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Biomedical Waste: An Introduction to its Management

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Abstract— Biomedical Waste, (BMW), are those potential hazardous waste materials, consisting of solids, liquids, sharps, and laboratory waste which pose a grave danger to the health of humans as well as other living organisms. And in some cases, it may be lethal too. It is of extreme importance that this waste must be properly managed and disposed off safely so as to prevent outbreak of infections to general public and disturb the health care settings in a society. About 57% of the total waste generated in Maharashtra is biomedical waste. It is essential to understand what biomedical waste is, classify them and to manage them accordingly. In this paper, a concise effort is undertaken so as depict biomedical waste substances generated, their origins and the methods to deal with them effectively.

Keywords— Hazardous, infection, biomedical, management, health;

I. INTRODUCTION

Biomedical Waste, (BMW) or bio wastes are those potential hazardous waste materials, consisting of solids, liquids, sharps, and laboratory waste. Biomedical waste differs from other types of hazardous waste, such as industrial waste, in that it comes from biological sources or is used in the diagnosis, prevention, or treatment of diseases. One of the major sources of biomedical wastes is hospitals and nursing homes. Hospital is one of the complex institutions which are frequented by people from every walk of life in the society without any distinction between age, sex, race and religion. All of them produce waste which is increasing in its amount and type due to advances in scientific knowledge and is creating its impact. The hospital waste, in addition to the risk for patients and personnel who handle these wastes poses a threat to public health and environment.

According to the Ministry of Environment and Forests (MoEF) gross generation of BMW in India is 4,05,702 kg/day of which only 2,91,983 kg/day is disposed, which means that almost 28% of the wastes is left untreated and not disposed finding its way in dumps or water bodies and re-enters our system. The indiscriminate dumping of biomedical wastes by hospitals and nursing homes was a source of pollution that caused dangers to the health and environment. In order to overcome this crisis, the Bio Medical Waste (Handling and Management) Rules, were notified in July 1998. The rules seek to introduce biomedical waste disposal practices in India. The emphasis is on ensuring a process change that will enable health care facilities to handle their waste through proper training and capacity building.

These Rules are applicable to all persons who generate, collect, receive, store, transport, treat, dispose or handle biomedical wastes. This includes hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories and blood banks.

Although the Bio-Medical Waste (Management and Handling) Rules have already been introduced a few years back, not much attention has been paid to bio-medical waste management so far. Even if something is done, it is most of the times not properly done.

The hospitals and the private nursing homes have raised a hue and cry against the cost of treatment and disposal of bio-medical waste. It has been reported that the private agencies have quoted a disposal charge @ Rs. 20/bed/day, which does not seem to be unreasonable.

II. CLASSIFICATION

Approximately 75-90% of the biomedical waste is non-hazardous and as harmless as any other Municipal waste[1]. The rest 10-25%, though mixed with non-hazardous waste, can be injurious to humans or animals and deleterious to environment. Biomedical wastes can be categorized based on their origin and physical, chemical or biological characteristics.

- General waste: Largely composed of domestic or household type waste. It is non-hazardous to human beings, e.g. kitchen waste, packaging material, paper, wrappers, and plastics.
- Pathological waste: Human body parts, tissues and organs.
- Infectious waste: The wastes which contain pathogens in sufficient concentration or quantity that could cause diseases. It includes cultures and stocks of infectious agents from laboratories, waste from surgery, waste originating from infectious patients.
- Sharps: Physically hazardous biomedical waste like needles, broken glass, saws, nail, blades, and scalpels.
- Pharmaceutical waste: Drugs and pharmaceutical products that are contaminated outdated or have been spilled.
- Chemical waste: chemicals disposed in cleaning, housekeeping, and disinfecting.
- Radioactive waste: It includes solid, liquid, and gaseous waste that is contaminated with radionuclides generated from in-vitro analysis of body tissues and fluid, in-vivo body organ imaging and tumour localization and therapeutic procedures.

III. SOURCES

The main sources of biomedical waste are hospitals, medical clinics, laboratories and pharmaceutical factories. Other sources include:

- Blood donation camps
- Slaughter houses
- Cosmetic services
- Vaccination centres
- Funeral services.

IV. MANAGEMENT OF BIOMEDICAL WASTE

Due to the grave potential threats biomedical waste pose, managing and regulating its collection, storage, transportation, treatment and disposal method is essential. Safe disposal of biomedical waste is also a legal requirement in India. The objectives of BMW management are:

- To prevent transmission and spreading of pathogens and diseases
- To prevent injury to people in health care services and workers who handle BMW
- To prevent general exposure to the harmful effects of the cytotoxic, genotoxic and chemical biomedical waste
- To prevent environmental degradation.

A. Handling Equipment

Protective gear must be used by the handling personnel to prevent any direct contact with the BMW.

1) Gloves: Heavy-duty rubber gloves should be used for waste handling by the waste retrievers. This should be bright yellow in colour. After handling the waste, the gloves should be washed twice. The gloves should be washed after every use with carbolic soap and a disinfectant. The size should fit the operator.

2) Aprons, gowns, suits or other apparels: Apparel is worn to prevent contamination of clothing and protect skin. It could be made of cloth or impermeable material such as plastic. People working in incinerator chambers should have gowns or suits made of non-inflammable material.

3) Masks: Various types of masks, goggles, and face shields are worn alone or in combination, to provide a protective barrier. It is mandatory for personnel working in the incinerator chamber to wear a mask covering both nose and mouth, preferably a gas mask with filters.

4) Boots: Leg coverings, boots or shoe-covers provide greater protection to the skin when splashes or large quantities of infected waste have to be handled. The boots should be rubber-soled and anti-skid type. They should cover the leg up to the ankle [2].

Fig 1 Personal handling equipment

B. Storage and Containment

The key to minimization and effective management of biomedical waste is segregation and identification of the waste. BMW must be segregated from other types of waste at the point where it is created. It must be kept from direct contact with humans, animals, insects, and environmental elements, such as rain and wind. Limited access should be granted and to people who are trained and authorized to handle this waste.

- Sharps must be contained in leak-proof, rigid, puncture-resistant, break-resistant containers which are labelled and tightly lidded during storage, handling, and transport.
- For biomedical waste, excluding sharps, dispose of the waste in leak-proof plastic bags strong enough to prevent ripping, tearing, breaking, or bursting under normal conditions of use. Rigid plastic, single-use, or approved multiple-use marked containers may also be used. Biomedical waste that is held in plastic bags should

additionally be placed in another leak-proof container such as disposable or reusable pails, drums, or bins during storage or transport.

- Secure bags or containers to prevent leakage or expulsion during storage.
- The container holding the biomedical waste should be conspicuously labelled with the international biohazard symbol and the words "Biomedical Waste" (or words that clearly denote biomedical waste).

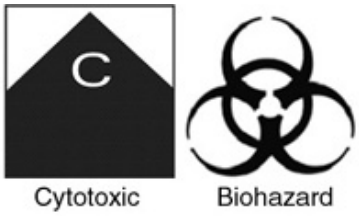

Fig 2 standard symbols

- Biomedical waste contained in disposable containers as prescribed above, shall be placed for storage, handling, or transport in disposable or reusable pails, cartons, boxes, drums, dumpsters, or portable bins. The containment system shall have a tight fitting cover and be kept clean and in good repair.
- These containers shall not be used for other purposes even after the biohazard symbol is removed.

C. Transportation of BMW

The waste should be transported for treatment either in trolleys or in covered wheelbarrow. Manual loading should be avoided as far as far as possible. The Container containing BMWs should be lidded before transportation. Before transporting the bag containing BMWs, it should be accompanied with a signed document by Nurse/ Doctor mentioning date, shift, quantity and destination.

Special vehicles must be used so as to prevent direct contact with the waste by the transportation operators, the scavengers and the public. The transport containers should be properly enclosed. The effects of traffic accidents should be considered in the design, and the driver must be trained in the procedures he must follow in case of an accidental spillage. It should also be possible to wash the interior of the containers thoroughly.

Fig 3 Biomedical Waste Transport Vehicle

D. Handling devices

1) Trolleys: The use of trolleys will facilitate the removal of infectious waste at the source itself, instead of adding a new category of waste.

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. Care should be taken not to directly dump waste into it. Only packed waste (in plastic bags) should be carried. Care should also be taken not to allow liquid waste from spilling into the wheelbarrow, as it will corrode. These are ideal for transferring debris within the institution. Wheelbarrows also come in various sizes depending on the utility.

3) Chutes: Chutes are vertical conduits provided for easy transportation of refuse vertically in case of institutions with more than two floors. Chutes should be fabricated from stainless steel. It should have a self-closing lid. These chutes should be fumigated everyday with formaldehyde vapours. The contaminated linen (contaminated with blood and or other body fluids) from each floor should be bundled in soiled linen or in plastic bags before ejecting into the chute. Alternately, elevators with mechanical winches or electrical winches can be provided to bring down waste containers from each floor. Chutes are necessary to avoid horizontal transport of waste thereby minimizing the routing of the waste within the premises and hence reducing the risk of secondary contamination.

E. Treatment

1) Chemical processes:

These processes use chemical that act as disinfectants. Sodium hypochlorite, dissolved chlorine dioxide, per acetic acid, hydrogen peroxide, dry inorganic chemical and ozone are examples of such chemical. Most chemical processes are water-intensive and require neutralizing agents.

2) Thermal processes:

These processes utilize heat to disinfect. Depending on the temperature they operate it is been grouped into two categories, which are Low-heat systems and High-heat systems.
Low-heat systems (operates between 93-177°C) use steam, hot water, or electromagnetic radiation to heat and decontaminate the waste. Examples are:

- Autoclaving is a low heat thermal process and it uses steam for disinfection of waste. Autoclaves are of two types depending on the method they use for removal of air pockets are gravity flow autoclave and vacuum autoclave.
- Microwaving is a process which disinfects the waste by moist heat and steam generated by microwave energy.

High-heat systems (operates between 540-8,300°C) employ combustion and high temperature plasma to decontaminate and destroy the waste. Examples are:

- Hydroclaving - steam treatment with fragmentation and drying of waste.
- Incineration is a burn technology. It is a controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed/denatured under high temperature.

Fig 4 Incinerator for contraband drugs

Fig 5 Autoclave

3) Mechanical processes:

These processes are used to change the physical form or characteristics of the waste either to facilitate waste handling or to process the waste in conjunction with other treatment steps. The two primary mechanical processes are
Compaction - used to reduce the volume of the waste
Shredding - used to destroy plastic and paper waste to prevent their reuse. Only the disinfected waste can be used in a shredder.

4) Irradiation processes:

These processes expose wastes to ultraviolet or ionizing radiation in an enclosed chamber. These systems require post shredding to render the waste unrecognizable.

5) Biological processes:

These processes use biological enzymes for treating medical waste. It is claimed that biological reactions will not only decontaminate the waste but also cause the destruction of all the organic constituents so that only plastics, glass, and other inert will remain in the residues.

V. BIOMEDICAL WASTE MANAGEMENT RULES

The Ministry of Environment and Forest established the Biomedical Waste Management & Handling Rules in 1998 under the Environment Protection Act [3]. In accordance with these rules, it is the duty of every "occupier" i.e. a person who has the control over the institution or its premises, to take all steps to ensure that waste generated is handled without any adverse effect to human health and environment. It consists of six schedules. The BMW rules classify it into 10 categories.

Schedule I
Categories of Biomedical Waste

Option	Waste Category	Treatment & Disposal
Category No. 1	**Human Anatomical Waste**	Incineration/deep burial
Category No. 2	**Animal Waste**	Incineration/deep burial
Category No 3	**Microbiology & Biotechnology Waste**	local autoclaving / micro-waving / incineration
Category No 4	**Waste sharps**	disinfection (chemical treatment/autoclaving/micro- waving and mutilation/ shredding
Category No 5	**Discarded Medicines and Cytotoxic drugs**	Incineration /destruct ion and drugs disposal in secured landfills

Category No 6	**Solid Waste**	Incineration autoclaving / micro-waving
Category No. 7	**Solid Waste**	disinfection by chemical treatment autoclaving/micro-waving and mutilation/shredding
Category No. 8	**Liquid Waste**	Disinfection by chemical treatment and discharge into drains.
Category No. 9	**Incineration Ash**	disposal in municipal landfill
Category No. 10	**Chemical Waste**	chemical treatment and discharge into drains for liquids and secured landfill for solids

Depending on the category, different types of BMW are stored in different coloured containers. Schedule II gives standard colour codes for different categories [4].

Schedule II
Colour Coding and Type of Disposal for BMW

Colour Coding	Type of Container -I	Waste Category	Treatment options as per Schedule I
Yellow	Plastic bag	Cat. 1, Cat. 2, and Cat. 3, Cat. 6.	Incineration/deep burial
Red	Disinfected container/plastic bag	Cat. 3, Cat. 6, Cat.7.	Autoclaving/Microwaving/ Chemical Treatment
Blue/White translucent	Plastic bag/puncture proof Container	Cat. 4, Cat. 7.	Autoclaving/Microwaving/ Chemical Treatment and destruction/shredding
Black	Plastic bag	Cat. 5 and Cat. 9 and Cat. 10. (solid)	Disposal in secured landfill

Fig 6 Coloured Plastic Bags for Biomedical Waste

VI. BENEFITS OF BIOMEDICAL WASTE MANAGEMENT

BMW management plays a vital role in preventing any outbreak of infectious diseases and protecting the society from transmission of these diseases. Here are few benefits that biomedical waste management programs provide [5].

- Reduction in the cost of medical expenses due to reduced cases of infections
- Hygienic and healthy environment in medical centres
- Low incidence of community and occupational health hazards
- Low impact on ecological system
- Potential epidemics are prevented
- Low incidence of community and occupational health hazards
- Improved public health and cleaner environment
- Improved image of the healthcare establishment and increased quality of life.

VII. CONCLUSIONS

Biomedical waste should be safely and efficiently identified, segregated, stored, transported and disposed after appropriate treatment. Its effective implementation in our community is of prime importance to protect public health and environment. With a growing population, biomedical waste is also growing in quantity in our country. Management of this waste is a rising concern in India. Segregation of BMW at its origin is the key to the efficiency of waste management. Following regulations and scientifically managing BMW is in the best interest of the public as well as the environment.

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