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A Review on Segregation and Management of Biomedical Waste

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ABSTRACT:-
Any kind of waste which may be either solid or liquid containing injurious materials produced by healthcare facilities is known as biomedical waste. Management of these biomedical wastes involves separating, gathering, storing, transporting, processing and its dumping. It requires commitment at all levels from healthcare employees to sanitation workers because improper management of biomedical waste causes direct health risk to the public, the healthcare personnels and the environment. Thehealthcareprofessionalsadministrators working under public and private sector institutes, auxiliariesworking in different colleges and hospitals and various health workers of the society should be made aware of the rules related to disposal of biomedical waste.
For effective waste management in healthcare units, the authorities and policy makers should incorporate frequent training and awareness programmes for the healthcare personnels. An attempt has been made through this article to impart knowledge among the healthcare personnels, so that they strictly abide by the biomedical waste management rules and regulations specified by concerned governing bodies.
Keywords: *Waste Management; Biomedical Waste; Healthcare Services; Infectious; Hazardous*.

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I. 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. In order to lead a healthy life, medical care is also necessary but the waste produced through healthcareevents represents a serious threatto the human world and environment(1).The waste produced by various health linkedeventsduring diagnosis, treatment and immunization which may contain harmful transmissible agents and sometimes emitting radiation is referred as biomedical waste(2).Healthcare personnels, public andenvironment around them will be under threat if there is no proper management of these biomedical wastes (3).Proper biomedical waste management is needed for worldwide hospitals and healthcare centres,as they produce large quantity of wastes daily(4). Biomedical waste management involvethe following events which includesseparating, gathering, storing, transporting, processing and its dumping(5)which has been vividly discussed through this present article.

TYPES OF WASTE:-

Biomedical Waste Management and Handling Rules, 1998 framed in India,defined "Biomedical Waste",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). According to World Health Organization (WHO)85% healthcare wastes are harmless,10% communicable and 5% non-communicable butincluded as harmful wastes. Around15-35% of healthcare waste is communicable in nature whichdepends upon theentire amount of waste produced(2,3,4,7).

CLASSIFICATION OF BIO-MEDICAL WASTE(1,2,3,5,8,9)**:-**

The World Health Organization (WHO) has categorized medical waste into 8typeswhile according to Ministry of Environment and Forest, Government of India (1998), Biomedical Waste Management & Handling Rules - 1998, describes 10 categories.

SOURCES OF BIO-MEDICAL WASTE(4,9):-

Hospital discards are hazardous for patients and healthcare personnels as well as poses a danger to the ecosystem and society at large(1,10). Depending upon the amount of hospital discards generated, they are divided into major and minor sourcesas depicted in Table 1:

Table1 Sources of Waste Production

Major Sources	Minor Sources
Primary health centres	Physicians / dentists' clinics
Medical/Dental educational hubs and research institutes/allied paramedic services	Vaccination centres
Blood bankcentres/morgues/postmortemhubs	Sites of blood donation
Public and private sector hospitals and clinics	Animal / slaughter houses
Veterinary colleges and animal research hubs	Psychiatrist dispensaries/beauty parlours
Biotechnology establishments	Institutions for handicapped persons
Production Units	Funeral services

REQUIREMENT FOR MANAGEMENTOF BIO-MEDICAL WASTE: -

Management of biomedical waste is needed because of thesereasons listed below:

1.Patients acquiringnoscomial infections due to improper methods for controlling infectionand inappropriatedisposalof biomedical waste (4,11,12).

2. Healthcare personnels and persons who handle healthcare wastes may get infected from injury caused due to sharp objects. (4,12).

3. Persons who handle healthcare wastes, scavengers and the society adjacent to the hospitals may have a risk of infection (4,10,12).

4. Personswho handle wastes at all stages may be at a risk related to harmful chemicals and drugs (12).

5. "Disposables "may be at a risk of getting recycled, repacked and sold by corruptpeople (4,12,13).

6. Discarded or expired drugs may be at a risk of getting repacked and sold to innocent customers (12).

7.Infected human discards like needles and syringes are liable to be cause pollution of the environment, bad odour, multiplication and growth of vectors such as insects, rodents and worm which threaten to communicate disease like typhoid, cholera, hepatitis and AIDS.(4,12,14,15).

Thus, the vital problems in India associated with healthcare waste can be attributed to improper waste management, lack of knowledge about transmission of disease, lack of funds and improper methods ofwaste disposal (4,16,17).

MANAGEMENT OF BIO-MEDICAL WASTE: -

Following are thestagesin management of biomedical waste:

I. Waste Production
II.Waste Separation
III.Waste Gathering
IV.Waste Storing
V.Waste Transporting
VI.Waste Processing and Dumping

I.Waste Production- Different types of waste and its generation site are shown in Table 2:

Table 2 Types of waste, its source and its disposal authority

Category	Source of Generation	Disposed By
Non-Harmful (General waste)	Household, workplace, market, shops etc	Government bodies
Harmful (Transmittable&contaminated waste)	Dental and Medical hospitals, Clinics,Laboratories, CT scan, Radio-imaging, etc.	Hospitals, Clinics, Laboratories, Radiology centresitself

II. Waste Separation-According to Biomedical Waste Management Rules, 2016,bio-medical waste has been categorized to improve the segregation of waste at sources (6), as enlisted in Table 3:

Table 3 Categorization, Segregation and Various methods of waste disposal

Colour coded Bags/Bins/Container	Waste Type	Colour and type of bags	Processing and dumpingmethods
(1)	(2)	(3)	(4)
	(a) Anatomical waste of humans: Organs, body parts,tissues and aborted fetus	Non-chlorinated plastic bags,yellow coloured	Deep burial/burning/plasma pyrolysis process
	(b) Anatomical waste of animals: Organs, body parts,tissues and dead		

Yellow	animals which are used for various experimentsin researchlaboratories, veterinary colleges and hospital or other research centres		
	(c) Soiled Waste: Objects like cotton swabs, plaster casts, dressingsinfected with blood or body fluids and bags containing residual or discarded blood or its components		Deep burial* orburningor using plasma pyrolysis technology. Alternative method includes microwaving/hydroclaving/autoclaving followed by mutilation or shredding
	(d) Expired or Discarded Medicines: Spurious or expired drugs likeanitibiotics, cytotoxic medicines and items like vials, plastic or glass ampoules soiled with the cytotoxic medicines	Containers or non-chlorinated plastic bags which areyellow colour coded	Discarded or expired drugs and objects soiled with the drugs should be returned to the supplier for burning/plasma pyrolysis at temperature $>1200^0$c or to common biomedical waste treatment centre for burning/pyrolysis at temperature$>1200^0$c or encapsulation process
Yellow	**(e) Chemical Waste:**Used or leftover disinfectantsand chemicals used in manufacture of biological products	Non-chlorinated plastic bags or containers, yellow in colour	Chemicals are sent to biohazardous waste treatment centre where it should be processed and discarded by burning/encapsulation process/plasma pyrolysis
	(f) Chemical Liquid Waste: Used or leftover disinfectants, x-ray film developing liquid, contagious secretions, aspirations, body fluids, formalin, housekeeping and laboratory related discarded liquids and also chemicals used in manufacture of biological products	Systems used for gathering the wastes should be separated and sent to the liquid waste treatment centre	After the chemicals are separated, they should be pre-processed prior to mixing with other waste waterand those of the sewage system.
	(g) Discarded linen mattresses: Body fluid or blood soiledbeddings	Proper packaging material or non-chlorinated plastic bags which are yellow colour coded	Disinfected with non-chlorinated chemical followed by burningor using Plasma pyrolysis. Alternative method includes sterilization followed by mutilation or shredding
	(h)Microbiological, Biotechnologicaland laboratory waste: Animal and cell cultures, stocks or specimens of microorganisms, live or attenuated vaccines, blood bags, biomedical and industrial laboratory cultures and production of biological, residual toxins, dishes and devices used for cultures.	Autoclavable containers or safe plastic bags	Pre-process to disinfect with non chlorinated chemicals instantly, according to method mentioned by National AIDS Control Organization or World Health Organization and then sent for burning
Red	**Recyclable Contaminated Waste:** Discarded disposable items such as catheters. i.v. sets, tubing, bottles, intravenous tubes and sets,vaccutainers with their needles cut and gloves, urine bags and syringes (without needles and fixed needle syringes)	Containers or non-chlorinated plastic bagsred coloured	Microwaving/hydroclaving/autoclaving followed by mutilation or shredding Processed waste to be sent recognized or certified recyclers for energy recovery like plastics to diesel or fuel oil or for road making whichever is possible. Dumping of plastic waste is contraindicated.
White (Translucent)	**Sharps waste with metals included:** Any sharp objects likeneedles, syringes with fixed needles, needles from needle tip cutter or burner, blades or any other infecteditems that may cause puncture and cuts. This also includes infected or discarded metal sharps.	Tamper proof, puncture proof and leak proof containers	Dry Heat Sterilization/Autoclaving followed by mutilation/shredding or encapsulation in cement concrete/ metal container and sent for final discarding to landfill or iron foundries or selected concrete waste sharp pit
Blue	**(a) Glassware:** Infected or broken glass including and medicine vials and ampoules except those tainted with cytotoxic drugs.	Blue colouredcardboard boxes	Metallic implants or glass wastes are disinfected by cleaning with detergent and Sodium Hypochlorite then through microwaving/autoclaving/hydroclavingfollowed by 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.
In 2020,Central Pollution Control Board gave guidelines 2020 (18)as listed below-
Red bags should contain PPEs such as goggles, face-shield, splash proof apron, plastic coverall, hazmat suit, nitrile gloves should be gathered.
Yellow bags should contain used masks (including triple layer mask, N95 mask, etc.), head cover/cap, shoe-cover, disposable linen gown, non-plastic or semi-plastic coverall.

III. Waste Gathering-
1. Separated or Segregated wastes that are of different categories need to be collected in separate containers or bins with proper colour coding.
2. Positioning of containers or bins should be such that 100 % waste collection is achieved.
3. Big hospitals, maximum storage time is 8-10 hours while that of nursing home is 24 hours (5).
4.Labelling of container or bin should appropriately display the ward or room from where it is collected, so that its source can be traced back.

IV. Waste Storing-
1. Every healthcare unit must have a storage area for medical waste until it is hoarded off for processing and dumping.
2. The area meant for storage should be selected judiciously which is isolated from the general public and shoulddisplay warning symbols & signs.
3. Storage area mustbe dry andprotected.
4. Care should be taken so that the area has no seepage of water, windproof, entry of rodents, insects and animals.
5. Three months is the maximum time allowed for storage of bio-hazardous waste(19,20).

V. Waste Transporting-
Carts and containers which are not used for other purposes can be used for transportation of biohazardous waste. Transporting vehicle should have the name and address of transporter marked on it. Biohazard sign should be dyed properly on the transporting vehicle. During transportation proper system to secure the weight should be confirmed. There should be rounded corners in these transports so that they can be easily cleaned every day. Before discarding the disposable plastics to seller, it should be subjected to shredding. Maximum storage time of 48 hours is allowed for unprocessed biomedical waste (5,21,22).

VI. Waste Processing and Dumping-
There are many processing optionswhich ensuresprotection during handling and discarding of the waste. It also protects the ecosystem. Most common methods used for processing of biomedical waste are burning/incineration, steam sterilization,chemical processing,radiation treatment, inertization, encapsulation and dumping of waste in land (20).

i)Burning/Incineration

Pathological and pharmaceutical waste are converted to ashes, flue gases and heat through this process.The waste which are burnt should not be chemically processed with any chlorinated disinfectants.Temperature required for burning should be within $800\text{-}1400^0$ C. The mass of wasteis reduced by 90-95% and thus minimizes the side effects on the ecosystem (20).Fuel used for the incinerator should contain low sulfur like diesel.

ii) Steam Sterilization

Alternative process to incineration is steam sterilization or autoclaving. Temperature required for autoclaving is 121^0cwith pressure of about 1pascal for 20-30 minutes. In this process, infectious agents are deactivated and killed. It is also a cost-effective method without any detrimental health effects (20).

iii) Chemical processing
Liquid wasteis sterilized, so that it can be easily discarded locally by chemical processing. Several methods are employedlikepH neutralization, precipitation,oxidation and reduction thus converting the harmful waste into less toxic substances. Chemical disinfectants used are chlorine dioxide, sodium hypochlorite, formaldehyde, glutaraldehyde, ethylene oxide, according to the nature of waste (20).Sodiumhypochlorite (1-2%) should be used according to the guidelines given in 2018 by Biomedical Waste Management (amendment) Rules.Except for microbiological, laboratory and highly contagious waste there is no requirement for chemical pre-processing before incineration/burning (12).

iv) Radiation treatment

Recently, gamma, electron-beam, ultraviolet and X-rays are used to process waste. Gamma rays that are fatal to micro-organisms are used to disinfect waste in a radiation chamber by exposing it to a radioactive cobalt-60.It is an expensive method.Protection of workers from harmful effects of radiations such as cancer, radiation sickness or even death must be given a top priority (20).

v) Inertization

For reduction of hazardous elements seepinginto surface water or ground water and also to avertscavenging, the wastes are mixed with cement and other substance prior to dumping. 65% waste by parts, 15%lime, 15% cement and 5% water is mixed as slurry for this inertization process.

vi) Encapsulation

High density containers made of polyethylene or metal are filled with waste mixed with a medium of immobilizes the waste.Plastic, foam, cement mortar or clay are generally used to immobilizing medium.After the medium has set, the drums are sealed and dumped in landfill sites. It is an easy, cost-effective and safe method but not recommended for non-sharp infectious waste.

Dumping of waste in land

Dumping of waste in land is done where the wasteis disinfected by the different processing methods.Land disposal is advisable where there is low groundwater level and secluded from flooding areas. Wastes which are radiologically active are usually dumpedin ocean beds isolated from human occupancy.Rules and regulations for dumping of processedbiomedical waste are separate for every state and local authorities (20).

II. Conclusion:-

Biomedical waste management is becoming a challenging issue which has become a worldwide humanitarian topic today. All healthcare personnel and auxiliaries must be scientifically updated and proper knowledge should be imparted to them through training programmes, which will allow them to take up responsibilities in safe and proper waste disposal. Public too must be made aware about matters related to biomedical wastes through participation in the waste minimization programmes. 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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