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Biomedical Waste Management
A Step Towards A Healthy Future

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INTRODUCTION

The management of health-care waste is a subject of considerable concern to public health and infection control specialists, as well as the general public. It is a well known fact that in several types of health care activities, various types of hazardous and contagious materials are generated. Even though the consequences of discarding such waste carelessly are well known, it is only recently that adequate initiatives to manage this wastage in scientific manner are being taken in India.

Unscientific disposal of health care waste may lead to the transmission of communicable diseases spreading through air, water and direct human contact and by blood and infectious body fluids. These could be responsible for transmission of hepatitis B, C, E and AIDS within the community. Diseases are spread by improper treatment and disposal of waste. In addition to their infectious and toxic characteristics, the highly variable and inconsistent nature of medical waste streams has increased public concern about storage, treatment, transportation, and ultimate disposal.

Appropriate management of health care waste is thus a crucial component of environmental health protection and it should become an integral feature of health care services.

DEFINITION

According to Biomedical Waste (Management and Handling) Rules, 1998 of India, "Biomedical waste" means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological, and including categories as mentioned below.

CLASSIFICATION OF HEALTH-CARE WASTE

- **Infectious waste:** Waste suspected to contain pathogens; e.g. laboratory cultures; waste from isolation wards; tissues (swabs), materials, or equipments that have been in contact with infected patients; excreta.
- **Pathological waste:** Human tissues or fluids e.g. body parts; blood and other body fluids; fetuses.
- **Pharmaceutical waste:** Waste containing pharmaceuticals; e.g. pharmaceuticals that are expired or no longer needed; contaminated pharmaceuticals (bottles, boxes).
- **Genotoxic waste:** Waste containing cytostatic drugs (often used in cancer therapy)/ genotoxic chemicals
- **Chemical waste:** Waste containing chemical substances e.g. laboratory reagents; film developer; disinfectants and solvents that are expired or no longer needed.
- **Wastes with high content of heavy metals:** Batteries, broken thermometers, blood pressure gauges, Pressurized containers, gas cylinders, gas cartridges, aerosol cans.
- **Radioactive waste from radiotherapy:** Waste containing radioactive substances e.g. unused liquids from laboratory research; contaminated glassware, packages or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides.

SOURCES OF BIOMEDICAL WASTES

Between 75 and 90% of the waste produced by the health-care providers is non-risk or general biomedical waste, comparable to domestic waste. It comes mostly

from administrative and housekeeping functions of the health care establishments, and also includes waste generated during maintenance of health-care premises. The remaining 10-25% health-care waste is regarded as hazardous and may create a variety of health risk. Sources of biomedical waste can be classified as major and minor sources.

Major Sources

- Govt. hospitals/private hospitals/nursing homes/ dispensaries.
- Primary health centers.
- Medical colleges and research centers/paramedic services.
- Veterinary colleges and animal research centers.
- Blood banks/mortuaries/autopsy centers.
- Biotechnology institutions.
- Production units.

Minor Sources

- Physicians/ dentists' clinics
- Animal houses/slaughter houses.
- Blood donation camps.
- Vaccination centers.
- Acupuncturists/psychiatric clinics/cosmetic piercing.
- Funeral services.
- Institutions for disabled persons.

BIOMEDICAL WASTE GENERATION

Estimates for an average distribution of health-care wastes useful for preliminary planning of waste management.

- 80% - general health-care waste; which may be dealt with by the normal domestic and urban waste management system;

Table 1: Categories of biomedical wastes and disposal techniques

Option	*Waste category*	*Treatment and disposal*
Category No. 1	Human Anatomical Waste (human tissues, organs, body parts)	Incineration / deep burial
Category No. 2	Animal Waste.(animal tissues, organs, body parts carcasses, bleeding parts, fluids, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospital, animal house)	Incineration /deep burial
Category No. 3	Microbiology and biotechnology waste. (waste from laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, waste from production of biological, toxins, dishes and devices and for transfer of cultures)	Local autoclaving / microwaving/ incineration
Category No. 4	Waste sharps (needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)	Disinfection (chemical treatment / autoclaving/ Microwaving and mutilation/shredding)
Category No. 5	Discarded medicines and cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	Incineration / destruction and drugs disposal in secured landfills
Category No. 6	Solid waste (items contaminated with blood, and fluids including cotton, dressings, soiled plaster casts, linen, beddings, other material contaminated with blood)	Incineration/autoclaving/microwave
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 (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	Disinfection by chemical treatment and discharge into drains
Category No. 9	Incineration ash (ash from incineration of any bio-medical waste)	Disposal in municipal landfill
Category No. 10	Chemicals used in production of biological, chemicals used in disinfection, as insecticides, etc.	Chemical treatment and discharge into drains for liquids and secured landfill for solids

Table 2: Color coding and type of container for disposal of biomedical wastes

Color coding	*Type of container*	*Waste category*	*Treatment options as per schedule*
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

- 15% - pathological and infectious waste;
- 1% - sharps waste;
- 3% - chemical and pharmacological waste;
- < 1% - special waste; such as radioactive or cytotoxic waste, pressurized containers or broken thermometers and used batteries.

HOW BIOMEDICAL WASTE MANAGEMENT IS BENEFICIAL?

- Leads to a cleaner and healthier surroundings.
- Decreased incidence of nosocomial infections.
- Reduction in the cost of infection control within the hospital.
- Disease and death due to reuse and repackaging of infectious disposables is eliminated.
- Segregation and appropriate treatment of medical waste reduces cost of waste management and generous revenue.

MANAGEMENT OF BIOMEDICAL WASTES

The steps involved in waste management include:

- Waste minimization.
- Segregation.
- Collection.
- Storage.
- Transportation.
- Treatment.
- Disposal.

TREATMENT AND DISPOSAL TECHNOLOGIES OF BIOMEDICAL WASTE

Incineration

This used to be the method of choice for most hazardous biomedical wastes, and is still widely used. Incineration is a high temperature, dry oxidation process, which reduces organic and combustible waste to inorganic incombustible matter and results in a very significant reduction of waste volume and weight. The process is usually selected to treat waste that can not be recycled, reused or disposed off in a land fill site. Waste types not to be incinerated are:

a. Pressurized gas containers ;
b. Large amount of reactive chemical wastes;
c. Silver salts and photographic or radiographic wastes;
d. Halogenated 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.

The advantages of incinerator include good disinfection efficiency and drastic reduction of weight and volume of waste. The residues may be disposed off in landfills. There is no need for highly trained operators it has a relatively low investment and operating cost.

But there is a significant emission of atmospheric pollutants. Need for periodic removal of slag and soot and Inefficiency in destroying thermally resistant chemicals and drugs such as cytotoxics are its disadvantages.

AUTOCLAVING

The autoclave should be dedicated for the purposes of disinfecting and treating bio-medical waste. When operating a gravity flow autoclave, medical waste is subjected to:

i. A temperature of not less than 121ºC and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 60 minutes; or
ii. A temperature of not less than 135ºC and pressure of 31 psi for an autoclave residence time of not less than 45 minutes; or

iii. A temperature of not less than 149°C and a pressure of 52 psi for an autoclave residence time of not less than 30 minutes.

When operating a vacuum autoclave, medical waste is first subjected to a minimum of one pre-vacuum autoclave to purge the autoclave of all air. The waste is then subjected to the following:

i. A temperature of not less than 121°C and pressure of 15 psi for an autoclave residence time of not less than 45 minutes; or

ii. A temperature of not less than 135°C and pressure of 31 psi for an autoclave residence time of not less than 30 minutes.

Spore testing: The autoclave should completely and consistently kill the approved biological indicator at the maximum design capacity of each autoclave unit. Biological indicator for autoclave is bacillus stearothermophilus spore dials or spore strips with at least 1×10^4 spores per ml. Under no circumstances will an autoclave have minimum operating parameters less than a residence time of 30 minutes, regardless of temperature and pressure, a temperature less than 121°C or a pressure less than 15 psi.

Routine test: A chemical indicator strip/tape that changes color when certain temperature is reached can be used to verify that a specific temperature has been achieved. It may be necessary to use more than one strip over the waste package at different location to ensure that the inner content of the package has been adequately autoclaved.

DISPOSAL OF LIQUID WASTE

Liquid pathological and chemical waste should be appropriately treated before discharge into the sewer. Pathological waste must be treated with chemical disinfectants, neutralized and then flushed into the sewage system.

Chemical waste must be neutralized with appropriate reagents and then flushed into the sewer system. This method requires highly qualified technicians for operation of the process and uses hazardous substances that require comprehensive safety measures.

The effluent generated from the hospital should conform to the following limits:

Parameters	*Permissible limits*
pH	6.5-9.0
Suspended solids	100 mg/l
Oil and grease	10 mg/l
BOD	30 mg/l
COD	250 mg/l
Bio-assay test	90% survival of fish after 96 hours in 100% effluent

These limits are applicable to those hospitals, which are either connected with sewers without terminal sewage treatment plant or not connected to public sewers. For discharge into public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act, 1986 should be applicable.

MICROWAVING

Most microorganisms are destroyed by the action of microwave at a frequency of about 2450 MHz and a wavelength of 12.24 cm. The water contained within the waste is rapidly heated by the microwaves and the infectious components are destroyed by heat conduction. The efficiency of the microwave disinfection should be checked routinely through bacteriological and virological tests.

Through the special arrangement of the entry of microwaves into treatment chamber, the waste is evenly heated to a temperature of 97-100°C. Microwaving makes it possible for treatment of waste at site (point of generation) and waste does not require shredding. Microwaving is suitable for the treatment of most infectious waste and is done in special microwaving waste treatment facility, with the exception of body parts, human organs, contaminated animals carcasses and metal items.

It has good disinfection efficiency under appropriate operating conditions and drastic reduction in waste volume. It is environmentally sound although it has relatively high investment and operating costs and potential operation and maintenance problems.

DEEP BURIAL

1. A pit or trench should be dug about 2 meters deep. It should be half filled with waste, and then covered within 50 cm of the surface, before filling the rest of the pit with soil.
2. It must be ensured that animals do not have any access to burial sites. Covers of galvanized iron / wire meshes may be used.
3. On each occasion, when wastes are added to the pit, a layer of 10 cm of soil shall be added to cover the waste.
4. Burial must be performed under close and dedicated supervision.

5. The deep burial site should be relatively impermeable and no shallow well should be close to the site.
6. The pits should be distant from habitation and sited so as to ensure that no contamination occurs of any surface water or ground water. The area should not be prone to flooding or erosion.
7. The location of the deep burial site will be authorized by the prescribed authority.
8. The institution shall maintain a record of all pits for deep burial.

INERTIZATION

The process of inertization involves mixing waste with cement and other substances before disposal, in order to minimize the risk of toxic substances contained in the wastes migrating into the surface water or ground water. A typical proportion of the mixture is: 65 percent pharmaceutical waste, 15 percent cement and 5 percent water. A homogenous mass is formed and cubes or pellets are produced on site and then transported to suitable storage sites.

It is relatively inexpensive and not applicable to infectious waste.

BIOMEDICAL WASTE MANAGEMANT AND HANDLING RULES

Guidelines

i. Non-infectious wastes should be segregated as a separate category and these wastes shall not be mixed with other categories.
ii. Each ward of health facilities should have at least two colored containers and other colored container can be placed at centralized places.
iii. All the items should be made non-reusable before they taken out of the hospital.
iv. For disfigurement of needles and syringes, all hospitals should provide adequate number of needle destroyers and syringes cutters at appropriate locations such as Nursing desk, OT, blood bank, etc.
v. The needles after disinfections/destruction shall be collected in a puncture proof container and the container may be buried.
vi. A detailed study should be carried for the treatment of liquid effluent generated in the hospital. This may be carried out through a recognized institutions/consultants.
vii. An inventory of various hazardous chemicals used in medical treatment shall be prepared. The possibilities of recycling of such hazardous chemicals should also be looked into.
viii. Infectious waste has to be kept separately in lidded bins lined with polyethylene bags wherever needed.
ix. Under no circumstances should the infections waste be mixed with non-infectious bags.
x. The bag lining the bin should be only 3/4th full to ensure that the waste does not spill out.
xi. While carrying the bag containing infectious waste it has to be sealed/tied.
xii. Bags containing infectious waste have to be disposed off through incineration, autoclaving, or micro waving as per recommendations.
xiii. Properly labeled waste containers minimize confusion in handling and disposal of waste. Therefore, all containers should be of prescribed colour and labeled properly.
xiv. Blood bags, syringes and sharps should be handled with extreme care. The doctor supervisor should ensure that such items are either out or disfigured before removing them from the nursing desk/OT.
xv. Always separate the syringes barrel from its plunger before disinfecting it.
xvi. All the employees working in the hospital or other wise coming in contact with waste must be vaccinated against hepatitis B.
xvii. All the workers should put on gloves while dealing with infectious waste especially sharps.
xviii. Sharps should not be left casually counter tops, food trays, on beds or on the floor as grievous injuries can result.
xix. Segregation of hospital waste is the key to ensure that 90% of the waste which is non-infectious is treated easily. At no stage should infectious waste come in contact with-non-infectious waste. If mixed, with the infectious waste, non-infectious waste has to be treated as infectious waste.
xx. A system should be worked out to develop common treatment facility for the bio-medical waste. The municipal authorities in large cities to set up common hospital waste treatment facilities, so that small nursing homes and clinics can make use of such facilities. Household clinical waste can also be sent to such facilities for necessary treatment.

In India, there is a poor hospital waste disposal system, barring a few hospitals. We need a cost effective and environment friendly technology. This will require intensive awareness programs with greater resource allocation. A more coordinated effort from the pollution control authorities and better training of health care workers and administrators is required.

SUGGESTED READING

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