Review Article

Biomedical Waste Management in India

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Abstract

Biomedical waste (BMW) is any waste produced during the diagnosis, treatment of human research activities pertaining to or in the production or testing of biological or in health camps. The basic principle of good BMW practice is based on the concept of 3Rs, likely, 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. Biomedical waste management is of utmost importance and mandatory for each and every individual to stay fit and healthy. The new rules are given to improvise the transportation, disposal techniques and segregation and it further helps in decreasing the environmental pollution. With the help of proper team work and support from the government, health care workers will be able to follow proper bio medical waste guidelines for its disposal. Thus, this review article focusses on the various types of waste with its methods of disposal and recent rules regarding bio medical waste handling.

Keywords Biomedical, waste, disposal, incineration, management

Introduction

According to Bio-Medical Waste (Management and Handling) Rules, 1998 of India, "Bio-medical waste means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals, or in research activities pertaining to that or in the production or testing of biological of all categories [1].

Hospital Waste refers to all wastes emanating from hospitals and other similar medical care facilities, whether solid, liquid, gaseous or mixed, which are discharged and not intended for further use [2].

WHO Classification of health care waste [1]

1. **Infectious waste** are the wastes that comprises of pathogens, e.g. laboratory cultures, waste from isolation wards, swabs, materials and equipment's that have been in contact with infected patients, etc.
2. **Pathological waste-** human tissues or fluids e.g. body parts, blood, fetuses, etc.
3. **Sharps-** sharp waste like needles, infusion sets, scalpels, knives, blades, broken glass, etc.
4. **Pharmaceutical waste-** like expired or no longer needed pharmaceuticals, pharmaceutical bottles and boxes.
5. **Genotoxic waste-** like waste containing cytostatic drugs often used in cancer therapy, genotoxic chemicals.
6. **Chemical waste-** like laboratory reagents, film developer, expired disinfectants, solvents, etc
7. **Waste with high content of heavy metals-** batteries, broken thermometers, blood pressure gauges, etc.
8. **Pressurized containers-** gas cylinders, gas cartridges, aerosol cans.
9. **Radioactive waste-** contaminated glassware, absorbent paper, urine and excreta from patients treated or tested with unsealed radio nuclides, sealed sources.

Simplified classification of Hospital waste

1. Non-hazardous waste
2. Sharps
3. Surgical and infectious waste
4. Chemicals, radioactive and pharmaceutical wastes
5. Other hazardous hospital/medical waste

Categories of bio-medical waste[2]

1. **Human anatomical waste, blood and body fluids:** wastes consisting of human tissues, organs, body parts, body fluids, blood and blood products and items saturated or dripping with blood, body fluids removed during/after

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treatment, surgery or autopsy or medical procedures.

2. **Animal wastes:** wastes consisting items contaminated with blood and fluids, wastes from surgery treatment and autopsy, wastes consisting of animal tissues, organs, body parts, bleeding, fluids blood and blood products, and wastes of experimental animals used in research.
3. **Microbiology:** wastes from laboratory cultures, human and animal cell culture used in research and infectious agents from research and industrial laboratories, stocks or specimens of microorganisms, live or attenuated vaccines, wastes from production of biological dishes and devices used to transfer of cultures.
4. **Waste sharps:** wastes consisting of sharps such as needles, syringes, scalpels, blades and glass, that are capable of causing puncture and cuts. This includes both used and unused sharps.
5. **Highly infectious wastes:** waste consisting highly infectious living and non-living pathogens. Exposure to which could cause diseases.
6. **Isolated waste:** biological waste from discarded materials contaminated with blood, excretion, secretions from human and animals isolated due to communicable diseases.
7. **Discarded medicines:** waste comprising outdated, contaminated and discarded medicines.
8. **Discarded glassware:** waste generated from glassware and used equipments.
9. **Soiled wastes:** waste generated from soiled cotton, dressing, linens and beddings, including packaging material.
10. **Disposables:** waste generated from disposable items other than the waste sharps.
11. **Liquid wastes:** waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities.
12. **Biotechnology waste:** waste generated from activities involving genetically engineered organisms or products and their cultures not declared to be safe.
13. **Slaughter house waste:** waste generated in the form of animal tissues, blood and body fluids
14. **Incineration waste:** ash from incineration of any bio medical wastes.

Sources of health care waste

Government and Private hospitals, Nursing homes, Physician's clinics, Dental clinics, Dispensaries, Primary health care centers, Medical research and training establishments, Mortuaries, Blood banks and collection centers, Animal and Slaughter houses, Laboratories, Research organizations, Vaccination centers and Biotechnology institutions.

Health care waste generation

Several surveys have provided an indication of typical health care waste generation and it shows that this differs not only from country to country but also within the country. There are many factors on which waste generation depends like methods of waste management, type of health care establishment, hospital specializations etc.

In middle- and low-income countries health care waste generated is lower than that in high income countries. Developing countries that have not performed their own surveys of health care waste, find the following estimates of an average distribution of health care waste useful for planning of waste management:

- 80% general health care waste that can be dealt with by the normal domestic and urban waste management system
- 15% pathological waste
- 3% chemical and pharmacological waste
- 1% sharps waste
- Less than 1% special waste like radioactive waste or cytotoxic waste, etc.

The average composition of waste obtained from 10 large hospitals in Mumbai, Kolkata, Delhi and Nagpur during the period 1993-1996 was: (National Environmental Engineering Research Institute 1997)[3]

- Paper- 15% by wt
- Plastics- 10% by wt
- Rags- 15% by wt
- Metals and sharps- 1% by wt
- Infectious waste- 1.5% by wt
- Glass- 4% by wt
- General waste (food, sweeping, etc.)- 53.5%

Health hazards of health care waste

There can be severe health hazards due to exposure to health care waste because the waste has the following:

a. It contains infectious agents
b. It contains toxic chemicals or pharmaceuticals
c. It contains sharps
d. It can be genotoxic
e. It can be radio active

Such individuals are highly at risk which includes those who handle such waste and who generate it.

Main groups at risk are

a. Medical doctors, nurses, health care auxiliaries and hospital maintenance personnel
b. Patient in health care establishments
c. Visitors to health care establishment

d. Workers in support service allied to health care establishments such as laundries, waste handling and transportation
e. Workers in waste disposal facilities such as land pits or incinerators including scavengers.

Treatment of Disposal Technologies for Health care waste [1- 3]

1. Incineration

This has been the method of choice for most hazardous health care wastes, and is still widely used. It is a process where oxidation takes place at a high temperature. In addition, there is reduction of organic, combustible waste into inorganic noncombustible waste. Thus, there is a huge reduction in the volume and weight of the waste. The process is usually selected to treat wastes that cannot be recycled, reused or disposed of in a land fill site.

Incineration requires no pretreatment provided that certain wastes are not included in the matter to be incinerated.

Characteristics of wastes that suitable for incineration are:

a. Low heating volume- above 2000 kcal/kg for single chamber incinerators and above 3500 kcal/kg for pyrolytic double chamber incinerators
b. Content of combustible matter above 60%
c. Content of non-combustible solids below 5%
d. Content of non-combustible fines below 20%
e. And moisture content below 30%

Waste types not to be incinerated are:

a. Pressurized gas containers
b. Large amount of reactive chemical wastes
c. Silver salts and photographic and radiographic wastes
d. Halogen plastics such as PVC
e. Waste with high mercury or cadmium content, such as broken thermometers, used batteries and lead-lined wooden panels
f. Sealed ampules or ampules containing heavy metals.

Types of incinerators

Incinerators can range from a very basic combustion unit that operates at a much lower temperatures to extremely sophisticated, high temperature operating plants. It should be carefully chosen on the basis of available resources, the local situation and the risk-benefit considerations.

Three basic kinds of incineration technologies are used for treating health care waste;

a. **Double chamber Pyrolytic incinerator** which may be especially designed to burn infectious health care waste.
Advantages: very high disinfection efficiency, adequate for all infectious waste and most pharmaceutical and chemical waste.
Disadvantages: incomplete destruction of cytotoxic waste. Relatively high investment and operating cost.

b. **Single chamber Furnace** with Static grate which should be used only if pryolytic incinerator is not affordable.
Advantages: very high disinfection efficiency.
Disadvantages: significant emission of atmospheric pollutants, need for periodic removal of slag and soot, inefficiency in destroying thermally resistant chemicals and drugs such as cytotoxics.

c. **Rotary kilns** operating at high temperatures, capable of causing decomposition of genotoxic waste and heat resistant chemicals.
Advantages: adequate for all infectious waste, most chemical waste and pharmaceutical waste.
Disadvantages: high investment and operating cost.

2. Chemical disinfection:

To kill or activate the pathogens, chemicals are added to waste. This method is more preferable to treat the waste like stools, hospital sewage, urine etc.
However solid wastes including microbiological cultures, sharps, etc. may also be disinfected chemically with certain limitations before they are dumped in the land fields.
Advantages: highly efficient disinfection under good operating conditions and some chemical disinfectants are relatively inexpensive.
Disadvantages: requires highly qualified technicians for operating the process

3. Wet thermal treatment

Wet thermal treatment or steam disinfection is based on exposure of shredded infectious waste to high temperature, high pressure steam, and is similar to the autoclave sterilization process.
Advantages: environmentally sound and relatively low investment and operating cost.
Disadvantages**:** shredders are subjected to frequent breakdown and poor functioning.

4. **Screw feed technology**
It is a non-burning, dry disinfection procedure in which the waste is shredded into pieces and heated in a rotating auger.
The waste is reduced to 80 of its volume and by 20-35% by weight. This process is suitable for treatment of infectious wastes and sharps, but it should not be used to process pathological, cytotoxic or radio-active waste [1].

5. **Microwave irradiation**
Most microorganisms are destroyed by the action of microwave of frequency of about 2450 MHz and a wave length of 12.24 nm. The efficiency of the microwave disinfection should be checked routinely through bacteriological and virological tests.
Advantages: good disinfection efficiency under appropriate operating conditions, drastic reduction in waste volume and environmentally sound.
Disadvantages: relatively high investment and operating cost.

6. **Land disposal (Municipal Disposal Sites)**
If a municipality or medical authority genuinely lacks the means to treat waste before disposal, the use of landfills had to be regarded as an acceptable disposal route. There are two types of disposals; land open dumps and sanitary landfills. Health care waste should not be deposited on or around open grounds.

Sanitary landfills are designed to have at least four advantages over open ground:
a. Geological isolation of waste from environment
b. Appropriate engineering preparation before the site is ready to accept waste, staff present on site to control operations
c. Organized deposits and daily coverage of waste [1].

7. **Inertization**
The process of inertization involves mixing of waste with cement and other substances before disposal, in order to minimize the risk of substances contained in the wastes migrating into the surface water or ground water. A homogenous mass is formed and cubes or pellets are produced on site and then transported to suitable storage sites.
Advantages: relatively inexpensive
Disadvantages: not applicable to infectious waste.

Biomedical Waste Management Rules
[4, 5, 6]

In India, the safe disposal of waste has now become mandatory for all the healthcare facilities. In 1998, the Biomedical Waste Management & Handling Rules came into force. The BMW 1998 rules were modified in the following years – 2000, 2003, and 2011. The draft of BMW rules 2011 remained as draft only and it was not notified due to lack of its standards. Currently, Ministry of Environment, Forest and Climate change in March 2016 have amended the BMWM rules. The differences between 1998 and 2016 rules are given below in Table 1 & 2.

Segregation, Packaging, Transport and Storage:

a. Biomedical waste shall not be mixed with other waste.
b. Biomedical waste shall be segregated into containers or bags in accordance to Schedule II, prior to its storage, transport or disposal. The containers shall be labeled in accordance with schedule III.
c. If the containers are to be transported to other places for disposal or treatment they shall carry a label of information in accordance with Schedule IV
d. Biomedical waste shall be transported in specially authorized vehicles as specified by the respective govt.
e. No untreated biomedical waste shall be stored for more than 48hrs.

Table 1: Difference between biomedical waste rules 1998 and 2016 [7]

BMW 1998	BMWM rules, 2016
Application	
These camps and such healthcare-related activities not covered under BMW 1998 rules	The realm of the rules have been expanded to include vaccination camps, blood donation camps, surgical camps, or any other health care activity
Duties of occupier	
Pretreatment of the laboratory waste, blood bags, etc. was not required	Pretreatment of the laboratory waste, microbiological waste, blood samples, and blood bags
Use of chlorinated plastic bags, gloves, and blood bags was mentioned	Phase-out the use of chlorinated plastic bags, gloves, and blood bags within 2 years
Liquid waste not to be separated at source and ETP is not mandatory	Liquid waste to be separated at source by pretreatment and ETP is required
Training and immunization not compulsory	Provide training to all HCWs in BMW rules and handling and immunize all HCWs against hepatitis B and tetanus
No barcoding system was in place	Establish a bar code system for bags or containers containing BMW for disposal
Reporting of accidents not specified and mentioned	Report all major accidents
Duties of the operator of a CBMWTF	
No such recommendation were in place	To establish barcoding and GPS of BMW waste carrying vehicle within 1 year
No such records were maintained	Maintain all records of incinerator/hydroclaving/autoclaving for a period of 5 years
No such records were maintained	Maintain a log book of each cycle of treatment with all details such as time, date, weight, duration, and hours of treatment
CBMWTF	
Every HCFs shall set up a requisite BMW treatment facility or ensure requisite treatment at a CBMWT	No occupier shall establish on their site a BMW treatment and disposal plant, if, a CBMWTF is available within 75 km of the HCF If no CBMWTF not available, the occupier should establish a BMW treatment and disposal plant after taking prior permission from authority
Segregation, packaging, transportation, and storage of BMW	
BMW classified into 10 categories based on treatment options	BMW classified into 4 categories based on treatment options
If untreated BMW should be stored beyond 48 h, authorization needed	IF untreated human anatomical waste, animal anatomical waste, soiled waste, and biotechnology waste should be stored beyond 48 h, no authorization needed
Treatment and disposal of waste	
Chemical treatment with 1% hypochlorite	Chemical treatment with at least 10% hypochlorite having 30% residual chlorine for 20 min or any other equivalent chemical reagent that should demonstrate $\log_{10}$ 4 reduction efficiency for microorganisms
Deep burial to be allowed in towns with population>5 lakhs	Deep burial is only an option in remote rural or remote areas, where there is other disposal option. The groundwater table level should be a minimum of 6 m below the lower level of deep burial pit
Cytotoxic drugs disposal in secured landfills	Cytotoxic waste and items contaminated with cytotoxic waste should be returned to manufacturer or CBMWTF for incinerator at 1200° C or encapsulation or plasma pyrolysis at 1200° C
All drugs discarded in black bags	All drugs including expired antibiotics should be sent back to manufacturer or to incinerator
All infected metal, plastic, and glass waste to be put in blue bag and then sent for autoclaving, microwaving, and incinerator	The BMW waste to be segregated – plastics in red bag, sharps in white container (after mutilation), and glass articles in cardboard box with blue marking; then sent to authorized recycler
This was not included	After proper treatment of plastics and glassware, these recyclables should be given to recyclers having valid registration
Authorization	
All HCFs treating 1000 or more patients/month need to obtain authorization from SPCB	One time authorization for nonbedded HCFs and for bedded HCFs, the validity of authorization should be coordinated with consent order
Standards for emission from incinerators	
Permissible limit for SPM-150 mg/Nm³	Permissible limit for SPM-50 mg/Nm³
Residence time in secondary chamber of incinerator at least 1s	Residence time in secondary chamber of incinerator 2 s
Standards for dioxin and furans – not defined	Standards for dioxin and furans- 0.1 ngTEQ/Nm³
Monitoring of implementation	
Not defined	Ministry of environment, forest and climate change should review the implementation of the rules in the country once a year
Not defined	SPCB of each state shall constitute district level monitoring committee under the chairpersonship of district collector or district magistrate or additional district magistrate to monitor the compliance of the above BMW rules
Not defined	The district level monitoring committee shall submit its report once every 6 months to the SPCB

SPCB = State pollution control board, HCFs = Health care facilities, ETP = Effluent treatment plant, CBMWTF = Common bio-medical waste treatment and disposal facility, BMW = Biomedical waste, BMWM = Biomedical waste management, SPM = Suspended particulates matter, HCWs = Healthcare workers

Table 2: Difference in schedule for biomedical waste of 1998 and 2016 [7]

Schedule	1998	2016
Schedule I	Categories of waste	Color code and type of waste with treatment and disposal
Schedule II	Color/code type of waste, waste category, treatment option	Standard for treatment of disposal of BMW (Autoclaving/ Microwaving/deep burial/dry heat sterilization/chemical disinfection)
Schedule III	Label of BMW category/bags	List of prescribed authorities and their duties
Schedule IV	Label for transport of BMW	Part A - label for container/bag Part B - label for transport of BMW bag/container
Schedule V	Standard for treatment and disposal of BMW	Added to schedule II
Schedule VI	List of prescribed authorities and their duties	Added to schedule III

BMW = Biomedical waste

Conclusion

The waste produced in the course of health care activities carries a higher potential for infection and injury than any other type of waste. Hence, it is necessary to have reliable and safe methods for waste handling. Inappropriate handling may lead to severe public health consequences and a major impact to the environment. Appropriate management of health care waste is thus a crucial component of environmental health protection and it should become an integral part of health care services.

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