MAVEN eISSN: 2581-4443 | www.idahow.org

REVIEW ARTICLE

A Review on Management of Biomedical Waste - Today's Necessity

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Abstract

Biomedical waste is any kind of waste either solid or liquid containing harmful materials generated by healthcare facilities. Management of these biomedical wastes involves activities such as segregation, collection, storage, transportation, treatment and its disposal. It requires commitment at all levels from healthcare employees to sanitation workers because improper management of biomedical waste causes direct health hazard to the society, the health care workers and the environment. Biomedical waste disposal rules need to be taught among qualified health personnel, hospital administrators of private and governmental institutes, other auxiliaries of hospitals and colleges and various health workers of the society.

Health care policy makers need to increase the level of training and education of personnel working in health care units regarding effective waste management. An attempt has been made through this article to create awareness among the personnel involved in health care services, so that they strictly abide by the biomedical waste management rules and regulations specified by concerned governing bodies. (2020, Vol. 04; Issue 01: Page 13 - 22)

Keywords: Waste Management; Biomedical Waste; Healthcare Services; Infectious; Hazardous.

Introduction

Health and disease are the two facets of human life. In order to maintain a healthy life every individual attempts to fight disease through medical care. Hence medical care is vital for our life and health, but the waste generated from these healthcare activities represents a real problem of living nature and human world (1). Waste product which is infectious, hazardous, and sometimes radioactive and is generated during the various medical related activities such as diagnosis, treatment and immunization is known as biomedical waste (2). Inadequate management of these wastes may be associated with risks to healthcare employees, patients, communities and their environment (3). Every day, relatively large amount of waste is generated in the health care hospitals and facilities around the world which need proper biomedical waste management (4). The activities that are usually performed as part of health care waste management involve segregation, collection, storage, transportation, treatment and disposal of biomedical waste (5) has been vividly discussed through this present article.

Types of waste

According to Biomedical Waste Management and Handling Rules, 1998 of India, "Biomedical Waste", also known as, the infectious waste is defined as "any waste, which is generated during the

diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in the health camps" (4, 6). World Health Organization (WHO) states that 85% of hospital wastes are actually non- hazardous, whereas 10% are infectious and 5% are non-infectious but they are included in hazardous wastes. About 15% to 35% of hospital waste is regulated as infectious waste. This range is dependent on the total amount of waste generated (Fig 1) (2-4, 7).

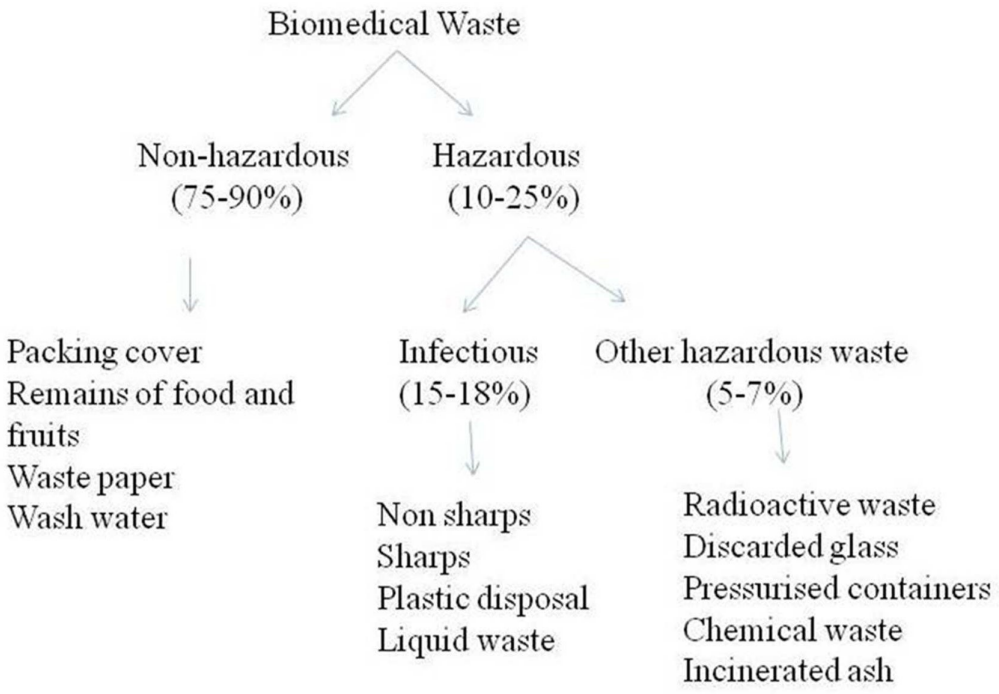

Fig 1: Types of biomedical waste

Classification of biomedical waste

The World Health Organization (WHO) has classified medical waste into 8 categories: (1-3, 5, 8, 9)

1. General Waste
2. Pathological
3. Radioactive
4. Chemical
5. Infectious to potentially infectious waste
6. Sharps
7. Pharmaceuticals
8. Pressurized containers

While according to Ministry of Environment and Forest, Government of India (1998), Biomedical Waste Management & Handling Rules - 1998, describes 10 categories, as enlisted in table 1.

Sources of biomedical waste Hospital waste not only poses risk for patients and personnel who handle them but it is also a threat to public health and environment (1, 10). The sources of biomedical waste are categorized as major and minor sources according to the quantities produced, as depicted in table 2 (4, 9).

Need of biomedical waste management

The management of hospital waste is a necessity due to following reasons:

1. Patients acquiring noscomial infections due to poor infection control practices and improper waste management (4, 11, 12).
2. Injuries from sharps leading to infection to all categories of hospital providers and waste handlers (4, 12).
3. Risk of infection outside hospital for waste handlers and scavengers as well as general public living in the vicinity of the hospitals (4, 10, 12).
4. Risk associated with hazardous chemicals and drugs to persons handling wastes at all levels (12).
5. Risk of recycling of "Disposables" which are being repacked and sold by unscrupulous elements (4, 12, 13).
6. Risk of spurious drugs due to repacking of disposed off drugs to unsuspecting buyers (12).
7. Risk of environmental pollution, unpleasant smell, growth and multiplication of vectors like insects, rodents and worms which may lead to the transmission of diseases like typhoid, cholera, hepatitis and AIDS through injuries from syringes and needles contaminated with human (4, 12, 14, 15). Thus, the vital problems in India associated with healthcare waste can be attributed to the absence of proper waste management, lack of awareness about the health hazards from biomedical wastes, insufficient financial and human resources, and poor control of waste disposal (4, 16, 17).

Table 1

Category	Waste Content	Components	Method of treatment and disposal
No. 1	Human Anatomical Waste	Human tissues, organs, body parts	Incineration / deep burial
No. 2	Animal Waste	All types of animal tissues, organs, body parts carcasses, bleeding parts etc generated by different health sectors	Incineration / deep burial
No. 3	Microbiology and Biotechnology Waste	Wastes from laboratory cultures, stocks or specimens of micro-organisms used in research	Local autoclaving / micro waving / incineration
No. 4	Waste sharps	Needles, syringes, scalpels, blades, glass etc that may cause puncture and unused sharps	Disinfections (chemical treatment / autoclaving / microwaving and mutilation / shredding
No. 5	Discarded Medicines and Cytotoxic drugs	Out-dated, contaminated and discarded medicines	Incineration / Destruction and disposal of drugs in secured landfills
No. 6	Solid Waste	Items contaminated by blood and body fluids including cotton, dressings, soiled plaster casts, lines, bedding, etc	Incineration , autoclaving / micro waving

No. 7	Solid Waste (Recyclable)	Waste generated from disposable items other than waste sharps such as tubings, catheters, intravenous sets etc	Disinfections by chemical treatment, autoclaving / microwaving and mutilation / shredding
No. 8	Liquid Waste	Waste generated from laboratory and washing, cleaning, house- keeping and disinfecting activities	Disinfections by chemical treatment and discharge into drains
No. 9	Incineration Ash	Ash from incineration of any bio-medical waste	Disposal in municipal landfill
No. 10	Chemical Waste	Chemicals used in production of biological, chemicals used in disinfection, as insecticides, etc	Chemical treatment and discharges into drains for liquids and secured landfill for solids

Table 2

Major Sources	**Minor Sources**
Primary health centres	Physicians / dentists' clinics
Medical colleges and research centres / paramedic services	Vaccination centres
Blood banks / mortuaries / autopsy centres	Blood donation camps
Government hospitals / private hospitals / nursing homes / dispensaries	Animal / slaughter houses
Veterinary colleges and animal research centres	Acupuncturists / psychiatric clinics / cosmetic piercing
Biotechnology institutions	Institutions for disabled persons
Production Units	Funeral services

Management of biomedical wastes

Steps in the management of biomedical waste include:

1. Waste Generation
2. Waste Segregation
3. Waste Collection
4. Waste Storage
5. Waste Transportation
6. Waste Treatment and Disposal

1. Waste Generation

Different types of waste and its generation site are shown in Table 3.

Table 3

Type	Site of Generation	Disposal By
Non--Hazardous waste / General waste	Office, Kitchen, Administration, Hostels, Stores, Rest rooms etc.	Municipal/Public Authority
Hazardous (Infectious & toxic waste)	Dental and Medical hospitals, Clinics, Laboratories, CT scan, Radio- imaging, etc.	Hospitals, Clinics, Laboratories, Radiology centres itself

2. Waste Segregation

According to Biomedical Waste Management Rules, 2016, bio-medical waste has been classified to improve the segregation of waste at sources (6), as enlisted in table 4.

Table 4

Category	Type of Waste	Type of Bag or Container to be used	Treatment and Disposal options
(1)	(2)	(3)	(4)
Yellow	(a) Human Anatomical Waste: Human tissues, organs, body parts and fetus below the viability period (as per the Medical Termination of Pregnancy Act 1971, amended from time to time).	Yellow coloured non- chlorinated plastic bags	Incineration or Plasma Pyrolysis or deep burial
	(b) Animal Anatomical Waste: Experimental animal carcasses, body parts, organs, tissues, including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses.		
	(c) Soiled Waste: Items contaminated by blood, body fluids like dressings, plaster casts, cotton swabs and bags containing residual or discarded blood and blood components		Incineration or Plasma Pyrolysis or deep burial* In the absence of above facilities, autoclaving or microwaving / hydroclaving followed by shredding or mutiliaton or combination of sterilization and shredding. Treated waste to be sent for energy recovery.
	(d) Expired or Discarded Medicines:	Yellow coloured non- chlorinated	Expired cytotoxic drugs and items contaminated with cytotoxic drugs to be

Yellow	Pharmaceutical waste like anitibiotics, cytotoxic drugs including all items contaminated with cytotoxic drugs along with glass or plastic ampoules, vials etc.	plastic bags or containers	returned back to the manufacturer or supplier for incineration at temperature >1200^{0}c or to common biomedical waste treatment facility or hazardous waste treatment, storage and disposal facility for incineration at >1200^{0}c or Encapsulation or Plasma Pyrolysis at >1200^{0}c. All other discarded medicines shall be either sent back to the manufacturer or disposed by incineration.
	(e) Chemical Waste: Chemicals used in production of biological and used or discarded disinfectants.	Yellow coloured containers or non- chlorinated plastic bags	Disposed of by incineration or Plasma Pyrolysis or Encapsulation in hazardous waste treatment storage and disposal facility.
	(f) Chemical Liquid Waste: Liquid waste generated due to use of chemicals in production of biological and used or discarded disinfectants, Silver X-ray film developing liquid, discarded Formalin, infected secretions, aspirated body fluids, liquid from laboratories and floor washings, cleaning, house-keeping and disinfecting activities etc.	Separate collection systems leadingto effluent treatment system.	After resource recovery the chemical liquid waste shall be pre-treated before mixing with other waste water.
	(g) Discarded linen mattresses: Beddings contaminated with blood or body fluid.	Non- chlorinated yellow plastic bags or suitable packing material.	Non-chlorinated chemical disinfectants followed by incineration or Plasma Pyrolysis or for energy recovery. In absence of above facilities shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery or incineration or Plasma Pyrolysis.
	(h) Microbiology, Biotechnology and other clinical laboratory waste: Blood bags, Laboratory cultures, stocks or	Autoclave safe plastic bags or containers	Pre-treat to sterilize with non chlorinated chemicals on-site as per National AIDS Control Organisation or World Health

	specimens of microorganisms live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures.		Organisation guidelines thereafter for incineration.
Red	Contaminated Waste (Recyclable): (a) Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catherers, urine bags, syringes (without needles and fixed needle syringes) and vaccutainers with their needles cut and gloves	Red coloured non- chlorinated plastic bags or containers	Autoclaving or microwaving / hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making whichever is possible. Plastic waste should not be sent to landfill sites.
White (Translucent)	Waste sharps including Metals: Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps.	Puncture proof, Leak proof, tamper proof containers	Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal container or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Boards or Pollution Control Committes) or sanitary landfill or designated concrete waste sharp pit.
Blue	(a) Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic waste.	Cardboard boxes with blue coloured marking	Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through autoclaving or microwaving or hydroclaving and then sent for recycling.
	(b) Metallic Body Implants		

[*Disposal by deep burial is permitted only in rural or remote areas where there is no access to common bio-medical waste treatment facility. This will be carried out with prior approval from the prescribed authority.]

According to Central Pollution Control Board Guidelines 2020, used PPEs such

as goggles, face-shield, splash proof apron, plastic coverall, hazmat suit, nitrile gloves should be collected in Red bags whereas used masks (including triple layer mask, N95 mask, etc.), head cover/cap, shoe-cover, disposable linen gown, non-plastic or semi-plastic coverall should be collected in Yellow bags (18).

3. Waste Collection

i. Segregated wastes of dissimilar categories need to be collected in individual containers or bins.

ii. The containers or bins should be positioned in such a way that 100 % gathering is achieved.

iii. The period of storage should not more than 8-10 hrs in big hospital and 24 hrs in nursing homes (5).

iv. Each container or bin should be clearly labelled to show the ward or room where it is kept. The reason for this labelling is that, it may be required to trace the waste back to its source.

4. Waste Storage

i. Healthcare facilities must provide a storage area for medical waste until it is collected for treatment and disposal.

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

iii. It should be stored in a dry and secured area before being transported.

iv. The area must be protected from water, wind, rodents, insects and animals.

v. Hazardous biomedical waste should not be stored for more than 3 months (19, 20).

5. Waste Transportation

Transportation of Bio-Medical wastes can be done by carts and containers that are not used for any other function. 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. These means of transport should be easily cleanable with rounded corners because they need to be cleaned each day. All disposable plastic should be subjected to shredding before disposing off to vendor. No unprocessed bio-medical waste stored more than 48 hours (5, 21, 22).

6. Waste Treatment and Disposal

There are several treatment options which maximize safety during handling and disposal of the waste. It also minimizes environmental hazards. Incineration, Autoclaving, Chemical treatments, Irradiation, Inertization, Encapsulation and Land Disposal are the most common methods used for treatment and decontamination of biomedical waste (20).

i. Incineration

It is a treatment process used to convert pathological and pharmaceutical waste into ash, flue gases and heat. The waste which is going to be incinerated should not be chemically treated with any chlorinated disinfectants. Operating temperature for incineration should be in the range of 800-14000c. It decreases the mass of waste by 90-95% and thus reduces adverse effects on the environment (20). Low sulphur fuel like Diesel shall be used as fuel in the incinerator.

ii. Autoclaving

It is a process of steam sterilization and is the most common alternative to incineration. It operates on the principle of a pressure cooker. Autoclaving requires a temperature of 1210c and pressure of about 15 pounds per square inch (psi) for 20-30 minutes. This treatment is applied to inactivate the infectious agents and to sterilize the equipment used in medical services. It is less costly and carries no documented health impacts (20).

iii. Chemical treatments

This treatment is often used to decontaminate liquid waste, so that it can be disposed off locally. It makes use of several techniques such as oxidation, reduction, precipitation and pH neutralization to convert waste into less hazardous substances. Chemical disinfectants used are chlorine dioxide, sodium hypochlorite, formaldehyde, glutaraldehyde, ethylene oxide, according to the nature of waste (20). As per Biomedical Waste Management (amendment) Rules, 2018, 1% to 2% sodium hypochlorite should be used. There is no need of chemical pre- treatment before incineration, except for microbiological, lab and highly infectious waste (12).

iv. Irradiation

These systems are presently being used in waste treatment operations which include gamma, electron-beam, ultraviolet and X- rays. Irradiation sterilizes waste in an enclosed chamber by exposing it to a radioactive cobalt-60 which gives out gamma rays that are lethal to micro- organisms. It is very expensive as compared to other methods and precautions must be taken to protect workers from harmful effects of radiations such as cancer, radiation sickness or even death (20).

v. Inertization

It is the process of mixing waste with cement and other substances before disposal in order to minimize the risk of toxic substance migrating into surface water or ground water and to prevent scavenging. Proportion of 65% waste 15% lime 15% cement and 5% water is used.

vi. Encapsulation

Encapsulation involves filling containers made of high density polyethylene or metal drums, with waste. These containers are then filled up with a medium of immobilizing material such as plastic, foam, cement mortar or clay. After the medium has dried, the containers are sealed and disposed off in landfill sites. Simple, low-cost and safe method but not recommended for non-sharp infectious waste (20).

Land Disposal

Land disposal is typically used for remediation of waste which is decontaminated by above applicable treatment methods. Land-filling should be done at locations where groundwater level is low and which are far from flooding sources. Radioactive wastes are generally dumped in the oceans far away from human habitations. Every state and local government has its own rules and regulations for disposal of disinfected waste (20).

Conclusion

Management of the bio medical waste is becoming a challenging issue which has become a worldwide humanitarian topic today. All healthcare personnel and auxiliaries must be scientifically updated and trained to create awareness and foster responsibilities for prevention of exposure and unsafe disposal of the waste. Public too must be sensitized to the issues related to biomedical wastes and should participate in the programs organized for waste minimization. This would ensure protection of the public, the health employees involved and create a safe and healthy environment. As various developments are changing the face of health care science today, a holistic approach to manage healthcare waste is the need of the hour.

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