BIOMEDICAL WASTE

The wastes produced by hospitals, nursing homes, clinics, research laboratories, diagnostic centres etc. are potential sources of health hazards, and need to be specially treated and disposed off. The greatest risk of clinical waste is from the infectious and sharp components like needles, syringes etc. In addition to its infectivity, the medical waste is highly toxic and may possess variable radioactivity. Ministry of Environment and Forests has revised the Bio Medical Waste (Management and Handling) Rules promulgated under the Environment Protection Act of 1986. The Rules now called the Bio Medical Wastes (Management and Handling) Rules 2016.

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. Karnataka tops the chart with 62,241 kg/day of BMW. Uttar Pradesh, Maharashtra and Kerala come next with 44,392 kg/day, 40,197 kg/day and 32,884 kg/day of BMW generation respectively.

Around 53.25% of Health Care Establishments (HCEs) are in operation without the adequate authorization from State Pollution Control Board (SPCB)/Pollution Control Committee (PCC) which means that waste generated from such facilities goes unaccounted and is dumped without any adequate treatment illegally.

Categories of Bio Medical Waste			
Category	**Type of Waste**	**Type of bag or container to be used**	**Treatment and Disposal options**
Yellow	**a) Human Anatomical Waste:** Human tissues, organs, body parts and foetus below the viability period (as per the Medical termination of Pregnancy Act 1971, amended from time to time).	Yellow coloured non-chlorinated plastic bags	Incineration or plasma pyrolysis or deep burial
	b) Animal Anatomical Waste: Experimental animal carcasses, body parts, organs, tissues, including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses.		

c) Soiled waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs and bags containing residual or discarded blood and blood components.		Incineration or Plasma pyrolysis or deep burial In absence of above facilities, autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery.
d) Expired or Discarded Medicines: Pharmaceutical waste like antibiotics, cytotoxic drugs including all items contaminated with cytotoxic drugs along with glass or plastic ampoules, vials etc.	Yellow coloured non-chlorinated plastic bags or containers	Expired cytotoxic drugs and items contaminated with cytotoxic drugs to be returned back to the manufacturer or supplier for incineration at temperature >1200°C or to common bio-medical waste treatment facility or hazardous waste treatment, storage and disposal facility for incineration at >1200°C or Encapsulation or plasma Pyrolysis at >1200°C. All other discarded medicines shall be either sent back to manufacturer or disposed by incineration.
e) Chemical Waste: Chemicals used in production of biological and used or discarded disinfectants	Yellow coloured containers or non-chlorinated plastic bags	Disposed of by incineration or Plasma Pyrolysis or Encapsulation in hazardous waste treatment, storage and disposal facility.
f) Chemical Liquid Waste: Liquid waste generated due to use of chemicals in production of biological and used or discarded	Separate collection system leading to effluent treatment system	After resource recover, the chemical liquid waste shall be pre-treated before mixing with other

	disinfectants, Silver X-ray film developing liquid, discarded formalin, infected secretions, aspirated body fluids, liquid from laboratories and floor washings, cleaning, house-keeping and disinfecting activities etc.		wastewater. The combined discharge shall conform to the discharge norms given in Schedule III.
	g) Discarded linen, mattresses, beddings contaminated with blood or body fluid.	Non-chlorinated yellow plastic bags or suitable packing material	Non-chlorinated chemical disinfection followed by incineration or plasma pyrolysis or for energy recovery. In absence of above facilities, shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recover or incineration or plasma pyrolysis.
	h) Microbiology, Biotechnology and other clinical laboratory waste: Blood bags, Laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for culture	Autoclave safe plastic bags or containers	Pre-treat to sterilize with non-chlorinated chemicals on-site as per national AIDS control Organisation or world Health Organisation guidelines thereafter for Incineration.
Red	**Contaminated Waste (Recyclable)** (a) wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syrings (without needles and *fixed needle syringes*) and vaccutainers with their needles cut) and gloves.	Red coloured non-chlorinated plastic bags or containers	Autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recylers or for energy recovery or plastics to diesel or fuel

			oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites.
White (Translucent)	**Waste sharps including Metals:** Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps	Puncture proof, Leak proof, tamper proof containers	Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal container or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Boards or Pollution Control Committees) or sanitary landfill or designated concrete waste sharp pit.
Blue	a) **Glassware:** Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes.	Cardboard boxes with blue colored marking	Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through autoclaving or microwaving or hydroclaving and then sent for recycling.
	b) **Metallic Body Implants**	Cardboard boxes with blue colored marking	

Apart from the various categories of wastes, Schedule II of the Rules has also incorporated the storage and disposal of municipal solid waste (MSW) generated from the hospitals. The Rules expounds that the MSW such as paper waste, food waste and other non-infectious wastes generated from the hospitals should be stored in black coloured bags/containers and disposed as per the Municipal Solid Waste (Management and Handling) Rules 2000.

TREATMENT, DISPOSAL OF BIOMEDICAL WASTES

All plastic disposable items contained in medical wastes are vulnerable for reuse without proper sterilization, unless destroyed completely. The waste should be disposed off in a manner which does not cause any harm to the people or their environment. There are various methods which may be used for disposing biomedical wastes

1. **Chemical Process**
   - Chemical Disinfection

2. **Thermal Process**
   - Autoclaving
   - Hydroclaving
   - Microwaving
   - Incineration
   - Plasma pyrolysis and gasification

In addition to the above methods, land filling may also sometimes be used for disposal of some particular types of biomedical wastes. The landfills sites should, however, always be away from the residential areas, as it could be dangerous for the community health.

Landfill or burial of hospital waste may pose the following problems:-

a) Difficulty posed in safe transport
b) Health threat to community
c) Difficult availability of waste landfill sites
d) Potential source of air, soil and groundwater contamination

Biomedical wastes are generally not taken for burial, but are usually disposed of by thermal process, like autoclaving, Hydroclaving, microwaving, and incineration .Chemical disinfection followed by mutilation or shredding may also sometimes be adopted for disposal of the waste items like syringes, needles, gloves etc.

1. **Chemical Disinfection**

The waste is disinfected by using chemicals like chlorine compounds, such as bleaching powder, other chemicals like iodine, alcohol, phenolic compounds, formaldelyde, etc. may also sometimes be used. However, 1% solution of hypochlorite is most commonly used. Many of the waste items may even need shredding before disinfection, as to help in providing sufficient contact between the waste and the disinfectant. The disinfected waste will usually be shredded. In this method, the shredded wet wastes containing disinfectant chemicals will need final disposal.

Standards for efficacy of chemical disinfection

Microbial activation efficacy is equated to "Log10 kill" which is defined as the difference between the logarithms of number of test microorganisms before and after chemical treatment. Chemical disinfection methods shall demonstrate a 4Log10 reduction or greater for Bacillus Subtilis in chemical treatment systems.

2. **Autoclaving**

Autoclaving (steam sterilization) is a low heat thermal process and is designed to bring steam into direct contact with the wastes, in a controlled manner and for sufficient duration to disinfect the waste. The three basic types of steam autoclave systems are:-

a) **Gravity-type Autoclave**

In this type the pressure of steam alone is used to evacuate air from the treatment chamber. Its cycle time is approximate 60-90 minutes for full steam penetration.

As per the guidelines of biomedical waste rules 2016, when operating a gravity flow autoclave, medical waste shall subject to:

(i) Temperature of not less than 121°C 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 135°C and a 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.

b) **Pre-vacuum type Autoclave**

In this evacuates air from the treatment chamber using vacuum pumps. Its cycle time is approx 30-60 minutes as time to heat the air within the chamber is eliminated.

The waste shall be subjected to the following:

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

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

c) **Retort-type Autoclave**

It consists of large volume treatment chambers designed for much higher steam temperature and pressure.

3. **Hydroclaving**

An innovation of the autoclave where, indirect heating is done by providing steam into the outer jacket of a double Waller container, while the waste inside the inner container is turned on by a suitable mechanism. This causes the wastes to be fragmented and continuously tumbled against the hot vessel walls. The moisture content of the waste changes into steam and the vessels starts to pressurize. In the absence of enough moisture in the waste to pressurize the vessel, a small amount of steam is added until the desired pressure is reached. The treatment time is hardly 15 minutes at 132°C or 30 minutes at 121°C. In the process, sufficient sterilization occurs and the resultant waste is fragmented and dehydrated with reduction in volume and weight.

4. **Microwaving**

In this method, heating occurs inside the waste material. This process involved pre-shredding the waste, injecting it with steam, and heating it for 25 minutes at 25 °C, under a series of microwave units. Microwaving however cannot be used for human organs or tissue wastes or for hazardous and radioactive wastes. This technique does not reduce the volume of waste also.

5. Incineration

This system involves the high temperature combustion, under controlled conditions, to convert waste containing infectious and pathological material to inert mineral residues and gases. In this process dioxins are released which are very harmful. Generally this treatment is used for hazardous liquid and solid wastes like those released from hospitals or industries. There are mainly two types of incinerators which are as follows:-

a) Liquid waste Incinerators

This type of incinerators is used for burning liquid wastes. Such an incineration system will involve injecting the liquid wastes at 350-700 kPa into combustion chamber.

b) Rotary kiln Incinerators

These are most versatile of all the types of incinerators, as they can burn solid, liquid, and gaseous and sludge wastes. Throughout the world, these incinerators are used for destruction of non-liquid hazardous wastes.

All incinerators shall meet the following operating and emission standards

A. Emission Standard

Parameter	Standards	
	Limiting concentration in mg Nm^3 unless stated	Sampling Duration in minutes, unless stated
1. Particulate matter	50	30 or 1 Nm^3 of sample volume, whichever is more
2. Nitrogen Oxides NO and NO_2 expressed as NO_2	400	30 for online sampling or grab sample
3. HCI	50	30 or 1 Nm^3 of sample volume, whichever is more
4. Total Dioxins and Furans	0.1ngTEQ/Nm^3(at 11% O_2)	8 hours or 5 Nm^3 of sample volume, whichever is more
5. Hg and its compounds	0.05	2 hours or 1Nm^3 of sample volume, whichever is more

B. Operating standards

1. Combustion efficiency (CE) shall be at least 99.9%.
2. The combustion efficiency is computed as follows: $C.E. = \frac{\%\ CO_2}{\%\ CO_2 + \%\ CO} \times 100$
3. The temperature of the combustion chamber after plasma gasification shall be 1050 ± 50°C with gas residence time of at least 2 seconds, with minimum 3 % Oxygen in the stack gas.
4. The temperature of the primary chamber shall be a minimum of 800°C and the secondary chamber shall be a minimum of 1050°C ± 50°C.

C. Stack height

Minimum stack height shall be 30 meters above the ground.

6. **Plasma pyrolysis or gasification**

Like incineration, pyrolysis, gasification and plasma technologies are thermal processes that use high temperatures to break down waste. The main difference is that they use less oxygen than traditional mass-burn incineration. They typically rely on carbon-based waste such as paper, petroleum-based wastes like plastics, and organic materials such as food scraps. The pyrolysis process thermally degrades waste in the absence of air (and oxygen). Gasification is a process in which materials are exposed to some oxygen, but not enough to allow combustion to occur. Temperatures are usually above 750°C. The main product of gasification and pyrolysis is syngas, which is composed mainly of carbon monoxide and hydrogen (85 per cent), with smaller quantities of carbon dioxide, nitrogen, methane and various other hydrocarbon gases.

Standards for deep burial

1. A pit or trench should be dug about two meters deep. It should be half filled with waste, and then covered with lime 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 galvanised iron or 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 wastes.
4. The pits should be distant from habitation, and located so as to ensure that no contamination occurs to surface water or ground water. The area should not be prone to flooding or erosion.
5. The ground water table level should be a minimum of six meters below the lower level of deep burial pit.

Standards for dry heat sterilization

Waste sharps can be treated by dry heat sterilization at a temperature not less than 185°C, at least for a residence period of 150 minutes in each cycle, which sterilization period of 90 minutes. There should be automatic recording system to monitor operating parameters.

Standards for liquid waste

The effluent generated or treated from the premises of occupier or operator of a common biomedical waste treatment and disposal facility, before discharge into the sewer should confirm to the following limits-

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

adopting suitable technology such as in Road Construction, Co-incineration etc. The Municipal Authority or the operator intending to use such technology.

9. Each SPCB or PCC shall prepare and submit Annual Report to CPCB by **30th day of September** each year. The Central Pollution Control Board (CPCB) shall consolidate the report on use of plastic carry bags, sachets/pouches etc. and management of plastic waste. The consolidated report along with recommendations on implementation of the Plastic Waste (Management & Handling) (Amendment) Rules, 2011 will be submitted to MoEF by **30th Day of December**.

The Government has notified the Plastic Waste Management Rules, 2016, in suppression of the earlier Plastic Waste (Management and Handling) Rules, 2011. The Minister of State for Environment, Forest and Climate Change, Shri Prakash Javadekar, said here today that the minimum thickness of plastic carry bags has been increased from 40 microns to 50 microns. He stated that 15, 000 tonnes of plastic waste is generated every day, out of which 9, 000 tonnes is collected and processed, but 6, 000 tonnes of plastic waste is not being collected. Shri Javadekar also said that the rules, which were admissible upto municipal areas, have now been extended to all villages. The Minister said that notifying the new Plastic Waste Management Rules is a part of the revamping of all Waste Management Rules. "This will help in achieving the vision of our Prime Minister of Swacchh Bharat and cleanliness is the essence of health and tourism", Shri Javadekar added.

The draft rules, namely the Plastic Waste Management Rules, 2015 were published by the Government of India vide G.S.R. 423(E), dated the 25th May, 2015 in the Gazette of India, inviting public objections and suggestions. The Plastic Waste Management Rules, 2016 aim to:

1. Increase minimum thickness of plastic carry bags from 40 to 50 microns and stipulate minimum thickness of 50 micron for plastic sheets also to facilitate collection and recycle of plastic waste
2. Expand the jurisdiction of applicability from the municipal area to rural areas, because plastic has reached rural areas also;
3. To bring in the responsibilities of producers and generators, both in plastic waste management system and to introduce collect back system of plastic waste by the producers or brand owners, as per extended producers responsibility;
4. To introduce collection of plastic waste management fee through pre-registration of the producers, importers of plastic carry bags/multilayered packaging and vendors selling the same for establishing the waste management system;
5. To promote use of plastic waste for road construction as per Indian Road Congress guidelines or energy recovery, or waste to oil etc. for gainful utilization of waste and also address the waste disposal issue; to entrust more responsibility on waste generators, namely payment of user charge as prescribed by local authority, collection and handing over of waste by the institutional generator, event organizers.
6. An eco-friendly product, which is a complete substitute of the plastic in all uses, has not been found till date. In the absence of a suitable alternative, it is impractical and undesirable to impose a blanket ban on the use of plastic all over the country. The real challenge is to improve plastic waste management systems.