BIOMEDICAL WASTE MANAGEMENT: NEED FOR HUMAN CIVILIZATION

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ABSTRACT:

Biomedical waste is generated in various medical institutions and research establishments. Generally classified as health care general waste and health care risk waste. The management of health care waste is essential and pertinent to the existence of our society. Although health care waste management is a costly affair, but following the principles laid down by World Health Organization for the management of health care waste, we can not only reduce the cost but also be able to achieve the sustainability of waste management. "3R" reduction, reuse and recycle are the three important steps of the effective waste management practices. Practising effective, safe and scientifically sound collection, storage, transport and disposal of biomedical waste, will help us achieve better health standard for the community.

Keywords: *Biomedical waste, Medical Waste management, Health care waste.*

An old saying says **"Cleanliness is next to Godliness"**. The essence of this was appositely practiced by Dravidians, who in 5000 BC, by immaculate town planning and safe and effective sewerage systems manage all solid and liquid wastes generated by them. They were the pioneers as far as longevity of the civilization is concerned, by implementing effective and scientific waste management; which is borne out from of Mohenjo-Daro and Harappa.

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.

Bio medical waste can be classified as:[2]

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:

A) Infectious waste – This type of waste is suspected to contain pathogens namely bacteria, viruses, fungi or parasites in concentrations sufficient to cause disease in susceptible hosts. Cultures and stocks of infectious agents from laboratory work, tissues and dressing generated from autopsies, surgeries and treatment of infected patients and animals, materials or equipment in contact with blood and infected body fluids.
B) Pathological waste – It consists of tissue, organs, body parts, human foetuses and animal carcasses, blood and body fluids. Recognisable human or animal body parts are also called as anatomical waste. This category should be considered as a subcategory of infectious waste, even though it may include healthy body parts.
C) Sharps – It includes syringes, needles, scalpels, saws, infusion sets, knives, blades, broken glass or other items that can cause cut or puncture wounds.
D) Pharmaceutical waste – It includes expired, unused, spilt and contaminated pharmaceutical products, drugs, vaccines and sera that are no longer required and need to be disposed of in appropriate manner. It also include items that are used in handling of pharmaceuticals.
E) Genotoxic waste – It includes cytostatic drugs, vomit, urine or faeces from the patients treated

with cytotoxic drugs, chemicals and radioactive materials. Genotoxic waste have mutagenic, teratogenic and carcinogenic properties.

F) Chemical waste – Chemical waste consists of discarded solid, liquid or gaseous chemicals and should be considered hazardous if it is toxic, corrosive, inflammable, reactive (explosive, water-reactive) or genotoxic.

G) Waste with high content of heavy metals – It represent a subcategory of hazardous chemical waste. Mercury (thermometers, blood pressure gauges, amalgam), (2) cadmium (discarded batteries) and lead waste (reinforced wood panels for radiation proofing in radiology department) can be generated from hospitals.

H) Pressurized containers – Gases used in healthcare are often stored in pressurized cylinder, cartridges and aerosol cans, which may be reusable. Gases in containers should be handled with care. Containers may explode if incinerated or accidentally punctured.

I) Radioactive waste – It includes disused sealed radiation sources, liquid or gaseous materials contaminated with radioactivity, in vitro analysis of body tissues and fluids, in vivo organ imaging, tumor localization and treatment and various clinical studies involving the use of radioisotopes. Certain radionuclides like C-14 have much longer half lives of more than thousand years which need to be specially managed in a centralized treatment facility for radioactive wastes.

WASTE CLASSIFICATION

According to schedule I of Ministry of environment and forests, there are 10 categories of waste as shown in schedule I.[3] Colour coding and type of container for disposal of biomedical waste recommended in India is shown in Schedule II.[3]

SCHEDULE I[3]

OPTION	WASTE CATEGORY	TREATMENT AND 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/microwaving/Incineration
Category No. 4	Waste sharps	Disinfection (chemical treatment)/ autoclaving/microwaving and mutilation/shredding
Category No. 5	Discarded Medicines and Cytotoxic drugs	Incineration/Destruction ion and drugs disposal in secured landfills
Category No. 6	Solid Waste (Items contaminated with blood, and body fluids)	Incineration/ autoclaving/microwaving
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	Disinfection by chemical treatment and discharge in drains
Category No. 9	Incineration Ash	Disposal in Municipal landfills
Category No. 10	Chemical Waste	Chemical treatment and discharge into drains for liquids and secured landfills for solids.

It should be taken into consideration that no chemical pre-treatment should be done before incineration and chlorinated plastics should not be incinerated. Deep burial should be practised in areas with population less than five lakhs or in rural areas. Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical agent so as to ensure disinfection.

SCHEDULE-II[3]

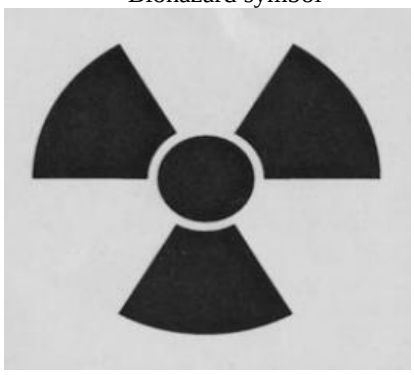
Recommended Colour Coding and Type Of Container for Disposal of Bio-Medical Wastes

Colour Coding	**Type of Container**	**Waste Category**	Treatment option as per Schedule I
Yellow	Plastic Bag	Cat 1, 2, 3, 6 (human anatomical waste, animal waste, microbiology & biotechnology waste, solid waste)	Incineration / deep burial
Red	Disinfected Container / Plastic Bag	Cat 3,6,7 (microbiology & biotechnology waste, solid waste)	Autoclaving / Microwaving Chemical Treatment
Blue / White Translucent	Plastic Bag / Puncture Proof Container	Cat 4,7 (waste sharps, solid waste)	Autoclaving / Microwaving Chemical Treatment and Destruction / Shredding
Black	Plastic Bag	Cat 5,9,10 (discarded medicine and cytotoxic drugs, incineration ash, chemicals)	Disposal in Secured Landfill

WHO recommended segregation scheme for various type of health care waste generated in health care institutions is shown in Table 3. Radioactive waste is not generated in all the hospitals. Using an international hazard symbol on each waste container is also recommended. Several symbols used for labelling hazardous health care waste are reproduced in Figure 1.

Biohazard symbol

Chemical hazard symbol



Old radiation symbol

New radiation symbol

Fig. 1: Biohazard[3, 4], radiation[4] and chemical hazard symbols. [3, 4]

Note: The new radiation symbol was adopted by the United Nations in 2007, but the older symbol is still widely recognized and expected to remain in common use for many years

Table 3: WHO recommended segregation scheme. [4]

Type of waste	Colour of container and markings	Type of container
Highly infectious waste	Yellow, marked "HIGHLY INFECTIOUS", with biohazard symbol#	Strong, leak-proof plastic bag, or container capable of being autoclaved
Other infectious waste, pathological and anatomical waste	Yellow with biohazard symbol#	Leak-proof plastic bag or container
Sharps	Yellow, marked "SHARPS", with biohazard symbol#	Puncture-proof container
Chemical and pharmaceutical waste	Brown, labelled with appropriate hazard symbol#	Plastic bag or rigid container
Radioactive waste	Labelled with radiation symbol#	Lead box
General health-care waste	Black	Plastic bag

#- See figure 1 (biohazard, radiation and chemical hazard symbols)

WASTE MANAGEMENT

The health care waste management system can be made efficient by the implementation of waste management hierarchy as shown in Figure 2.[4] Hierarchy based on "3 Rs" namely reduce, reuse and recycle The most preferred action is avoidance or reduction of waste generation, placed at the top of inverted pyramid. Reuse and recycle will further decrease the amount of waste generated, making treatment and final disposal of waste manageable.

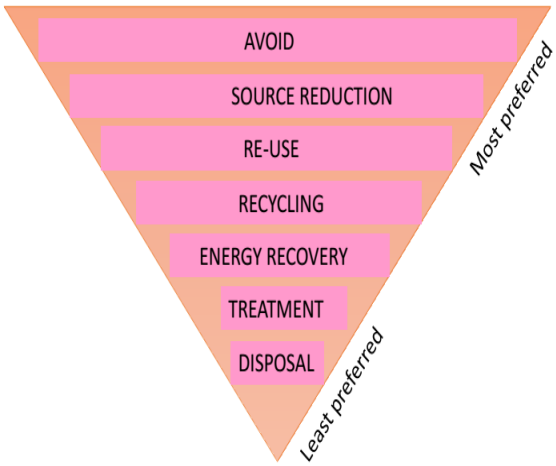


Fig. 2: Waste Management Hierarchy[5, 6]

WHO recommends five guiding principles for effective and controlled management of waste.[7]

The "Polluter pays" principle – it implies that all producers of waste are legally and financially responsible for the safe and environmentally sound disposal of waste.

The "Precautionary" principle is defined and adopted under the Rio declaration on Environment and Development (UNEP, 1972) as principle 15: "Where there are threats of serious or irreversible damage to the environment, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation".

The "duty of care" principle stipulates that any person handling or managing hazardous substances or wastes or related equipment is ethically responsible for using the utmost care in that task.

The "proximity" principle recommends that treatment and disposal of hazardous waste take place at the closest possible location to its source to minimize the risks involved in its transport.

The 'prior informed consent" principle as embodied in various international treaties is designed to protect public health and the environment from hazardous waste.

WASTE MINIMIZATION[6]

Waste minimization is most preferred method in the waste management system as it will lead sustainable program. Reduction at source, reuse, recycling, segregation and composting are the methods employed for waste minimization. Segregation facilitates waste minimization by decreasing amount of biohazard waste generated and solid waste which can be cost effectively managed through recycling and composting. Composting is used for food discards, yard and kitchen waste. Rich compost generated by various composting techniques like simple un-aerated static piles to aerated windrows to vermin composting, can be used for agriculture.

WASTE SEGREGATION AND STORAGE

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. General waste containers should be placed beside infectious waste containers. Minimizing the number of hazardous waste containers in patient care areas (except sharp container which should be readily available) may decrease waste, taking care that decreasing the number may lead to non-compliance.

Staff should be trained neither to commit errors nor make any attempt to correct errors of segregation by removing items from a bag or container after disposal. Two bags of different colour should not be placed inside one another. However, if general and hazardous wastes are accidentally mixed, the mixture should be treated as hazardous healthcare waste as segregation carries the risk of spread of infection.

WASTE COLLECTION

General health care waste should be disposed of with domestic refuse. Basic steps in health care waste handling for HCGW and HGRW is shown in Table 4.[7, 8] Sharps whether contaminated or not, should be collected together in puncture proof covered containers usually made of metal or high density plastic. Dense cardboard can also be used at places where metal or high density plastic is costly or unavailable. Containers should be rigid and impermeable so that they can retain any residual liquid from the syringes along with the sharps. Needles and syringes should be rendered unusable and containers should be temper proof in order to discourage abuse. International infectious substance label (Figure 1) should be marked on the containers containing infectious waste. Highly infectious waste should be sterilized immediately by autoclaving, wherever possible. Cytotoxic waste should be collected in strong, leak proof containers and labelled as "cytotoxic waste" as shown in figure 1.[3, 4, 7] Small amount of chemical and pharmaceutical waste can be collected with infectious waste while large quantities of expired pharmaceuticals should be returned to pharmacy for disposal. Pharmaceutical waste such as spilled or contaminated drugs or packaging containing drug residues should not be returned as it can contaminate the pharmacy, rather deposited in correct container.[9] Chemical waste should be packed and transported in chemical resistant container to specialized facilities for disposal. Identity of the chemical waste should be clearly marked and different types of hazardous chemical wastes should not be mixed. Heavy metals like cadmium and mercury should be collected separately and mixing with the general waste should be avoided so as to achieve minimization. Aerosol waste once completely emptied, if not destined for incineration may be collected with general health care waste. Low level radioactive infectious waste like swabs and syringes can be incinerated and may be collected in yellow bag or containers for infectious waste.[10]

All general, i.e. non-hazardous, waste should be handled in the same manner as domestic refuse and collected in black bags. Since costs for safe treatment and disposal of hazardous health-care waste are typically more than 10 times higher than those for general waste. As the containers used for collecting the sharps are more expensive than the bags used for other infectious waste, general and infectious healthcare waste except the sharps should not be deposited in sharps containers. This will help in minimizing the costs of healthcare waste collection and management. When a disposable syringe is used, for example, the packaging should be placed in the general waste bin and the used syringe in the yellow sharps container. In most circumstances, the needle should not be removed from the syringe because of the risk of needle stick injury. Special care is to be taken if needle is to be removed and disposed.

Table 4: Health care waste management for HCGW and HGRW[7, 8]

Type of Waste	Storage at source	Collection on site	Treatment	Collection off site	Waste Disposal
NON INFECTIOUS WASTE					
Kitchen waste	Green Container	Garbage holding area		Hog Dealer and Piggery owner	ANIMAL FEEDS
Bottles and Cans	Black Container				COMPOSTING
Papers and Cartons				Junk shop dealer	RECYCLING
AEROSOL AND PRESSURIZED CONTAINER					
Aerosol can	Red container	Designated storage area	Crushed	Municipal collection system	Landfill
Pressurized container				Collection by supplier	Disposal by supplier
INFECTIOUS WASTE					
	Yellow container	Garbage holding area	Non-Burn technologies	Municipal collection system	Landfill
CHEMICAL WASTE					

Chemical waste	Yellow container	Designated storage area			Sink
		Delay to decay	Non-Burn technologies	Municipal collection system	Recycling
SHARPS					
Sharps (needles, blades)	Puncture proof container	Designated storage area	Non-Burn technologies	Municipal collection system	Landfill
			Chemical Disinfectant		Burying
EXPIRED PHARMACEUTICAL WASTE					
Pharmaceutical waste	Yellow container	Designated storage area	Delay to decay	Collection by supplier	Disposal by supplier
RADIOACTIVE WASTE					
Radioactive waste	Orange container/Lead box labelled with radioactive symbol[#]	Designated storage area	Delay to decay	Collection by supplier	Disposal by supplier
PATHOLOGICAL WASTE					
Pathological waste	Yellow container		Crematorium		
			Non-burn technologies	Municipal collection system	Recycling
		Refrigerator	Chemical disinfectant		Concrete vault Burying

#- See figure 1 (biohazard, radiation and chemical hazard symbols).

WASTE STORAGE

Staff should ensure that waste bags are tightly closed or sealed when they are three-quarters full. Bags should not be closed by stapling. Sharp container should be placed inside labelled yellow infectious health care waste bag before it is mobilised from the hospital area. A designated area inside the health care Institute should be used as central storage facility, the recommendations for which are given in Tale 5:

Table 5: Recommendations for Central storage facility for health care waste[7]

1. The storage area should have an impermeable, hard-standing floor with good drainage; it should be easy to clean and disinfect.
2. There should be a water supply for cleaning purposes.
3. The storage area should afford easy access for staff in charge of handling the waste.
4. It should be possible to lock the store to prevent access by unauthorized persons.
5. Easy access for waste-collection vehicles is essential.
6. There should be protection from the sun.
7. The storage area should be inaccessible for animals, insects, and birds.
8. There should be good lighting and at least passive ventilation.
9. The storage area should not be situated in the proximity of fresh food stores or food preparation areas.
10. A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area.
11. Floors, walls and ceiling of storage area must be kept clean in accordance to established procedures, which at minimum should include at least once per week.
12. Should have spillage containment equipment.

Biodegradable general and hazardous waste should not be stored longer than 2 days to minimize microbial growth, putrefaction and odours. Sharps can be stored without problem but other infectious waste should be kept cool or refrigerated at a temperature preferably no higher than 3 ºC to 8 ºC if stored for more than week.

Unless a refrigerated storage room is available, storage time for health care waste i.e the delay between production and treatment should not exceed the 72 hours and 48 hours in winter and summer respectively in temperate climate. In warm climate, the time limit is 48 hours during cool season and 24 hours during hot season. A separated

designated secure location is provided for storage of cytotoxic waste.

Radioactive waste should be stored in containers that prevent dispersion, behind lead shielding.[10] Waste that is stored during radioactive decay should be labelled with type of radionuclide, date and details of required storage conditions. The decay storage time for radioactive waste should be until the radioactivity is substantially reduced and the waste can be safely disposed of as normal waste. A minimum storage time of 10 half-life times for radioisotopes in wastes with a half-life of less than 90 days is a common practice.[10] For eg: I-125 has a half-life of 60.2 days (<90 days), therefore decay storage time for I-125 shall be 60.2 days × 10 = 602 days. Radioactive waste with half-life of more than 90 days must be collected and stored externally until collected by national disposal site by government agency or specialist contractor.

WASTE TRANSPORT[11]

Health care waste should be transported through the quickest and shortest possible route. After departure from the source, avoid handling of the waste or if deemed necessary should be pre-arranged and take place in adequately designed and authorized premises. For an efficient and effective collection system route, a designated personnel responsible for zone should schedule collection and logical planning of the route. In general, "from clean to dirty" principle for waste collection should be followed.[11] Collection should start from most hygienically sensitive medical areas (intensive care units, theatres, dialysis units) and follow a fixed route around other medical areas and interim storage locations. Route must have logical progression and must be laid out from the farthest point possible (Figure 3). Collection frequency should be refined through experience to ensure that there are no overflowing waste containers at any time. Biologically active waste or infectious waste must be collected at least daily. Time of collection regardless of category should be at the start of every shift. Collected waste should be stored at central storage facility and transfer to vehicles for off-site transportation at transfer stations.

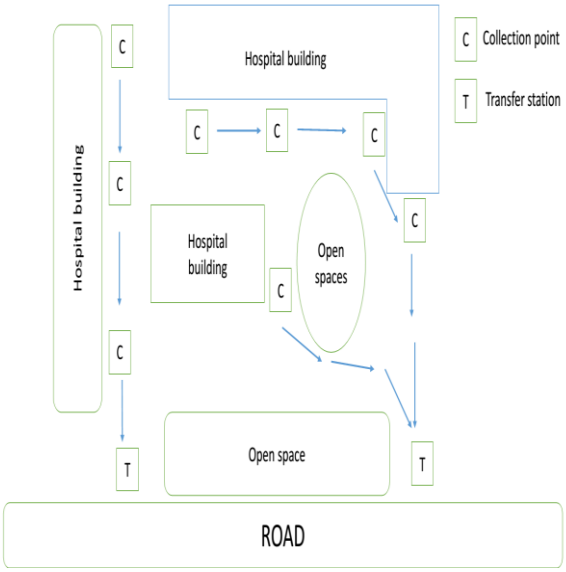


Figure 3: Laid our plan of collection and transport of health care waste from various collection points to transfer station inside the hospital.

CONCLUSION

Medical wastes should be classified according to their source, type and risk factors associated with their handling, storage and ultimate disposal. The reduction, reuse, recycling and segregation of waste at source is the key step in making waste management cost effective. Waste generation particularly biomedical waste imposes direct and indirect costs on society as it is a source of epidemic. The challenge before our civilization is to scientifically manage growing quantities of biomedical waste. We need to implement the waste management practices by heart and sensitize ourselves so that we can eradicate the biohazards associated with the biomedical waste and protect our environment and health of community. For the betterment of health managers and the longevity of community, biomedical waste management should be implemented as the grass root level.

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