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BIOMEDICAL WASTE MANAGEMENT AND UTILIZATION METHOD

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Abstract
This study plays an important role in the management of biomedical waste within hospital settings, exploring its profound impact on both environmental sustainability and human health. The escalating generation of biomedical waste presents a pressing challenge, necessitating comprehensive strategies for collection, segregation, transportation, treatment, and discarding. The environmental ramifications of inadequate biomedical waste management are vast, encompassing soil, water, and air contamination. Furthermore, the potential transmission of infectious agents poses a direct threat to public health. Investigating the interconnectedness of these issues, our research examines the evolution management of biomedical waste practices and their implications for mitigating environmental pollution and safeguarding human well-being. We analyze various treatment methods, ranging from traditional incineration to modern technologies like autoclaving and microwaving, assessing their efficacy in rendering biomedical waste harmless. A comparative evaluation sheds light on the environmental footprint and economic feasibility of each approach. Ultimately, this research provides insightful information about enhancing biomedical waste management protocols, advocating for sustained methods that save the environment but also prioritize the health and safety of both healthcare workers and the general population.

Keyword: BMW, hazardous, segregation

INTRODUCTION

The latest advancements in healthcare facilities are specifically designed to prevent and safeguard community health. Advanced medical equipment is now accessible for use in a variety of procedures to treat illnesses. The advancement of scientific knowledge and its consequent improvement has led to a waste generation rate per patient in healthcare facilities. Hyper-dermic bandages, gloves, blades, scalpels, surgical cotton, clothing, abandoned medication and bodily fluids, Homo sapience tissues and Biological structure, chemicals, etc. are only a few of the wastes produced during the provision of healthcare. Additional pollutants produced in healthcare environments include PVC plastics, mercury-containing devices, radioactive wastes, etc. These are the healthcare goods that are most sensitive to environmental factors, therefore they require more care and monitoring (Remy, 2001).

Accordance to the World Health Organization, 85 percent of hospital wastes aren't genuinely harmful; the remaining 10% are contagious, and other than 5% aren't infectious but are nevertheless classified as hazardous waste. Hospital trash is classified as infectious waste in between 15% and 35% of cases. The entire amount of garbage produced determines this range (Glenn and Garwal, 1999). These wastes now pose a concern to the public because medical facilities are located in the center of the city. Improper Handling of medical waste can result in serious infections and pose a risk to humans handling it, the environment, and other people. Concerns about negative views by waste handlers, health, and environmental repercussions, and regulatory uncertainties are a few major issues in a nation's management of waste in Healthcare (Freeman, 1998).
This topic has received significant attention worldwide, and suitable waste management methods are being created and implemented. Several difficulties are being faced at many places in the implementation of this plan in practice. The waste disposal is governed by Government agencies and regulations including private organizations.

At present, there is no available information that describes the actual practice of handling the waste of health care products. The Ministry of Environment and Forests' Biomedical Waste (Management and Handling) (Second Amendment) Rules, 2000, are compliant with the planned hospital waste management plan. As a result, this study aims to assess biomedical waste handling and treatment in different healthcare settings.

2. Required of Biomedical Waste Management

Healthcare staff, the general public, and the environment are all directly put at risk for health problems when trash from these facilities is not properly managed. In parameter to decrease the risk of contamination for waste handlers, scavengers, and people living near hospitals, biological waste management and supervision are necessary outside of the hospital. The potential for contamination of the air, water, and soil, as well as the ash and emissions from inappropriate cremation, makes biomedical waste management necessary. It is crucial for getting rid of leftover medications that can be repackaged and sold. To protect public health and the environment, The government has established guidelines for the management, elimination, and treatment of solid and hazardous waste by the requirements of the Environment (Protection) Act, of 1986. Biomedical waste management substantially assists with both solid and hazardous waste management.
The Central Government used the powers afforded by Sections 6, 8, and 25 of the Environmental (Protection) Act, 1986 to draft the Bio-Medical Waste (Management and Handling) Rules 1998. Six schedules and fourteen separate rules were produced, and on July 27, 1998, they all came into force. 2016 saw further alterations made to them. These rules' main objective is to set up a licensing and reporting system for biological waste generated by hospitals and other healthcare facilities. Safety Act (1986). Any person or organization that generates, collects, receives, stores, transports, handles, discards, or manages biological waste in any way is subject to these restrictions. Additionally, they require these organizations to take all reasonable measures to ensure that the garbage is disposed of appropriately.
Various methods are to be used for the disposal of BMW are:
a) Incineration
b) Autoclave
c) local autoclaves
d) Microwaving
e) Chemical Treatment
f) Discarding in landfills
g) Sterilization
h) Hydroclaving treatment

The kind of waste determines most trash disposal strategies. Waste segregation, storage, and safe disposal are key components of an efficient biological waste management system in the workplace.

2.1 Segregation: The important step of segregating biological waste is essential to improve biomedical waste management. Reducing infectious trash in large quantities is necessary to keep garbage from piling up faster than management can handle. Biomedical wastes are to be gathered in properly labeled, different-colored plastic bags, according to Rule 6. Only authorized trucks are allowed to transport these waste materials. Moreover, Rule 6 stipulates that no untreated biological waste may be kept in storage for more than 48 hours without permission from the relevant authorities.

Biomedical waste segregation is essential to manage it safely and efficiently. Here's a guide on how bio-contaminated waste is typically segregated:

2.2. Color-coded Containers:

Color-coded containers in bio-contaminated waste management help in easy identification and proper segregation of different types of waste. Here are the common color codes:

a. Red Bag: Using a red bag for biomedical waste is a common practice to clearly distinguish and safely dispose of potentially hazardous materials in healthcare settings. The red color helps identify and handle these waste items appropriately. Contaminated waste items including gloves, syringes, urine bags, IV tubes, bottles, and catheters are recyclable.

b. Yellow Bag: Yellow Bags are frequently used to collect and discard medical waste that poses a potential infection risk. This category includes objects infected with body fluids, blood, and bodily fluid-contaminated materials like bandages and swabs. The color-coded system aids in proper waste management and ensures the safe handling of various types of medical waste.

c. Black Bag: The black bag is used for non-infectious, general waste in healthcare settings. This includes items like packaging materials, chemical waste, cytotoxic drugs, food waste, and non-hazardous items. The color-coded system helps differentiate between various types of waste, facilitating proper disposal procedures

d. White bag: White bag is commonly used in biomedical waste management to segregate and dispose of certain types of medical waste, such as non-sharp items like gloves, gauze, and other non-contaminated materials. These bags are designated for general medical waste that does not pose a significant risk of puncturing or leaking. It's important to follow proper disposal protocols and regulations when handling biomedical waste to ensure safety and compliance with environmental regulations.

e. Blue Bag: Blue bags are often designated for recyclable waste in healthcare settings. This may include materials like paper, cardboard, and certain plastics. Using color-coded bags helps streamline waste management processes and encourages recycling practices within medical facilities.

2.3. Segregation at Source:

Biomedical waste should be segregated at the point of generation (hospitals, clinics, labs, etc.).
Healthcare workers separate waste into appropriate categories immediately after use.

2.4. Categories for Segregation:

2.4.1 Infectious Waste:

Infectious waste, also known as biohazardous waste, includes materials infected with blood and other potentially infectious materials. Proper disposal is crucial to prevent the spread of infections. **Examples:** Used needles, bandages, and cultures.

2.4.2 Hazardous Waste:

Hazardous waste is defined as materials that pose a risk to human health or the environment due to their chemical or physical characteristics. Handling and disposing of these materials appropriately are necessary to minimize any potential risks. **Examples:** Chemical reagents, disinfectants, and pharmaceuticals.

2.4.4 Sharps Waste:

Sharps waste refers to medical waste that includes used needles, syringes, and other sharp objects used in healthcare settings. Proper disposal is crucial to prevent injuries and the spread of infections. If you have sharps waste, it's important to follow local regulations and guidelines for safe disposal, often involving special containers or designated drop-off locations. **Examples:** Needles, scalpels, and broken glass.

2.4.5 Pharmaceutical Waste:

Pharmaceutical waste encompasses expired, unused, or contaminated medications and other pharmaceutical products. Proper disposal is vital to prevent environmental contamination and protect public health. Many places have specific guidelines for disposing of pharmaceutical waste, often involving designated collection programs or authorized disposal facilities. It's essential to follow local regulations to ensure safe and responsible disposal. **Examples:** Expired drugs and pharmaceutical packaging.

2.4.6 Radioactive Waste:

Radioactive waste is defined as materials that contain components produced by radioactive processes, such as nuclear power generation, medical treatments, or research projects. Radioactive waste must be disposed of properly as it may have an impact on the environment and human health. Laws and protocols control how radioactive waste is managed and disposed of in many countries. These processes often involve the safe transportation, storage, and, in some cases, the placement of the waste in long-term geological repositories designed to keep it for an infinite amount of time. **Examples:** Radioactive isotopes and contaminated items.

2.5. Proper Packaging:

It needs to be packed correctly to keep diseases from spreading and to safeguard those handling biological waste. Biomedical waste includes items like used needles, syringes, and other medical materials. It should be segregated into categories such as sharps, infectious waste, and non-infectious waste. Packaging should be puncture-proof, leak-resistant, and labeled according to regulations. Following established guidelines for biomedical waste packaging is crucial to minimize risks and facilitate safe disposal.

2.6. Labeling:

Labeling is a critical aspect of various contexts, including biomedical waste, hazardous materials, and product information. Proper labeling ensures clear communication of contents, hazards, or instructions. When it comes to biomedical waste, labels ought to specify the kind of waste (e.g., infectious, sharps), proper disposal instructions, and any required safety precautions. Adhering to labeling regulations is essential for safety, regulatory compliance, and effective communication in diverse settings, from healthcare facilities to hazardous material storage.

2.7. Training and Awareness:

Training and awareness play key roles in promoting safety and compliance in various contexts, such as healthcare, workplace safety, and environmental protection. Providing training to individuals ensures they understand proper procedures, guidelines, and protocols. This is crucial in areas like biomedical waste disposal, where correct handling and disposal methods are essential. Additionally, People may contribute to a safer environment by being made aware of possible risks and the need of following safety practices. Regular training programs and awareness campaigns help maintain a culture of safety and responsibility.

2.8. Compliance with Regulations:

Compliance with regulations is vital in numerous fields, including healthcare, environmental protection, and waste management. It ensures that organizations and individuals adhere to established rules and standards, promoting safety, ethical practices, and legal obligations. In areas like biomedical waste disposal, complying with regulations helps prevent environmental contamination and protects public health. Regular updates and adherence to specific guidelines contribute to responsible practices. Failure to comply may lead to legal consequences and pose risks to individuals and the community, emphasizing the importance of staying informed and following established regulations.

3. TYPES OF WASTAGE

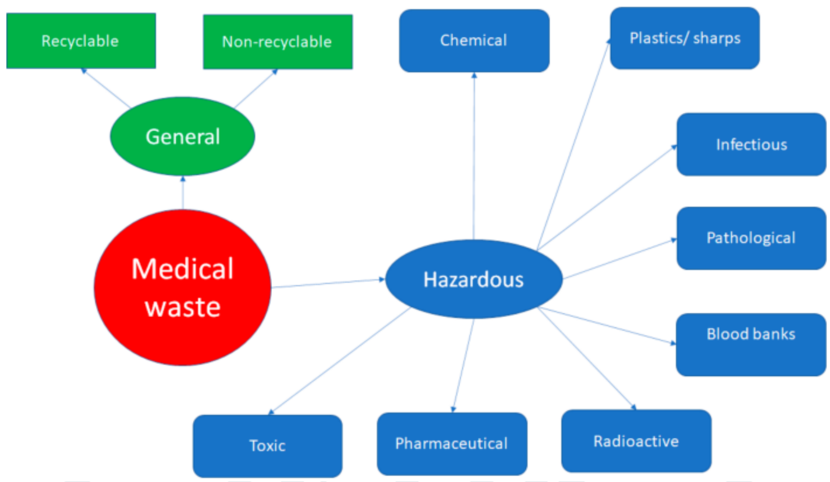


Fig: 1 diagram on medical waste categories

4. ENVIRONMENTAL AND HEALTH RISKS CAUSED BY BIOMEDICAL WASTE

All conventional medical facilities that serve patients—human or animal—such as clinics, hospitals, dentist offices, dialysis centers, blood banks, and university laboratories—produce biomedical waste. Health care waste is any material—biological or nonbiological—that is disposed of at a medical institution and isn't intended for any other use. The primary groups at a hospital or other healthcare facility that are at risk are as follows: - Medical personnel, such as nurses and physicians; - Patients; - Guests; - Employees in auxiliary services, such laundromats and pharmacies, as well as those in charge of gathering and moving garbage; - Support personnel who handle waste treatment and disposal of medical facilities. The hepatitis B (HBV), hepatitis C (HCV), and HIV viruses are the three most common infections among healthcare professionals. An estimated 3 million healthcare professionals globally are at risk of bloodborne infections each year, including 170,000 with HIV, 0.9 million with HCV, and 2 million with HBV. These numbers are approximations. Additionally, there is a risk to the workers who handle the collection and management of biological waste.

Infection Type	Pathogen Agents	Transmission Path
Gastrointestinal infections	Enterobacteria: Salmon ell, Shigella spp. Vibrio cholerae Helminths	Faeces or/and vomiting liquid
Respiratory infections	Mycobacterium tuberculosis Measles virus Streptococcus pneumonae	Respiratory secretions, saliva
Eye infections	Herpes virus	Eye secretions
Genital infections	Neisseria gonorrhoeae Herpes virus	Genital secretions
Skin infections	Streptococcus spp.	Purulent secretions
Anthrax	Bacillus anthracis	Secretions of skin lesions
Meningitis	Neisseria meningitidis	LCR
AIDS	HIV	blood, semen, vaginal secretions
Hemorrhagic fevers	Junin Viruses, Lassa, Ebola Marburg	Biological fluids and secretions

Biomedical waste, if the improperly handled, can result in various environmental and health risks expected to its potentially hazardous nature. Here's a detailed overview:

4.1. Infectious Disease Transmission:

Risk: Biomedical waste often contains infectious materials like used needles, syringes, and contaminated sharps. Poor handling or disposal practices can lead to the transmission of diseases such as HIV, Hepatitis B and C, and other bloodborne pathogens.

Impact: Increased incidence of infections among healthcare workers, waste handlers, and the general public if exposed to improperly managed biomedical waste.

4.2. Chemical Contamination:

Risk: Biomedical waste may include chemicals such as disinfectants, pharmaceuticals, and radioactive materials, which can contaminate the environment.

Impact: Soil and water pollution, pose risks to ecosystems, and aquatic life, and potentially enter the food chain with detrimental effects on human health.

4.3. Air Pollution:

Risk: Incineration of biomedical waste without proper controls can release toxic fumes and pollutants into the air, including dioxins, furans, and other harmful substances.

Impact: Respiratory problems, long-term health issues, and environmental degradation due to air pollution.

4.4. Occupational Hazards:

Risk: Healthcare workers, waste handlers, and those engaged in the gathering and removal of biological waste are at risk of direct exposure to infectious agents and harmful chemicals.

Impact: Increased occupational health risks, ranging from infections to chronic illnesses, affecting the well-being of individuals working in the cycle of waste management.

4.5. Water Contamination:

Risk: Improper disposal practices, such as dumping biomedical waste into water bodies or inadequate treatment, can contaminate water sources with pathogens and chemicals.

Impact: Spread of waterborne diseases, compromised water quality, and potential harm to aquatic ecosystems.

4.6. Community Exposure:

Risk: Poorly managed biomedical waste can lead to community exposure, especially in areas with inadequate waste disposal infrastructure.

Impact: Increased risks of infections and other health issues for residents living in proximity to improperly handled biomedical waste.

4.7. Antibiotic Resistance:

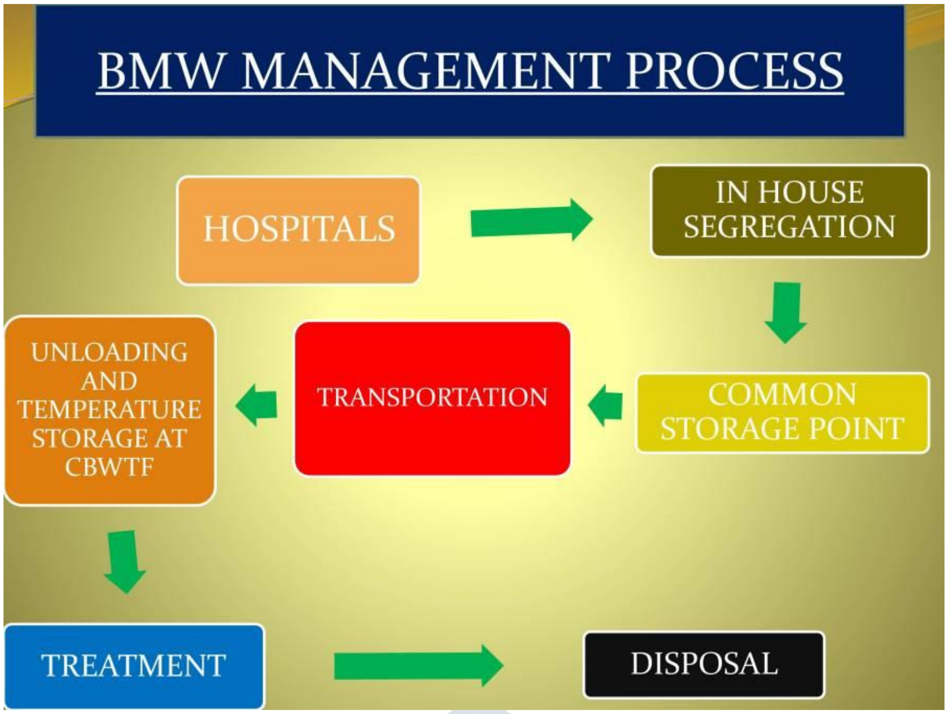
Risk: Improper disposal of pharmaceutical waste can contribute to the development of antibiotic resistance when drugs enter the environment.

Impact: Reduced effectiveness of antibiotics, posing a global health threat as the spread of drug-resistant microbes increases.

Addressing these risks requires stringent regulations, proper waste segregation, effective treatment methods, and awareness campaigns to promote responsible biomedical waste management practices.

5. Transport of BMW

Biomedical waste transport involves adhering to strict regulations to safely move and dispose of medical waste. Specialized vehicles equipped with proper containers are used to transport biomedical waste, ensuring containment and preventing potential hazards. Compliance with local and national regulations is crucial to minimize environmental and public health risks.



6. Biomedical Waste Storage

Common storage points for biomedical waste typically include designated areas within healthcare facilities such as hospitals, clinics, laboratories, and research institutions. These areas are equipped with specialized containers or bins designed to safely store biomedical trash up to a collection point for removal and treatment by authorized waste management companies or government agencies.

7. Biomedical Waste Treatment Method

Various techniques have been developed to make biological waste both visually pleasing and ecologically safe

7.1. Incineration:

The process of incinerating garbage involves burning it at a high temperature under controlled conditions to produce inert gases and materials. Incinerators can run on electricity, oil, or a mix of the two. More broadly, hospital trash is incinerated using three different types of incinerators: controlled air, rotary kiln, and multiple hearth types. To provide the best possible combustion, all varieties can feature main and secondary combustion chambers. The primary chamber of the multiple hearth incinerator is used for solid phase burning, while the secondary chamber is used for gas phase combustion. Because there is surplus air in both chambers, they are called excess air incinerators. The cylindrical shell of the rotary kiln is coated with refractory and tilted slightly to allow for easier mixing and flow of the waste within.

7.2. Autoclaving:

Autoclave treatment of clinical waste involves subjecting the waste to high-pressure steam at temperatures typically ranging from 121°C to 134°C for a specified period, usually around 15 to 30 minutes. This process effectively sterilizes the waste, killing pathogens and reducing the volume of waste. Autoclaving is a commonly used method for treating various types of biomedical waste, including sharps, laboratory materials, and other infectious waste items.

7.3. Microwaving:

Microwaving biomedical waste is another method used for treatment, although it's less common compared to autoclaving. In this process, the waste is exposed to microwave radiation, which generates heat and effectively sterilizes the waste. However, microwaving may not be as thorough as autoclaving and may not be suitable for all types of biomedical waste. It's important to follow proper protocols and guidelines when using microwaving as a method of waste treatment. Microwave technology has several benefits, such as reduced waste quantities, decreased chemical requirements, and the absence of harmful air emissions. However, investing costs are rather high at the moment. Laws permit the heating of biotechnological waste as well as solid, unclean, and microbiological trash in a microwave.

7.4. Hydroclave Treatment

Hydroclave treatment, also known as steam sterilization or steam autoclaving, is a procedure where clinical waste is treated using a combination of high-pressure steam and water. The waste is placed inside a chamber where it is subjected to steam at high pressure and temperature, typically around 121°C to 134°C. The process effectively sterilizes the waste, killing pathogens and rendering it safe for disposal. Hydroclave therapy is commonly used for a wide range of clinical waste, including sharps, laboratory materials, and other infectious waste items.

7.5. Chemical Treatment: Chemical treatment of biomedical waste involves using various disinfectants or chemical agents to neutralize pathogens and render the waste safe for disposal. This method typically involves soaking or spraying the waste with a solution containing chemicals such as chlorine-based compounds, peracetic acid, or other disinfectants. Chemical treatment is often used for liquid waste, known as laboratory fluids or blood, and may also be used in conjunction with other therapy methods for solid waste. Proper handling and discarding protocols must be followed to ensure the safety of workers and the atmosphere when using chemical treatment for biomedical waste.

7.6. Sanitary and Secured Landfilling:

Sanitary and secured landfilling is a waste disposal method designed to minimize atmosphere impact and public health risks. In this process, waste is discarded of in engineered landfills equipped with protective liners and systems to prevent soil and water contamination. Sanitary landfills aim to contain and isolate waste from the surrounding environment effectively. Secured landfilling involves implementing measures to prevent unauthorized access, reducing the risk of scavenging and potential exposure to hazardous materials. Proper management, monitoring, and adherence to regulations are crucial in ensuring that sanitary and secured landfilling practices are effective in safeguarding the environment and public health.

8. Disposal: After treatment, the treated biomedical waste is discarded of in accordioning with local regulations and environmental guidelines. This may involve landfill disposal for certain types of treated waste, while other waste streams may be subject to more stringent disposal requirements, such as high-temperature incineration for certain infectious materials

Overall, the disposal of clinical waste is a highly regulated process that requires careful planning, coordination, and adherence to strict protocols to protect public health and the environment. Proper disposal helps minimize the risk of disease transmission, pollution, and other adverse effects associated with improper handling of biomedical waste.

9. Documentation: Throughout the disposal process, proper documentation is maintained to track the generation, transportation, treatment, and final disposal of biomedical waste. This documentation helps ensure accountability and compliance with regulatory requirements.

10. Monitoring and Compliance: Regulatory agencies and waste management authorities monitor biomedical waste disposal facilities to ensure they adhere to applicable regulations and environmental standards. This includes conducting inspections, enforcing penalties for non-compliance, and providing guidance to healthcare facilities on best practices for waste management.

Conclusion

In conclusion, our investigation into biowaste contaminated waste management in Hospital settings underscores the urgency of adopting robust and sustainable practices to address the dual challenge of environmental impact and human health risks. The findings highlight the intricate balance required to manage biomedical waste effectively, acknowledging its potential harm while promoting eco-friendly solutions. The evolving landscape of waste treatment technologies demands a continuous reassessment of conventional practices, with a shift towards environmentally conscious alternatives. As hospitals strive for better waste segregation, efficient transportation, and advanced treatment methods, the path to minimizing the ecological footprint becomes clearer. Healthcare institutions must integrate comprehensive training programs for staff, ensuring adherence to proper waste disposal protocols. The synergy between technological advancements, regulatory frameworks, and conscientious practices emerges as the cornerstone for a successful biomedical waste management system. By prioritizing sustainable approaches, we can not only mitigate atmosphere pollution but also safeguard human health from the hazards posed by biomedical waste. This study advocates for a holistic and proactive approach to biomedical waste management, fostering a healthier and more sustainable future for both our ecosystems and communities.

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