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Facing Challenges of Biomedical Waste Management Strategies in India

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Abstract

Biomedical Waste (BMW) is defined as 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 substances. The management of Bio-medical waste is still infant all across the world. Improper management of waste generated in Health Care Facilities (HCFs) causes a direct negative impact on the community, health care workers and on the environment. The waste generated in these facilities essentially consists of solids and liquid, which may be infectious / biological (10% to 15%) and non-infectious / non-biological (85% to 90%). Effective management of BMW is not only a legal necessity but also a social responsibility. It is imperative upon all the health facilities, irrespective of their size and number of patients catered, to ensure appropriate BMW management at all levels starting from its generation to its final disposal. This study provides a comprehensive overview of India's current BMW scenario, impact on society, legal management and various other management methods.

Keywords: Biomedical waste, Healthcare, Infectious, Non-infectious, Environment.

INTRODUCTION

Biomedical waste (BMW) is the infectious waste, generated from hospitals [1, 15]. Hospitals are complex institutions which are frequented by people from all walks of life in the society without any distinction between caste, creed and religion. This is in addition to the normal inhabitants of the hospital, i.e., patients and staff. Hospitals produce waste which is increasing in amount and varied in type due to scientific advances and is creating its impact. Health care waste is a unique category of waste by the quality of its composition, source of generation, its hazardous nature and the need for appropriate protection during handling, treatment and disposal. Mismanagement of the waste affects not only the generators and operators but also the common people too [1, 14]. All human activities produce waste. Such waste may be dangerous and needs safe disposal. One such category of waste is Biomedical Waste (BMW), which is inevitably created by healthcare industry. Healthcare wastes can be classified primarily into three groups (Fig.1). In the persuasion of the aim of reducing health problems, eliminating potential risks and treating sick people, healthcare services generated such waste in hospitals, research institutions, health care teaching institutes, clinics, laboratories, blood banks, animal houses and veterinary institutes. Wherever generated, a safe and reliable method for handling of BMW is essential. Inadequate and inappropriate knowledge of handling of healthcare waste can pose a serious threat to human health and a significant impact on the environment as well. In India alone approximately 484 tonnes/day of medical waste is generated from around 1,68,869 HCFs [1, 11]. Out of this, only 447 tonnes /day is treated before disposal [11].

Need of biomedical waste management

As per the Bio-Medical Waste (Management and Handling) Rules notified by the Ministry of Environment and Forests in July 1998, it is the duty of every "occupier", (in this case the heads of hospitals and other healthcare facilities) i.e. a person who has control over an institution or its premises, to take all steps to ensure that Bio-Medical Waste (BMW) generated is handled without any adverse effect on human health and the environment [3]. Unmethodical

disposal of BMW, improper management and exposure to such waste possess serious threat to environment, health impact on the cause community and health care workers. Before final disposal of BMW, it needs specific treatment and management because of its infectious and hazardous characteristics [2, 17-21]. Improper disposal can cause:

1. Organic portion fermentation and attracts flies for breeding.
2. Development of resistant strains of microorganisms.
3. Risk association with sharps, hazardous chemicals, drugs and infections to the hospital personnel, waste handlers, scavengers and public living in near vicinity of hospitals.
4. The risk of air, water, and soil pollution directly due to waste, or defective incineration emissions and ash.
5. Patients can develop HIV, Hepatitis B & C etc.
6. Encourage to unscrupulous persons for repacking and reselling of used disposables and expiry drugs.

Legal management of biomedical waste

In 1998, the Government of India, has promulgated Biomedical Waste (Management and handling) rules, under the Environment (Protection) Act, 1986 which states that every concerned health personnel are expected to have proper knowledge, practice and capacity to guide others for waste collection, management and proper handling techniques [3]. For clean and green environment, on March 28, 2016, the Ministry of Environment, Forests and Climate change (MoEFsC) of India has released few amendments in BMW management rule which are given below [4].

1. Under 'Clean India Mission', BMW categories have been reduced from 8 (2011 amendment) to 4 for better segregation and treatment (Table 1).

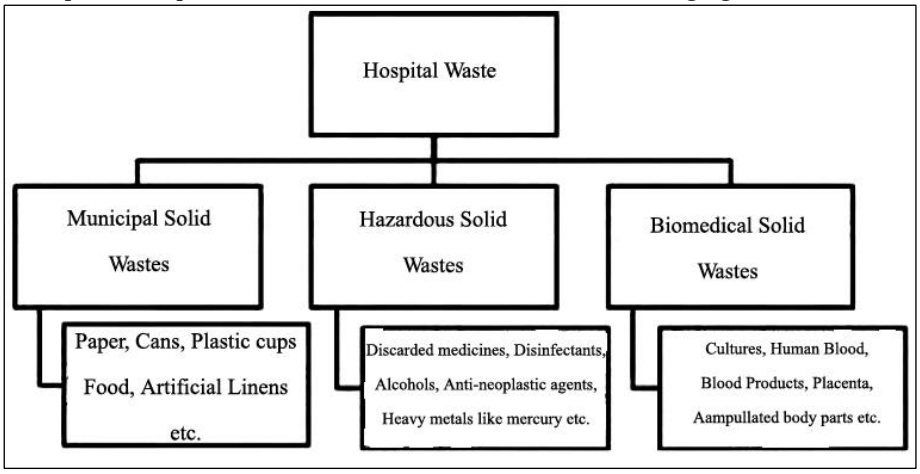

Figure 1: Classification of Biomedical Wastes

Table 1: Biomedical Waste Categories

S. No	Category	Type of Waste	Treatment and Disposal Options
1	Yellow	Human Anatomical Waste	Incineration / Plasma Pyrolysis / Deep Burial.
		Animal Anatomical Waste	Incineration / Plasma Pyrolysis / Deep Burial.
		Soiled Waste	Incineration / Plasma Pyrolysis / Deep Burial/ Autoclaving or microwaving / Hydroclaving.
		Expired or Discarded Medicines.	Returned back to the manufacturer for incineration / to CBWTF / Encapsulation / Plasma Pyrolysis.
		Chemical Waste	Incineration / Plasma Pyrolysis / Encapsulation.
		Chemical Liquid Waste	Pre-treated before mixing with waste water.
		Discarded Linen, Beddings	Chemical disinfection then incineration / Plasma Pyrolysis.
		Microbiology, Biotechnology and other Clinical Laboratory waste.	On-site Chemical disinfection, then incineration.
2	Red Contaminated Waste (Recyclable)	Wastes generated from disposable items.	Autoclaving / Microwaving / Hydroclaving / Mutilation.
3	White (Translucent)	Waste sharps including metals.	Autoclaving / Dry Heat Sterilization, shredding / Mutilation / Encapsulation.
4	Blue	Glassware	Disinfection through autoclaving / microwaving / Hydroclaving and then sent for recycling.
		Metallic Body Implants	

2. The HCFs will be now responsible for pre-treatment of laboratory, microbiological waste, blood samples and blood bags through disinfection/sterilisation on-site in the manner prescribed by the WHO or National Aids Control Organisation, regardless of whether final treatment and disposal will be happen on-site or at a Common Biomedical Waste Treatment Facility (CBWTF).
3. Waste will be collected routinely and regularly by a CBWTF within 75 kilometers of a healthcare centre.
4. Healthcare centres out of this range, must set up their own waste disposal and treatment facilities.
5. The new rules also have stricter standards of SPM emission from incinerators reduced from 150 mg/Nm^3 to 50 mg/Nm^3.
6. New rules also state the automatic authorization of bedded hospitals, while non-bedded hospitals have a one-time authorization.
7. Vaccination camps, blood donation centres and surgical camps will also follow BMW Management rules.
8. A bar-coding system is also in pipeline, where all BMW containers or bags are going to be tracked by the government.
9. Chlorinated plastic bags, blood bags and gloves will be phased out in next two years.
10. The MoEFsC will review HCF once a year through State health secretaries under the SPCB and CPCB.

At present scenario, either HCFs have their own instruments or they use CBWTFs for the management of BMW11, but the overall number of instruments are very less as compare to number of established HCFs in India.

Methods of biomedical waste management

There are various methods of biomedical waste management. Each method has some advantages and disadvantages (Table 2) [17, 19-22].

1. **Incineration**: Incineration is the controlled burning of the medical waste in a dedicated medical waste incinerator. It is a high temperature, (850-1400^{o}C) dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter. This process is usually selected to treat wastes that cannot be recycled, reused or disposed of in a landfill site [17, 21, 22].
2. **Plasma Pyrolysis**: Pyrolysis is a clean and effective technological application for rendering hospital waste environmentally benign. In this process, the intense heat of plasma energy has the effect of changing solid materials chemically in the absence of oxygen. Plasma energy is heat energy produced when electric current flows through a conductor gas such as helium, argon, nitrogen or air. Resistance of the ionized gas to the flow of electrical current (like any other conductor) creates extremely high temperatures of 21,000^{O} Fahrenheit in the form of plasma energy. It converts all organics into clean fuel gases and vitrifies inorganic material into an inert glassy slag [5, 22]. All by-products are recyclable.
3. **Deep Burial**: In remote locations, deep burial of healthcare wastes in the hospital premises is the only viable option. However, the hospital management should establish certain basic rules:
   i. Access to the disposal site should be restricted to authorized personnel only.
   ii. The burial site should be managed as a landfill, lined with of low permeability materials, such as clay, cement and distant from the habitation to prevent leaching of pollutants to groundwater and nearby wells.
   iii. Each layer of waste being covered with a 10cm layer of soil to prevent odours, as well as to prevent rodents and insects proliferating. Covers of galvanised iron/wire meshes may be used.
   iv. The area should not be prone to flooding or erosion.
   v. The institution shall maintain a record of all pits for deep burial [6, 22].
4. **Encapsulation**: It is the practice of putting the pharmaceuticals into barrels up to 75% capacity. The mixture of lime, cement and water (15:15:5) is added in to it. After filling, the sealed drums should be placed at the base of a landfill and covered with fresh municipal solid waste [7, 22].
5. **Shredding**: This is the best technique to reduce spreading of infections from BMW due to reusing of waste discarded by the HCFs like syringe, saline bottles, IV tubes, catheters, other plastic tubing etc. The shredder is usually used in combination with an autoclave or a microwave. The waste is fed into a hopper leading to a set of revolving blades/shafts that cut the waste into small pieces then pass through a mesh and are collected at the bottom. Larger particles retained on the mesh are once again passed through the cutters [9].
6. **Microwaving**: Microwave is the non-burn, 'inter-molecular' heating process based on molecular inactivation of cells for disinfection of medical waste. Microorganisms are electric dipoles, so therefore rotate as to align themselves with the alternating electric field of microwaves. These rotating molecules hit other molecules and dispersing energy, thus generating heat inside out. Due to this internal heating, temperature goes up to 200-300^{o}C which cause microbial inactivation and disinfection. In a microwave treatment unit, a loading device transfers the wastes into a shredder. The waste is then humidified, transferred to the irradiation chamber, which is equipped with a series of microwave generators and irradiated for about 20 minutes. After irradiation, the waste is compacted inside a container and enters the municipal waste stream [8, 22].
7. **Autoclaving**: Autoclaving is an efficient wet thermal disinfection process, which is not only

used for highly infectious waste, such as microbial cultures or sharp but also sterilization of reusable medical equipment. Moisture content of the waste and ease of penetration of the steam are 2 important factors for its working. Effective inactivation of all vegetative microorganisms and most bacterial spores in a small amount of waste (about 5– 8kg) requires a 60-minute cycle at 121°C (minimum) and 1 bar (100kPa), this allows for full steam penetration of the waste material.

8. **Hydroclaving**: It is an innovative steam sterilization technique. The instrument has double walled container, in which the steam is injected into the outer jacket to heat the inner chamber containing the waste. Moisture contained in the waste evaporates as steam and builds up the requisite steam pressure. Sturdy paddles slowly rotated by a strong shaft inside the chamber tumble the waste continuously against the hot wall thus mixing as well as fragmenting the same. In the absence of enough moisture, additional steam is injected. The system operates for 20 minutes at 132^{o}C and 36 psi steam pressure for sterilization. The total time for a cycle of hydroclaving is about 50 minutes. The treated material can further be shredded before disposal. The expected volume and weight reductions are up to 85% and 70% respectively [22].
9. **Chemical Treatment by Hydrolysis**: Alkaline Hydrolysis is a little-known technology but has good potentials. It is used to breaking down animal tissues, killing pathogens including prions and destroying hazardous chemicals like formaldehyde and chemotherapy drugs. If the waste is in solid form, the treatment process begins with the mechanical cutting or mashing procedure to reduce size and increase surface area of the waste, to make the chemical treatment more effective. Then wastes are reacted with highly corrosive form Sodium hydroxide or Potassium hydroxide or milder form Calcium oxide, or quicklime at 110-130^{o} C for 3-8 hours depending on the system and the pressure at which it is operated. The alkali decomposes proteins. After hydrolysis, solid residues or liquid effluents are generated. The solid effluents are filtered out, treated with liquid disinfectants and landfilled while the liquid filtrate diluted or neutralized and flush in to the sewer. Glutaraldehyde and Peracetic acid are the examples of chemical disinfectants [22].

Table 2: Advantages and disadvantages of BMW management techniques.

S. No.	Technique	Advantages	Disadvantages
1	Incineration	• Reducing the waste volume up to 90%, sterilizing process. • No need for pre-processing of waste. • Applied on all medical waste types. • Equipped with energy-recovery facilities. In cold climates, generated steam or hot water used to feed urban district-heating systems, while in warmer climates, it is used to generate electricity.	• Combustion of organic compounds generates gaseous emissions (steam, carbon dioxide, furans, dioxins, and nitrogen oxides), Toxic substances (metals, halogenic acids), Particulate matter, solid residues (ashes) and wastewater.
2	Plasma Pyrolysis	• Environmentally sound. • Suitable for all types of wastes. • Inert glassy slag used as concrete filler in roadbed construction, composition roofing and building insulation. • Gas can be used as a boiler gas or for methanol production. • Less toxic residues.	• Requires technical persons for its operation. • Expensive technique.
3	Encapsulation	• Very effective, cheap and safe process for the disposal of sharps and chemical or pharmaceutical residues.	• Along with combination of burning recommended for non-sharp infectious waste.
4	Microwaving	• Environment friendly, energy efficient and resource efficient. • Reduces or eliminates chances of infections through improper disposal of biomedical waste.	• Relatively high investment. • High operating costs. • Low potential operation.
5	Autoclaving	• No hazardous emissions. • Easy to operate. • Cost effective. • Less maintenance required. • No pre or post treatment required.	• For successful operation need drying mechanism. • Not useful in insufficient sunlight areas or heavy rain areas. • Generate foul odours. • Not suitable for all types of wastes.
6	Hydroclaving	• No harmful air emission, liquid discharges.	• Capital cost is very high.

S. No.	Technique	Advantages	Disadvantages
		• No chemicals requirement. • Reduced volume and weight of waste.	
7	Shredding	• Reduces the bulk of waste. • Easy transportation.	• The shafts or blades undergo wear and tear. • Need periodic replacement.
8	Chemical Treatment	• Cost effective • Convenient	• Consume chemicals. • The products of chemical reactions in the waste, pose problems. • Alkaline solutions and ozone can damage skin and lungs.

BIOMEDICAL WASTE MANAGEMENT IN JAMMU AND KASHMIR

It was found that BMW generated per bed per day was 0.197 kg. Infectious waste comprised 15% of the total whereas non-infectious component was 85% Medical Eligibility Criteria for Contraceptive Use. The color-coded bags collection rate per day was 48.8 kg, 28.4 kg, 17.02 kg and 7.75 kg for yellow, red, blue and white containers, respectively [13]. The quantity of waste generated per day and per bed differs greatly from one health facility to another and from one country to another country. The estimated bio-waste from any hospital consists of about 5-10% of hazardous waste; about 15-20% of BMW and the rest of 75-80% is municipal waste [16]. In accordance with the Bio-Medical Waste Management Rules, 2016, laid down by the Government of India with Amendments of 2018 and 2019, it is the duty of every occupier irrespective of the quantity of waste generated to take all necessary steps to ensure that Bio-Medical Waste is handled without any adverse effect on human health and the environment. All the Bedded and Non-Bedded Health Care Facilities (HCFs) are required to establish a bar code system for bags or containers containing Bio-Medical Waste (BMW), to account for and track the waste being sent out of the premises, for further treatment and disposal through Common Biomedical Waste Treatment facility (CBMWTF) as per Rule 4-I of BMW.

As of 2018, there were 3688 government health institutions in Jammu and Kashmir including Public Health Centres (PHCs), Community Health Centres (CHCs), and Sub-Centres. Over the past one or two decades, a large number of 'ill-equipped' Public Healthcare Centers, Sub-Centres, dispensaries, veterinaries and medical Shops have been established in the rural areas of Jammu and Kashmir. These healthcare facilities are producing large amounts of Bio-Medical Waste with no mechanism in place to safely transport and dispose of the same. At present, more than 35,000 medical shops are functioning and providing first-aid treatment in the rural areas of the Union Territory. On the one hand, these medical shops have the capacity to generate tonnes of BMW and on the other hand, the persons who run them are not equipped with the right training in BMW management. Also, the detailed estimate of BMW generated by the hospitals, private clinics, medical shops, dispensaries, households and other medical institutions in the UT remains unavailable. As a result, the precise impact of BMW on the environment and ecology is unknown due to the lack of data for validation. The sensitive situation in the wake of COVID-19 prompted the Jammu and Kashmir State Pollution Control Board (JKPCB) to issue a draft model for Bio-Medical Waste management at Panchayat (village) and Subdivision levels [18]. The model states that the segregation, collection, pre-treatment and storage of BMW is the responsibility of the hospitals, clinics, quarantine centres, isolation wards etc. So, for the safe disposal of BMW, Gram Panchayats, Panchayat Samitis, Group-Gram Panchayats, Gram Sewaks, Block / Tehsil level Offices, along with Zila Parishad were asked to ensure that they set up sufficiently robust BMW management mechanisms at the village levels. However, the directions of the JKPCB have not resulted in any positive changes. The heaps of BMW along with other solid waste, which serves as a reminder of the aforementioned fact, can be seen dumped along the roadsides and banks of bodies of water and these places are, unfortunately, considered as places to dispose of the waste in the majority of the villages.

On the basis of three months observations at Government Hospital, Gandhinagar Jammu, the average solid waste generation per bed/day and per bed/month has been calculated as 632.04 g and 18960.7 g [10]. The quantitative analysis of the waste reveals the maximum percentage of biodegradable (67.28%) followed by non-biodegradable wastes (32.72%).The present system followed for the biomedical waste management in the hospital involves collection of wastes by sweepers and disposing them into community dustbins. Wheel barrows are used by the sweepers for transferring the wastes from community bins to municipal trucks or open vehicles on weekly basis [10]. Finally the wastes are finally disposed at the Bhagwati Nagar area. It was surprising to record that the biomedical wastes generated from the Government Hospital, Gandhinagar Jammu is not disposed off in a safe and efficient manner thus posing a serious threat to all the living forms of the area [10]. The Union Territory of Jammu and Kashmir is facing a grim situation arising out of pollution due to pathological waste. There are three BMW treatment facilities in Jammu and Kashmir, out

of which one is situated in Samba district of Jammu division, whereas two are located in Lasjan and Lasipora areas of the Kashmir division. However, a very few number of healthcare institutions and medical shops in rural areas are disposing of the BMW at the aforementioned treatment facilities. And it is a fact that in rural areas, people consider the use of incineration as the preferred method of disposal of Bio-Medical Waste which is not environmental-friendly as the practice produces toxic gases giving rise to health complications.

The policy, practice (storage, collection, transportation and disposal), and compliance are crucial for setting up sustainable Bio-Medical Waste management mechanisms. The government should create awareness about Bio-Medical Waste management practices through the media and community-level communication interventions. Above all, the need for Biomedical Waste management should be supported through education, training, and the commitment of the healthcare staff and management. Creating large dumping sites and adapting to the newer, widely, accepted, economical, and environmental-friendly technologies are the first steps toward addressing the grave problem of Bio-Medical Waste management. The use of hydroclave technology, or, more precisely, advanced autoclave technology a safe and a closed loop system that renders the waste safe, producing a finely shredded dry waste which is significantly lowered in size and weight – treatment and disposal methods for clinical waste is one of the environmental friendly ways to look forward to. The government should keep a close watch on the medical institutions to ensure that they are following the Bio-medical Waste Management rules and averting any adverse effect to human health and the environment. Officials or individuals who fail to comply with these rules should be treated as offenders and summoned to make a court appearance, fined or imprisoned. In Doda region of Jammu and Kashmir, GMC administration / CMOs / Hospitals are planning to set up some Biomedical waste management plant as of now they are outsourcing this biomedical waste to private firm Anmol Pvt. Ltd. Jammu for proper disposal.

CONCLUSION

Health care is important for our life, but the waste generated from various medical activities poses a severe problem to various living forms and to our environment as well. Biomedical waste management in India is receiving greater attention due to stringent regulations made by the Ministry of health. Every HCF needs to set up requisite treatment facilities to minimise risk of biomedical hazards. Safe and effective management of biomedical waste is not only a legal necessity but also a social responsibility [10][22]. Some suggestions are:

1. BMW marked covered vehicles must be increased.
2. Alternatives transport must be used to collect the waste in case the driver is not present or bad condition of vehicles.
3. Colour code for BMW must be followed.
4. Regular training programme should be organised for the staff.
5. BMW Management Board must be established in each district.
6. Minimize the load of recycling and reusable items with proper cleaning and sterilization.
7. Segregation of various categories of waste must be done at the point of generation.
8. Pre-treatment of generated wastes would be done before its disposal [12].

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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