
HAZARDOUS AND BIOMEDICAL WASTE

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ABSTRACT

Biomedical waste has the potential to be hazardous and cause environmental pollution, so it is correct management and disposal, especially in hospitals and healthcare facilities, plays an important role in protecting both environment and public health. Biomedical waste includes a diverse range of materials originating from patients' care, research activities and medical interventions and inadequate treatment poses a significant risk. Common disposal methods such as incineration¹ are associated with environmental contamination and emissions of harmful fumes. Biomedical waste poses health risks through the spread of infectious diseases, especially injuries caused by sharp objects, and the release of toxic substances into the environment. The dangerous category includes infectious, potentially hazardous and radioactive waste, with about 10% of hospital waste considered infectious according to the World Health Organization. Various disposal techniques are used around the world, including incineration, autoclaving, microwaving, crushing, landfilling, and chemical treatment, each with advantages and limitations. This overview presents the classification of different categories of biomedical waste and its effects, processing and disposal methods discussed. In summary, the substantial impact of biomedical waste on the environment and public health requires careful handling and compliance. Implementation of sustainable waste management procedures, promoting recycling and adopting innovative technologies are essential to mitigate the adverse effects of biomedical waste on the environment and local communities.

Keywords: Sources of biomedical waste; Environmental pollution; Risks to public health; Waste management.

¹ Incineration means reducing something to ashes. In this method, waste material is burnt and converted to ashes. It is used to destroy household waste, chemical waste and biological waste (hospital wastes)

INTRODUCTION

Hospitals and various other laboratories generate large amounts of waste (including biomedical and infectious waste) that can cause various health problems and environmental hazards. Typically, in India, hospitals generate 1-2 kg of waste per bed per day and clinics generate 600 grams of waste per bed per day, of which more than 15% is hazardous or infectious waste; The material is mixed with the rest of the waste. As a result, the entire waste becomes contaminated. Therefore, waste separation and disposal require appropriate, effective and efficient laws and regulations. Sustainable management of these wastes is a social and legal responsibility for governments and general citizens. Therefore, to protect the environment and simplify these activities, these wastes must be properly collected, transported and disposed of. Various guidelines and regulations were issued by the Government of India in 1998 known as the “Biomedical Waste (Management and Management) Rules”., 1998.

These rules are constantly monitored, changed and updated from time to time as a cleaner and greener environment requires effective management. In 2016, the Government of India issued a new set of rules “Biomedical Waste Management Rules 2016²” with various amendments and additions to the old rules to improve facilities for collection, segregation, treatment and disposal of biomedical waste. We decided to publish it. Produced in hospitals and laboratories to reduce environmental pollution. Identified processing techniques include incineration, microwave ovens, autoclaves, and chemical treatments. This paper includes objectives, salient features and proposals for new regulations (Medical Bio-waste Management Regulations, 2016).

Hospital waste disposal can pose significant risks, leading to increased environmental pollution, as well as significant public health risks such as AIDS, hepatitis, plague, cholera and other similar diseases. Harmful substances present in biomedical waste have the potential to harm the atmosphere, water bodies and soil, thus leading to health problems for nearby populations. Inadequate management of medical waste results in contamination, the spread of diseases including typhoid, cholera, and hepatitis through the spread of insects, rats, and worms, and injuries caused by contaminated sharp objects.

Additional wastes generated in healthcare settings include radioactive waste, mercury-containing gadgets. Here are some of the most ecologically damaging consequences of the

² Biomedical Waste Management Rules 2016, New delhi 28th March 2016

healthcare industry. According to the World Health Organization (WHO), the composition of hospital waste is as follows: 85% is classified as non-hazardous, 10% is infectious, and the remaining 5% is noninfectious but hazardous waste.

About 15% of the waste generated in hospitals in the United States is classified as infectious waste. This the percentage of waste produced in India can range between 15% to 35%, depending on the total volume produced.

Safe and efficient management of biomedical waste is necessary to protect public health and the environment. Healthcare facilities must follow specific guidelines and regulations to ensure proper handling and disposal of biomedical waste. These guidelines include sorting waste into different categories, using appropriate containers and ensuring safe methods of transport and disposal. In addition, comprehensive training of health professionals is crucial to prevent accidents and promote compliance. By implementing these measures, healthcare facilities can minimize the risk of infectious disease spread and environmental contamination, thus protecting the well-being of patients, healthcare workers, and the general public..

SOURCES OF BIOMEDICAL WASTE

Hospital waste includes discarded material, both biological and non-biological, that is not intended for further purposes.

Using medical waste refers to a specific category of hospital waste that includes materials produced during patient diagnosis, treatment, immunization, and biomedical research. Biomedical waste, sometimes referred to as BMW, is generated in hospitals, research centers and other healthcare institutions. Clinics, laboratories, blood banks, animal shelters, and veterinary institutions³ are all examples of healthcare educational institutions.

Other sources of biomedical waste

Primary sources. The primary origin of biomedical waste is state hospitals, private hospitals, medical centres, nursing homes, medical schools, veterinary colleges, research centres, animal research centres, biotechnology institutions, blood banks, mortuaries and manufacturing units.

³ Veterinary science deals with the health and wellbeing of animals. L

□ Secondary sources. Facilities include acupuncturists⁴, dental clinics, animal and slaughterhouses, blood donation camps, immunization centres, cosmetic piercing studios and amputees. Significant sources include hypodermic needles, broken vials, ampoules⁵, intravenous needles, bandages, cotton, gauze contaminated with body fluids or blood, masks and gloves contaminated with body fluids or blood, sphygmomanometers⁶, broken thermometers, spilled drugs, waste aesthetic gases, cleaners, used disinfectants, organs, tissues, fetuses, body parts, spilled mercury and similar object.

Biomedical waste is divided into four colour categories.

Yellow: This category includes human anatomical waste, animal anatomical waste, dirty waste, expired or discarded waste, chemical waste and liquid chemical waste (leading to waste treatment systems). Bedding contaminated with blood and body fluids, microorganisms, biotechnology and other laboratory waste.

Red: Includes recyclable contaminated waste as well as waste generated from single-use items such as tubes, bottles, tubes and urine bags, syringes and gloves.

White (semi-transparent): contains sharps containing metal (including used, contaminated and discarded metal sharps)

Blue: Includes broken, contaminated or discarded glass and metal body implants.

CLASSIFICATION OF BIOMEDICAL WASTE

• Non-hazardous waste

This is about 85% of the waste generated in most healthcare facilities. This includes waste materials such as organic food waste, fruit peels, wastewater, paper cartons and packaging materials

• Hazardous waste

⁴ A person trained in acupuncture (therapy that uses thin needles inserted through the skin at specific points on the body to control pain and other symptoms)

⁵ A small sealed glass capsule containing a liquid, especially a measured quantity ready for injecting.

⁶ Is a device used to measure blood pressure

The remaining 10-25% of biomedical waste is in the categories of hazardous waste. Contains hazardous waste infectious characteristics about 15% - 18% and toxicity characteristics about 5% - 7% various hazardous wastes.

Types of biomedical waste

Different categories of organic waste, which will be briefly explained in later sections.

Contaminated waste: This waste contains pathogens, including laboratory waste, blood, tissues, cotton swabs, excreta, waste from isolation wards and infected equipment.

Medical waste: includes human tissues, body parts, blood samples and other biological materials liquid

Genotoxic waste: It contains genotoxic drugs along with cytotoxic drugs commonly used in cancer therapy chemicals

Pharmaceutical waste: refers to discarded materials including expired or unnecessary drugs, pharmaceuticals, and contaminated pharmaceutical chemicals.

Heavy metals are a form of waste worn, damaged thermometers, blood pressure gauges, gas cylinders and pressurized containers contain significant amounts of heavy metals.

Radioactive waste: refers to waste materials including contaminated glassware, urine and bodily waste of patients who underwent radionuclide treatment.

Chemical waste: includes spent laboratory chemicals, solvents and pesticides. Sharp objects. Sharps medical equipment such as shattered glasses, blades, syringes, scalpels and a needle, which has the ability to penetrate.

Some of the waste management processes that are applied till now are summarized below. Handling, segregation, mutilation, disinfection, storage, transportation and final disposal are vital steps for safe and scientific management of biomedical waste in any establishment. The key to minimization and effective management of biomedical waste is segregation (separation) and identification of the waste. The most appropriate way of identifying the categories of biomedical waste is by sorting the waste based on color. This has to be segregated into

containers/ bags at the point of generation in accordance with Schedule II of Biomedical Waste (management and Handling) Rules 1998⁷ as given in Table I.

General waste like garbage, garden refuse etc. should join the stream of domestic refuse. Sharps should be collected in puncture proof containers. Bags and containers for infectious waste should be marked with the Biohazard symbol. Highly infectious waste should be sterilized by autoclaving. Cytotoxic wastes⁸ are to be collected in leak proof containers clearly labeled as cytotoxic waste. Needles and syringes should be destroyed with the help of needle destroyer and syringe cutters provided at the point of generation. Infusion sets, bottles and gloves should be cut with curved scissors.

If the collection of biomedical waste is stored in a suitable place. They should be separated according to different categories and collected in one container. Length of stay 8-10 hours in hospitals (250 beds or more) and 24 hours in nursing homes or no record. Each container may be clearly labeled to indicate in which room it is kept. The reason for this tag is that you may need to trace it back to its source. A caution sign should be posted next to this storage area

Disinfection of sharps soiled linen, plastic and rubber goods are to be achieved at point of generation by usage of sodium hypochlorite with minimum contact of one hour. A fresh solution should be made in each shift. On site collection requires staff to close the waste bags when they are three quarters full either by tying the neck or by sealing the bag. Storage area needs to be impermeable and hard standing with good drainage. It should provide easy access to waste collection vehicles.

Biomedical waste should be transported within the hospital by means of wheeled trolleys, containers or carts that are not used for any other purpose. The trolleys have to be cleaned daily, of site transportation vehicle should be marked with the name and address of carrier. Biohazard symbols should be painted. A suitable system for securing the load during transport should be ensured. Such a vehicle should be easily cleanable with round corners. All disposable plastic should be subjected to shredding before disposing off to vendor. Final treatment of biomedical

⁷ Bio- medical management and handling rules, 1998, No 460, New Delhi 20 July 1998

⁸ Cytotoxic and cytostatic waste includes medicines in tablet, liquid, cream or aerosol form.

waste can be done by technologies like incineration⁹, autoclave¹⁰, hydro-Clave or microwave.

Biomedical waste categories and their disposal methods are tabulated in Table II.

DISPOSAL OF BIOMEDICAL WASTE METHODS

Awareness should be increased among producers of biomedical waste and processors of biomedical waste. Supporting the establishment of a Common Biomedical Waste Treatment Facility (CBWTF) would prove to be very useful in the disposal of biomedical waste.

Incineration: During high temperature incineration, solid wastes undergo effective oxidation removes the pathogenic¹¹ chemicals inside it. This process is sometimes referred to as controlled combustion treatment. The temperature range for incineration varies between 980 and 2000°C. After incineration, the waste becomes non-reusable, non-recyclable and unsuitable for disposal in landfills. The primary objective of the incineration process is to reduce the volume of solid waste. Inside of course in modern incinerators, the temperature reaches a level that is sufficiently elevated to generate a melt. Material this molten material is then subjected to a process that reduces its volume to 5% or lower even a little bit. However, the incineration process results in hazardous and carcinogenic emissions substances, which lead to significant environmental pollution and harmful effects on the human reproductive system and hormonal balance. Many hospitals in the Kurdistan region of Iraq use incineration systems.

Autoclaving: Autoclaves sterilize a wide range of infectious wastes including cultures and medical equipment. Sharps, blood contaminated items, microbiological waste, pathological waste and spoiled waste. Autoclaving is a thermal process in which waste is exposed to high temperatures for a time sufficient to effectively sterilize it. The autoclave must have the ability to withstand repeated use pressure accumulation and steam release, shall be constructed with suitable materials and engineering design, maintain specific temperature and pressure levels,

⁹ Is the destruction of something, especially waste material, by burning. Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration of waste materials converts the waste into ash, flue gas and heat.

¹⁰ Uses high pressure steam for a very specific period of time and temperature to kill pathogens, such as bacteria or viruses. This process disinfects the waste prior to final disposal

¹¹ Pathogens are biological agents, such as viruses, bacteria, fungi, or parasites, that can cause disease in living organisms

and undergo tests that are internationally compliant standards for safe operation of pressure vessels.

Microwaving: Microwaving is a steam-based technology that generates energy through microwaves. Using moist heat and steam, often lasting 30 minutes to 1 hour. Categories of biomedical waste processed using microwave technology includes laboratory waste, contaminated waste, infectious materials such as blood and body fluids, sharps and spoiled waste such as used cotton, bandages, and bed. Microwave technology should not be used to treat cytotoxic, explosive substances, hazardous waste, radioactive waste, contaminated animal carcasses or body parts.

Shedding/Cutting: During the cutting process, the organic waste is shredded or cut into small pieces, rendering waste unrecognizable. It helps prevent recycling of hazardous waste and serves as a marker that biological waste has been sterilized and is safe for disposal. Advanced single or Multiple shaft shredders, especially built for biomedical waste, can reduce the volume of such waste 80%.

Landfilling: Disposal of biomedical waste in landfills inevitably leads to gas production and Leachate¹² Dispersion of and contact with gas and leachate from a landfill site the surrounding environment can give rise to significant environmental problems, including health hazards, fires and explosions, noxious odors, damage to plant life, air pollution, groundwater contamination, and climate change.

Chemistry-based technology: The use of chemistry-based technology biological waste management different types of chemicals is used for biomedical waste management. Cultivation, sharps, liquid waste, human waste, laboratory waste and soft waste are processed using chemical techniques, hospitals pre-disinfect biological waste until transfer to disposal site.

Biomedical wastes generated from healthcare facilities, laboratories and even households pose significant environmental problems due to potential hazards and inappropriate disposal methods. The environmental effects of biomedical waste are multifaceted and require a

¹² Any contaminated liquid that is generated from water percolating through a solid waste disposal site, accumulating contaminants, and moving into subsurface areas.

comprehensive understanding for their effective management.

ENVIRONMENTAL AND HEALTH RISK CAUSED BY BIOMEDICAL WASTE

First, biomedical waste contains a variety of infectious pathogens, hazardous chemicals, and pharmaceuticals that can contaminate soil, water, and air if not properly managed. Improper disposal, such as landfilling or open burning, can lead to the release of toxins and pathogens into the environment, endangering ecosystems and public health. For example, mercury from broken thermometers and batteries can seep into soil and water, affecting aquatic life and entering the food chain.

Second, biomedical waste contributes to pollution and greenhouse gas emissions. Incineration, a common disposal method, releases harmful pollutants such as dioxins, furans and heavy metals into the atmosphere, which contribute to air pollution and climate change. In addition, long distance transportation of biomedical waste increases carbon emissions and exacerbates¹³ environmental degradation.

Third, improper disposal practices pose a risk to wildlife and biodiversity. Animals come into contact with biomedical waste while foraging or nesting, which can lead to ingestion and entanglement. This can lead to injuries, infections and even death, destroying fragile ecosystems and putting species at risk of extinction. Marine life is particularly sensitive to plastic debris such as syringes, tubing and packaging materials, which can suffocate or injure aquatic life.

In addition, mismanagement of biomedical waste can affect natural resources and ecosystems. Contaminated soil and water resources can affect agricultural productivity, impair the quality of drinking water, and pose risks to human health and food security. In addition, the reduction of resources such as energy and water in the production and disposal of biomedical waste aggravates environmental problems.

Biomedical waste poses significant risks to the environment and public health if not properly managed. It includes various types of waste generated from medical centers, laboratories, hospitals, clinics, diagnostic centers and other medical environments. These wastes can contain

¹³ In medicine, exacerbation may refer to an increase in the severity of a disease or its signs and symptoms.

infectious materials, hazardous chemicals, and radioactive materials, making their safe disposal important. Here are some steps you can take to overcome biomedical waste

CASE LAW

In the case of *Science, Technology and Environmental Research Foundation v. Union of India* (1999)¹⁴, related to mishandling and disposal of hazardous biomedical waste, particularly by hospitals, research institutes and laboratories in India. Indiscriminate disposal of biomedical waste poses a serious threat to the environment and public health.

The key issue before the Supreme Court of India is to address mismanagement of biomedical waste and lay down rules and guidelines for safe handling, treatment and disposal. In addition, the court must determine the responsibility of various stakeholders, including the central government, state government, health authorities and research institutions, in ensuring compliance with environmental norms and protecting public health.

In its ruling, the Supreme Court emphasized the need for proper management of biomedical waste to prevent pollution and protect human health. It directed the Central and State Governments to adopt comprehensive rules and guidelines for biomedical waste management.

In addition, the court emphasized the importance of public awareness and participation in waste management practices. It highlights the responsibility of healthcare institutions, laboratories and research institutions to adopt environmentally friendly practices and comply with regulatory requirements.

In general, the case of *Foundation for Research in Science, Technology and Ecology v. Union of India* (1999) was instrumental in establishing a legal framework for managing biomedical hazardous waste and promoting environmental sustainability in India. Public health.

STEPS TO OVERCOME

Laws and Regulations: Comprehensive laws and regulations are important to ensure proper management, treatment and disposal of biomedical waste. These regulations should cover all

¹⁴ *Science, Technology and Environmental Research Foundation v. Union of India* (1999), Writ Petition (civil) 657 of 1995

aspects including waste segregation, storage, transportation, treatment and final disposal. Detailed enforcement mechanisms should be established to ensure compliance.

Waste segregation: Proper segregation of biomedical waste at the point of production is essential to prevent contamination and promote safe transportation. Waste should be sorted into different streams using containers and color labels such as infectious waste, sharps, chemical waste and pharmaceutical waste.

Education and training: Health care workers and staff involved in handling biomedical waste should receive regular training in waste management practices such as sorting, packaging and disposal. They should be educated about the potential hazards associated with biomedical waste and trained in the effective use of personal protective equipment (PPE).

Use of safer alternatives: Encourage the use of safer alternatives and environmentally friendly products in healthcare settings to reduce the generation of hazardous biomedical waste. This includes measures such as reducing the use of single-use items, choosing reusable medical devices when possible, and replacing hazardous chemicals with less harmful alternatives.

Investment in infrastructure: Safe management of biomedical waste requires proper infrastructure. This includes creating designated areas for waste storage, treatment and disposal.

Conclusion and Recommendations on Hazardous and Biomedical Waste Management effective management of hazardous and biomedical waste is paramount to safeguarding public health and preserving the environment. As we've explored, these types of waste pose significant risks if not handled properly, including contamination of soil, water, and air, as well as potential health hazards to those exposed. In light of these challenges, it's essential to conclude with actionable recommendations for improving waste management practices.

CONCLUSION

Hazardous and biomedical waste management requires a comprehensive approach that encompasses stringent regulations, robust infrastructure, and ongoing education and awareness campaigns. While progress has been made in many regions, there are still significant gaps and challenges that need to be addressed to ensure the effective management of these types of waste.

First and foremost, regulatory frameworks must be strengthened and enforced to ensure compliance with waste management standards. This includes implementing strict guidelines for the segregation, collection, transportation, treatment, and disposal of hazardous and biomedical waste. Governments and regulatory bodies should also invest in monitoring and enforcement mechanisms to hold violators accountable and deter illegal dumping and improper disposal practices.

Furthermore, investment in infrastructure is crucial to support proper waste management practices. This includes establishing dedicated facilities for the treatment and disposal of hazardous and biomedical waste, as well as implementing technologies that minimize environmental impact and maximize resource recovery. Collaboration between government agencies, private sector stakeholders, and international organizations can help mobilize the financial and technical resources needed to build and maintain this infrastructure.

In addition to regulatory and infrastructure measures, education and awareness play a vital role in promoting responsible waste management behaviors. Training programs should be developed for healthcare workers, waste handlers, and the general public to raise awareness about the risks associated with hazardous and biomedical waste and provide guidance on safe handling and disposal practices. Community engagement initiatives can also help foster a culture of environmental stewardship and encourage individuals to take proactive steps to minimize waste generation and pollution.

Proper biomedical waste management is critical for ensuring the health of healthcare personnel, the general public, and the environment. Following the measures indicated above will help to guarantee that biomedical waste is handled and disposed of safely.

RECOMMENDATION

Strengthen Regulatory Frameworks: Governments should review and update existing waste management regulations to align with international best practices and ensure comprehensive coverage of hazardous and biomedical waste. Enforcement agencies should be adequately resourced to monitor compliance and take enforcement actions against violators.

Invest in Infrastructure: Public and private sector stakeholders should collaborate to invest in the development of infrastructure for the safe handling, treatment, and disposal of hazardous

and biomedical waste. This includes establishing centralized treatment facilities, implementing waste to energy technologies, and upgrading existing waste management infrastructure to meet current and future needs.

Promote Innovation: Research and development efforts should be supported to identify innovative technologies and approaches for the management of hazardous and biomedical waste. This includes advancements in waste treatment technologies, recycling and resource recovery processes, and alternative disposal methods that minimize environmental impact.

Enhance Education and Awareness: Public awareness campaigns should be launched to educate healthcare workers, waste handlers, and the general public about the importance of proper waste management practices. Training programs and educational materials should be developed to provide practical guidance on waste segregation, handling, and disposal procedures.

Foster Collaboration: Collaboration between government agencies, industry stakeholders, academia, and civil society organizations is essential to address the complex challenges associated with hazardous and biomedical waste management. Multi-stakeholder partnerships can facilitate knowledge sharing, resource mobilization, and the implementation of holistic solutions.

In conclusion, effective management of hazardous and biomedical waste requires a concerted effort from all stakeholders, including governments, regulatory bodies, healthcare providers, waste management companies, and the general public. By implementing stringent regulations, investing in infrastructure, promoting innovation, enhancing education and awareness, and fostering collaboration, we can mitigate the risks associated with these types of waste and build a more sustainable future for generations to come.

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