastes at the point of generation, and those involved with their management i.e. segregation, storage, transport, treatment and disposal.[2]Biomedical waste (BMW) is generated in hospitals, research institutions, health care teaching institutes, clinics, laboratories, blood banks, animal houses and veterinary institutes.[3]

Biomedical waste, also known as infectious waste or medical waste is defined as waste generated during

the diagnosis, testing, treatment, research or production of biological products for humans or animals. Biomedical waste includes syringes, live vaccines, laboratory samples, body parts, bodily fluids and waste, sharp needles, cultures and lancets.[4]

India generates around three million tonnes of medical wastes every year and the amount is expected to grow at eight percent annually.[5] According to the WHO, incorrect and improper management of healthcare bio waste can have direct impacts on the community.

Wastes generated in healthcare settings include sharps, pathological wastes, infectious wastes, radioactive wastes, mercury containing instruments, and polyvinyl chloride plastics. The WHO has stated that 85% of such hospital wastes are actually nonhazardous, around 10% are infectious, and around 5% are non infectious but hazardous.[6]

The basic principle of good BMW practice is based on the concept of 3Rs, namely, reduce, recycle, and reuse. The best BMW management (BMWM) methods aim at avoiding generation of waste or recovering as much as waste as possible, rather than disposing. Therefore, the various methods of BMW disposal, according to their desirability, are prevent, reduce, reuse, recycle, recover, treat, and lastly dispose. Hence, the waste should be tackled at source rather than "end of pipe approach. BMW treatment and disposal facility means any facility wherein treatment, disposal of BMW or processes incidental to such treatment and disposal is carried out.[7]

A strong emphasis on cleanliness and systemic disposal of all wastes including hospital waste is aimed by the Government of India and has been launched as the "Swachh Bharat" mission with a goal to make India "cleaner and greener" to create a better livable atmosphere.[8]

The absence of proper waste management, lack of awareness about the health hazards from BMWs, insufficient financial and human resources, and poor control of waste disposal are the most critical problems faced with healthcare waste.[9]The hazardous impact of medical waste on us and environment is enhanced manifold if the appropriate handling of these wastes is not adopted. Improper disposal methods of these wastes may lead to the spread of serious and harmful diseases such as AIDS, hepatitis B and C, and tuberculosis (TB) among the healthcare personnel, waste handlers, patients and their visitors, and community where the waste is indiscriminately deposited.[10]

Definition- Biomedical Waste (Management and Handling) Rules, 1998 of India "Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological.

"Bio-medical waste treatment facility" means any facility wherein treatment of disposal of bio-medical waste or processes incidental to such treatment or disposal is carried out; "Occupier" is any institution generating bio-medical waste, which includes a hospital, nursing home, clinic dispensary, veterinary institution, animal house, pathological laboratory and blood bank. A person who has control over that institution and/or its premises.

"Operator of a bio-medical waste facility" means a person who owns or controls or operates a facility for the collection, reception, storage, transport, treatment, disposa l or any other form of handling of bio-medical waste; "Schedule" means schedule appended to these rule.[11]

Bio medical waste can be classified as:[12] Health Care General Waste (HCGW) - Non- Hazardous Waste comprise about 85% .It constitutes food remnants, paper cartons, packaging material, fruit peels, wash water etc.

Health care Risk Waste (HCRW) - Hazardous Waste: HCRW is that portion of health care waste that is capable of producing injury or disease. It includes:

1. Infectious waste
2. Pathological waste
3. Sharps
4. Chemical waste
5. Pharmaceutical waste
6. Cytotoxic waste
7. Radioactivewaste

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Waste	Examples
Infectious waste	Waste contaminated with blood and other bodily fluids. (from discarded diagnostic samples)
	Cultures and stocks of infectious agents from laboratory work. (e.g. waste from autopsies and infected animals from laboratories)
	waste from patients with infections. (e.g. swabs, bandages and disposable medical devices)
Pathological waste	Human tissues, organs or fluids, body parts and contaminated animal carcasses
Sharps waste	Syringes, needles, disposable scalpels and blades, etc
Chemical waste	Solvents and reagents used for laboratory preparations, disinfectants, sterilants and heavy metals contained in medical devices (e.g. mercury in broken thermometers) and batteries
Pharmaceutical waste	Unused and contaminated drugs and vaccines
Cytotoxic waste	Waste containing substances with genotoxic properties (i.e. highly hazardous substances that are, mutagenic, teratogenic or carcinogenic), such as cytotoxic drugs used in cancer treatment and their metabolites
Radioactive waste	Such as products contaminated by radionuclides including radioactive diagnostic material or radiotherapeutic materials

Waste classification

According to schedule I of Ministry of environment and forests, there are 10 categories of waste as shown in schedule I. Colour coding and type of container for disposal of biomedical waste recommended in India is shown in Schedule II[13]. The World Health Organization (WHO) has classified medical waste into eight categories such as General Waste, Pathological, Radioactive, Chemical, Infectious to potentially infectious waste, Sharps, Pharmaceuticals, Pressurized containers whereas; In India, Ministry of Environment and Forest, Government of India (1998) has notified Bio- medical Waste Management & Handling Rules - 1998, which describes ten categories. Although the solid waste management has become one of the major topics of importance but still local bodies are unable to give the proper attention towards some special sources of wastes out of which biomedical waste is one. The sources of biomedical waste can be categorized as primary and secondary sources according to the quantities produced.

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SCHEDULE I

[See rules 3 (e), 4(b), 7(1), 7(2), 7(5), 7 (6) and 8(2)]

Part-1

Biomedical wastes categories and their segregation, collection, treatment, processing and disposal options

(Categories of Biomedical Waste)

Option Disposal	Waste Category	Components	Method of treatment and disposal
Category No. 1	Human Anatomical waste	Human tissues, organs, body parts	Incineration/Deep Burial
Category No. 2	Animal Waste	animal tissues, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses	Incineration/Deep Burial
Category No. 3	Microbiology and Biotechnology Waste	needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps	Local autoclaving/microwaving/Incineration
Category No. 4	Waste sharps	wastes comprising of outdated, contaminated and discarded medicines and drugs	Disinfection (chemical treatment)/ autoclaving/microwaving and mutilation/shredding
Category No. 5	Discarded Medicines and Cytotoxic drugs	wastes comprising of outdated, contaminated and discarded medicines and drugs	Incineration/Destruction ion and drugs disposal in secured landfills
Category No. 6	Solid Waste	items contaminated with blood and body fluids including cotton, dressings, soiled plaster	Incineration/ autoclaving/microwaving

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		casts, lines, beddings other material contaminated with blood	
Category No. 7	Solid Waste	wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc	Disinfection by chemical treatment/ autoclaving/microwaving and mutilation/shredding
Category No. 8	Liquid Waste	waste generated from laboratory and washing, cleaning, house- keeping and disinfecting activities.	Disinfection by chemical treatment and discharge in drains
Category No. 9	Incineration Ash e	ash from incineration of any bio-medical waste	Disposal in Municipal landfills
Category No. 10	Chemical Waste	chemicals used in production of Biologicals, chemicals used in disinfection and as insecticides	Chemical treatment and discharge into drains for liquids and secured landfills for solids.

SCHEDULE-II[13]

Recommended Colour Coding and Type Of Container for Disposal of Bio-Medical Wastes

Colour Coding	Type of Container	Waste Category	Treatment option as per Schedule I
Yellow	Yellow coloured non-chlorinated plastic bags	Human anatomical wastes, Animal anatomical wastes, Soiled wastes, microbiology & biotechnology waste	Incineration or Plasma pyrolysis or deep burial*
		Expired or discarded medicines	Return back to manufacturer or supplier for incineration at >1200°C

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	Separate collection system leading to effluent treatment system	Chemical liquid wastes	After resource recovery, the chemical liquid waste shall be pre-treated before mixing with other wastewater.
	Non-chlorinated yellow plastic bags or suitable packing material	Discarded linens, Mattresses, Beddings contaminated with blood or body fluids	Non-chlorinated chemical disinfection followed by Incineration or Plasma pyrolysis or for Energy recovery
	Autoclave safe plastic bags or containers	Microbiology, biotechnology, and other clinical laboratory waste	Pre-treat to sterilize with non-chlorinated chemicals onsite as per National AIDS Control Organization or WHO guidelines thereafter for Incineration
Red	Red coloured non-chlorinated plastic bags or containers	Contaminated Waste (Recyclable) Tubing, bottles, intravenous tubes and stes, catheters, urine bags, syringes (without needles) and gloves	Autoclaving or micro-waving / hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste should be sent to registered recyclers for energy recovery. Plastic waste should not be sent to landfill sites.
White (Translucent)	Puncture proof, leak proof, tamper proof containers	Waste sharps including metals	Autoclaving or Dry Heat Sterilization
Blue	Cardboard boxes with blue coloured marking	Glassware Metallic body implants	Disinfection or through autoclaving or microwaving or hydroclaving and then sent for recycling.
Black		Food waste, Mineral water bottles,Papers.	

Segregation

The "key for waste management" is waste segregation. Segregation (separation) is the key to minimization and effective waste management. Only a segregation system can ensure that the waste will be treated according to the hazards of the waste and that the correct disposal routes are taken, and the correct transportation equipment will be used.[14-15]

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Segregation is the process of separating different types of waste at the point of generation and keeping them isolated from each other. Recycling and resource recovery techniques applied appropriately will lead minimization of hazardous waste generated, prolonging the operational half-life of facility and conservation of resources. Proper placement and labelling of containers is essential for effectiveness of segregation process.[16]

Segregation of the waste is very important for the following reasons[17]:

1. General waste does not become infectious
2. Segregation reduces chances of infection
3. Treatment cost comes down
4. Non infectious waste can be recycled.
5. Segregation is carried out at the site of waste generation.

Example- wards, operation theatres, ICUs, stores, pharmacy, autopsy room, etc.

The waste is segregated according to different colour coding system of waste containers which is given below[18]:

1. Red bag: Recyclable contaminated waste such as bottles, intravenous tubes, catheters, urine bags, syringes and gloves.
2. Yellow bag: Human and animal anatomical waste, soiled waste including items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs, expired or discarded medicines, chemical waste (liquid), discarded linen, mattresses, beddings contaminated with blood or body fluid, microbiology, biotechnology and other clinical laboratory waste.
3. Black bag: Incineration ash and chemical waste (solid).
4. White bag: Waste sharps including needles, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts.
5. Blue bag: Metallic body

Storage of Biomedical Waste Management

Storage is basically done in the areas and steps between the point of waste generation and location of waste treatment and disposal.[19]

Storage area should be selected carefully which is unapproachable to the general public and must exhibit warning symbols & signs.

It should be stored in a dry and secured area before being transported. The area must be protected from water, wind, rodents, insects and animals. Hazardous biomedical waste should not be stored for more than 3 months.[20]

Any offsite holding of waste is also considered storage.[19]

1. Different types of containers are used for collection of waste.
2. The containers or bins should be positioned in such a way that 100 % gathering is achieved.
3. Sharps must be kept in puncture-proof containers to keep away injuries and infection to the employees handling them.
4. Once collection has done, then biomedical waste is stored in a appropriate place.
5. Segregated wastes of dissimilar categories need to be collected in individual containers or bins.
6. The period of storage should not more than 8-10 hrs in big hospital and 24 hrs in nursing homes.
7. Each container or bin should be clearly labelled to show the ward or room where it is kept.
8. The reason for this labelling is that it may be required to trace the waste back to its source.

Transportation of waste

Transportation of Bio-Medical wastes can be done by Carts and containers that are not used for any other function. The trolleys have to be cleaned each day. Offsite carrying vehicle should be marked with the name and address of transporter. Biohazard sign should be dyed. Appropriate system for securing the weight during transport should be ensured. Such a means of transport should be easily cleanable with rounded corners. All disposable plastic should be subjected to shredding before disposing off to vendor. No unprocessed bio- medical waste store more than 48 hours.

Pre- treatment- It is defined as the process that changes the character of hazardous waste to render them less hazardous or non-hazardous. Treatment of biomedical waste depends upon many factors like

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nature of the waste, volume of waste, technology (technologically and economically variable and environmentally safe) and it must meet regulatory standards.[21] There are several methods that have been successful in the treatment of infectious waste. The following are the methods that will show the treatment that may be available at your facility.

The methods are:

1. Autoclaving
2. Incineration
3. Thermal inactivation
4. Gas/Vapor Sterilization
5. Chemical disinfection

Autoclaving

Autoclaves are used to destroy microorganisms that may be present in medical waste before disposal in a traditional landfill. Autoclaves can be used to process up to 90% of medical waste, and are easily scaled to meet the needs of any medical organization [22].Small counter-top autoclaves are often used for sterilizing reusable medical instruments while large autoclaves are used to treat large volumes of medical waste. Steam sterilization is most effective with low-density material such as plastics, metal pans, bottles, and flasks[23].

High-density polyethylene and polypropylene plastic should not be used in this process because they do not facilitate steam penetration to the waste load. Plastic bags should be placed in a rigid container before steam treatment to prevent spillage and drain clogging. Bags should be opened and caps and stoppers should be loosened immediately before they are place in the steam sterilizer. Care should be taken to separate infectious wastes from other hazardous wastes. Infectious waste that contains non infectious hazards should not be steam-sterilized [24].

Incineration

It is a treatment process used to convert pathological and pharmaceutical waste into ash, flue gases and heat.[25]

This is a high temperature thermal process employing combustion of the waste under controlled condition for converting them into inert material and gases. Incinerators can be oil fired or electrically powered or a combination thereof. Broadly, three types of incinerators are used for hospital waste: multiple hearth type, rotary kiln and controlled air types. All the types can have primary and secondary combustion chambers to ensure optimal combustion.[26]

Thermal inactivation

Thermal inactivation involves the treatment of waste with high temperatures to eliminate infectious agents. This method is usually used for large volumes.[27] Liquid waste is collected in vessel and heated by heat exchangers or a steam jacket surround the vessel.

The types of pathogens in the waste determine the temperature and duration of treatment. After treatment, the contents can be discharged into the sanitary sewer in a manner that complies with State, Federal, and local requirements. This method requires higher temperatures and longer treatment cycles than steam treatment.

Gas/vapor sterilization

Gas/vapor sterilization uses gaseous or vaporized chemicals as the sterilizing agents. Ethylene oxide is the most commonly used agent, but should be used with caution since it is a suspected human carcinogen. Because ethylene oxide may be adsorbed on the surface of treated materials, the potential exists for worker exposure when sterilized materials are handled.

Chemical disinfection

Chemical disinfection is the preferred treatment for liquid infectious wastes. Consider the following: Type of microorganism, Degree of contamination , Amount of proteinaceous material present, Type of disinfectant, Contact time , Other relevant factors such as temperature, pH, mixing requirements, and the biology of the microorganism[27]. Ultimate disposal of chemically treated waste should be in accordance with State and local requirements. 1 % hypochlorite solution can be used for chemical disinfection[28]

Disposal

Disposal of waste depends on its category. Noninfectious waste like papers can be recycled. Biodegradable waste can be used for landfill or vermiculture or can be just buried. Infectious solid waste is incinerated. Infectious liquid waste is disinfected and flushed out in the drains.[29]

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Following steps shall be followed daily for the safe disposal of the liquid Bio-Medical Waste[30]

Step-1 Fill the top upper 5 litre can with 1% sodium hypochlorite's solution.

Step-2 Start collection of the liquid bio-medical waste from the wash basins to in the 50L can kept Beunder it low and keep the outlet valve closed.

Step-3 Drain the 1% hypochlorite's solution from the 5L can and adjust the quantity of the solution added should be such that it the mixture contains >2mg/L of residual chlorine next day morning. The residul chlorine should be measured for residual chlorine using a chloroscope.

Step-4 Open the outlet valve of the 50L can every day in the morning so that entire disinfected liquid is entirely drained into the sewer.

Step-5 Close the outlet valve of the 50L can and start filling the liquid Bio-Medical Waste.

Repeat the process every day Maintain the record of the consumption of the 1% sodium hypochlorite solution daily for the verification by KSPCB pollution control board officers.

Health hazard from biomedical waste

The improper management of bio-medical waste causes serious environmental problems in terms of air, water and land pollution. The nature of pollutants can be classified into biological, chemical and radioactive. Environment problems can arise due to the mere generation of bio-medical waste and from the process of handling, treatment and disposal.[31]Air Pollution can be caused in both indoors and outdoors. Bio-Medical Waste that generates air pollution is of three types - Biological, Chemical and Radioactive. Indoor air pollutants like pathogens present in the waste can enter and remain in the air in an institution for a long period in the form of spores or as pathogens itself. Chemical Pollutants that cause outdoor air pollution have two major sources- open burning and incinerators.[32]Open burning Nof bio-medical waste is the most harmful practice and should be strictly avoided Water Pollution is another major threat from Bio-medical waste. If the waste is dumped in low-lying areas, or into lakes and water bodies, can cause severe water pollution. Water pollution can either be caused due to biological, chemicals or radioactive substances. The pathogens present in the waste can leach out and contaminate the ground water or surface water. Harmful chemicals present in bio-medical waste such as heavy metals can also cause water pollution. Land Pollution is caused by the final disposal of all bio-medical waste. Even liquid effluent after treatment is spread on land. Hence, pollution caused to land is inevitable. Open dumping of bio-medical waste is the greatest cause for land pollution.[33]

RECOMMENDATIONS [34]

1. For the use of incinerator Training should be given to some number of persons from staff.
2. Specific fund should be allocated for the use of incinerator.
3. Every hospital should have special boxes to use as dustbin for bio-medical waste.
4. Bio-medical waste should not be mixed with other waste of Municipal Corporation.
5. Private hospitals should also be allowed to use incinerator, which is installed, in govt. hospital. For this purpose a specific fee can be charged from private hospitals.
6. Special vehicle i.e. bio-medical waste vehicle should be started to collect waste from private hospitals and private medical clinics and carry it up to the main incinerator.
7. As provided by bio-medical waste rules, the whole of the waste should be fragmented into colours due to their hazardous nature.
8. Bio-medical waste Management Board can be established in each District.
9. Either judicial powers should be given to the management board or special court should be established in the matters of environment pollution for imposing fines and awarding damages etc.
10. Housekeeping staff wear protective devices such as gloves, face masks, gowned, while handling the waste.
11. There is biomedical waste label on waste carry bags and waste carry trolley and also poster has put on the wall adjacent to the bins (waste) giving details about the type of waste that has to dispose in the baggage as per biomedical waste management rule. Carry bags also have the biohazard symbol on them.

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LEGISLATION IN RELATION TO BIOMEDICAL WASTE

Various governmental legislation related to BMW in India are following: It might be kept in mind that any individual can complain any suspected negligence in Management and Handling of BMW to the responsible authority.[35]

1	**The water Act, 1974**	prevention and control of pollution
2	**The Air Act, 1981**	prevention and control of pollution
3	**The Environment Act, 1986**	Protection
4	**The hazardous waste rules, 1998**	management and handling
5	**The Biomedical waste rules, 1998**	management and handling
6	**Municipal Solid waste rules, 2000**	management and handling
7	**The Biomedical waste rules Amendment, 2000 and 2003**	management and handling
8	**The Biomedical Waste Rules, 2011**	Management and Handling

Benefit of biomedical Waste Management[36]

1. Cleaner and healthier surroundings.
2. Reduction in the cost of infection control within the hospitals.
3. Reduction in the possibility of disease and death due to reuse and repackaging of infectious disposables.
4. Law incidence of community and occupational health hazards.
5. Reduction in the cost of waste management and generation of revenue through appropriate treatment and disposal of waste.
6. Improved image of the healthcare establishment and increase the quality of life.

Labelling of Biomedical Waste[37] :All bags, containers or bins directly used in the collection of bio-medical wastes should be labelled with appropriate Hazard Symbol. The labelling of the waste at the point of generation is in the form of a tag or adhesive label which is to be attached to the bag or container when it is collected by the cleaning staff. This waste tagging system allows waste audits conducted at treatment/disposal points to identify areas that are in compliance.

Inner bags and inner sharps containers are exempt from the labeling requirements of subsectionOuter containers shall be labeled with the transporter's name, address, registration number, and 24-hour telephone number prior to transport.

The transporter may provide labels for bags or sharps containers that are generator-specific, such as bar codes or specific container numbers.

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SCHEDULE IV

[See rule 8(3) and (5)]

Part A

LABEL FOR BIO-MEDICAL WASTE CONTAINERS or BAGS

Part B

LABEL FOR TRANSPORTING BIO-MEDICAL WASTE BAGS OR CONTAINERS

Day .....Month .....Year .....

Date of generation .....

Waste category Number .....

Waste quantity…….....

Sender's Name and Address
Number.....
....
Fax Number .....
Contact Person .....

Receiver's Name and Address: Phone
Phone Number ..... Telex Number.....
Telex Number.....
Fax Number.....
Contact Person .....

In case of emergency please contact:

Name and Address:

Phone No.

Note :Label shall be non-washable and prominently visible.

Conclusion

Waste generation should be minimized for the protection of environment and general public health. People must be sensitized to the issues related to biomedical waste and should participate in the programs organized for waste minimization. The medical employees must be trained to create awareness and foster responsibilities for prevention of exposure and unsafe disposal to the waste. Medical personnel should strictly follow all the rules.

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