Best Practices And Challenges In Bio-Medical Waste Management: A Study From Jamshedpur

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Abstract

This research presents an exploratory study on the current state of bio-medical waste management practices, with a specific focus on Jamshedpur, an emerging urban center in India. Effective bio-medical waste management is a critical aspect of healthcare systems, environmental safety and public health. Improper handling and disposal of such waste can lead to significant environmental degradation and public health hazards, making its management a top priority. To regulate and streamline this process, the Ministry of Environment and Forests introduced the Bio-Medical Waste Management Rules in 1998, which set standards and guidelines for the proper disposal of bio-medical waste.

This study aims to assess the various types and components of bio-medical waste generated by healthcare facilities in Jamshedpur. It explores the methods currently used for waste disposal and identifies any gaps or inefficiencies in the existing system. In addition to evaluating the current practices, the research examines potential solutions to enhance the effectiveness of bio-medical waste management in the city. These solutions include the adoption of advanced technologies, improving waste segregation and collection procedures and fostering greater awareness and training among healthcare professionals and the general public.

By providing a comprehensive analysis of the bio-medical waste management landscape in Jamshedpur, this study seeks to offer valuable insights for the improvement of waste disposal practices. The findings lay the groundwork for future research and intervention strategies aimed at addressing the challenges of bio-medical waste management and ensuring a safer, healthier environment for the community.

Keywords: Green practices, bio medical, waste management, Jamshedpur, circular economy, waste disposal practices.

Introduction

The term “Health Care Waste” or “Bio-Medical Waste” encompasses all waste materials generated from medical procedures in healthcare facilities, research centers and laboratories (WHO, 2017). These wastes pose a significant threat to public health and the environment due to their potentially infectious, hazardous, or harmful components. Bio-medical waste includes materials such as contaminated blood, body fluids, used bandages, swabs, surgical cultures, tissues, needles, syringes, scalpels, expired medications, disinfectants and solvents. According to health experts, the danger of these wastes extends beyond humans, as animals can also be adversely affected. The degree of hazard depends on the types and characteristics of the waste, such as the presence of infectious agents, sharp objects like needles, radioactivity, cytotoxic or geno-toxic substances, hazardous chemicals and biologically aggressive pharmaceuticals (WHO, 2017).

Poor management of bio-medical waste (BMW) can lead to severe consequences, including the spread of infectious diseases, environmental pollution nd harm to wildlife. Studies show that approximately 10–25% of BMW is hazardous, posing risks to all living organisms and the physical, chemical and microbiological contents of these wastes are harmful to anyone exposed during handling, treatment and disposal (Rai et al., 2020; Rao & Ghosh, 2020). The United Nations Human Rights Council (2011) has emphasized the need for additional measures to improve the safe and environmentally sound management and disposal of BMW.

Apart from the direct health risks from contact with BMW, indirect risks also arise, particularly during the incineration process. Improper incineration can release highly toxic gases, which can have long-term environmental impacts. A study by Batterman (2004) highlighted that inadequate incineration processes may result in insufficient waste destruction, with ash disposal exceeding the emission limits set by the Stockholm Convention by up to 40,000 times.

In the Indian context, bio-medical waste management is regulated under the Environment (Protection) Act, 1986and the Bio-Medical Waste (Management and Handling) Rules, 1998. These rules apply to all individuals and institutions involved in the generation, collection, receipt, storage, transport, treatment, or disposal of BMW. In 2016, the rules were revised to strengthen regulations on segregation, transportation and disposal, with amendments introduced in 2018 to further reduce the environmental impact of BMW.

In Jharkhand, the management of bio-medical waste has emerged as a critical challenge. According to the Jharkhand State Pollution Control Board (JSPCB) and environmentalists, nearly 60% of the bio-medical waste generated in hospitals, nursing homes and clinics remains untreated due to inadequate disposal facilities. Despite the presence of over 5,500 healthcare facilities in the state, only two common biomedical waste incineration plants are operational. A survey conducted by organizations such as Toxic Link and Lok Swar NGO revealed that hospitals across key cities, including

Jamshedpur, produce an alarming amount of untreated biomedical waste annually. For instance, it was found that 59% of the waste generated in hospitals remains untreated, primarily due to the hospitals' failure to comply with waste management rules and inadequate waste segregation practices.

The state of Jharkhand faces widespread non-compliance with regulatory guidelines, as evidenced by surveys conducted in cities like Ranchi, Dhanbad, Bokaro, Deoghar and Jamshedpur. For example, a significant number of hospitals do not adhere to the prescribed color-coded segregation guidelines for waste, which is essential for ensuring proper disposal. Hospitals in these cities often fail to segregate waste into four categories: yellow containers for infectious waste like body parts and blood-soaked materials; red containers for items like IV tubing and syringes; puncture-proof containers for sharp objects; and cardboard boxes for glassware and metallic implants. According to a study by CSE, 42% of hospitals do not follow even the most basic segregation practices, while 79% of hospitals transport their waste in open containers, increasing the risk of contamination and infection.

Jamshedpur, known as the "Steel City" of India, faces specific challenges in managing its bio-medical waste. The city is rapidly growing and the lack of effective waste management practices has contributed to worsening environmental conditions. With high PM2.5 levels, which are 2.8 times higher than the WHO's recommended limit, Jamshedpur's air quality poses a significant health risk to its residents. The improper handling of bio-medical waste, especially in healthcare facilities, compounds these risks by adding to environmental pollution and public health concerns.

This research presents an in-depth exploration of the current state of bio-medical waste management in Jamshedpur, a rapidly developing urban center. The study aims to examine the types and components of bio-medical waste generated by healthcare facilities in the city, with a particular focus on the methods employed for waste segregation, transportation and disposal. Additionally, the study identifies key challenges and gaps in the management practices and explores potential solutions to improve the efficiency and effectiveness of bio-medical waste management.

The study seeks to assess the impact of advanced technologies, optimized waste segregation practices and public awareness campaigns on improving the city's waste management infrastructure. Furthermore, the research will examine the role of healthcare professionals in ensuring proper waste disposal and the need for strict regulatory compliance to safeguard public health and the environment.

By investigating the current practices and identifying areas for improvement, this research aims to provide a comprehensive understanding of bio-medical waste management in Jamshedpur. It will also serve as a foundation for future research and interventions aimed at addressing the critical challenges in managing bio-medical waste and ensuring a safer, healthier environment for the growing population of Jamshedpur.

Review of Literature on Bio-Medical Waste Management

Bio-medical waste (BMW) management has gained significant attention worldwide due to its potential to cause public health and environmental risks. An effective bio-medical waste management system is vital in safeguarding both human health and the environment. This section reviews the literature surrounding bio-medical waste management with a particular focus on healthcare facilities, regulations, challenges and emerging solutions, especially in the context of India and the city of Jamshedpur.

Bio-medical waste refers to waste generated from healthcare establishments such as hospitals, nursing homes, clinics, laboratories and research centers. The World Health Organization (WHO) (2017) defines bio-medical waste as any waste that is generated during the diagnosis, treatment, or immunization of humans or animals. Bio-medical waste can be broadly classified into infectious, hazardous and non-infectious categories, based on its physical, chemical and biological characteristics. The classification also considers the presence of hazardous substances such as radioactive materials, cytotoxic drugs and chemically aggressive agents (WHO, 2017). According to the Bio-Medical Waste (Management and Handling) Rules, 1998 and its amendments, bio-medical waste in India is segregated into categories like infectious waste, sharps, pharmaceuticals and chemical waste (Government of India, 2016).

Improper disposal and management of bio-medical waste can lead to environmental contamination and health hazards. Several studies have highlighted the impact of bio-medical waste on both human health and the environment. Rai et al. (2020) and Rao & Ghosh (2020) stress that exposure to improperly disposed of bio-medical waste poses direct threats such as infections, toxicity and poisoning to both humans and animals. Poorly managed bio-medical waste, especially when mixed with municipal waste, can lead to the spread of infections like HIV, Hepatitis and Tuberculosis. Similarly, improper incineration of bio-medical waste can release toxic gases such as dioxins and furans, which are hazardous to the environment (Batterman, 2004).

In India, the regulation of bio-medical waste management falls under the Environment Protection Act, 1986and the Bio-Medical Waste (Management and Handling) Rules, 1998. These rules aim to ensure the safe handling, treatment and disposal of bio-medical waste generated by healthcare institutions. The rules were revised in 2016 and amended in 2018 to address growing concerns regarding segregation, collection and treatment processes (Government of India, 2016). These regulations mandate healthcare facilities to segregate waste into different categories and use color-coded bins for each type of waste. They also require the use of authorized waste handlers for collection, transportation and treatment, including incineration or autoclaving.

However, despite these rules, compliance remains an issue. A study conducted by Toxic Link and Lok Swar NGO (2019) found that a large number of healthcare facilities in Jharkhand, including Jamshedpur, do not follow the prescribed guidelines. Hospitals fail to segregate waste properly, which increases the risks of cross-contamination and poses a severe threat to public health.

India faces significant challenges in managing bio-medical waste effectively. A survey conducted by Toxic Link (2019) revealed that hospitals produce approximately 4,700 tons of biomedical waste annually, with 59% of this waste being left untreated. The study indicated widespread non-compliance with the segregation practices mandated by the Bio-Medical Waste (Management and Handling) Rules, 2016, as hospitals often fail to separate infectious and hazardous waste from non-hazardous waste. In Jharkhand, this issue is compounded by a lack of adequate disposal facilities. Only two incineration plants serve the state's 5,500 healthcare facilities and many hospitals do not possess incinerators of their own, leading to a backlog in waste treatment.

The management of bio-medical waste in Jharkhand has emerged as a critical concern, with studies highlighting the inefficient waste treatment infrastructure. According to the Jharkhand State Pollution Control Board (JSPCB), a substantial proportion of bio-medical waste generated in hospitals, nursing homes and clinics remains untreated due to the absence of proper disposal facilities. Despite the existence of over 5,500 healthcare facilities, there are only two operational common bio-medical waste incineration plants. Reports from Toxic Link and Lok Swar NGO (2019) and the JSPCB show alarming statistics, with significant portions of waste not being properly segregated or treated. Moreover, hospitals in Jharkhand, including Jamshedpur, often lack the necessary color-coded containers for waste segregation and fail to comply with standard operating procedures for waste management.

To address the challenges in bio-medical waste management, several technological advancements and innovative solutions have been proposed. For instance, autoclaving and microwave treatment are alternative waste treatment methods that can be employed in place of incineration to reduce harmful emissions. Advanced shredders and deep-burial techniques for disposal of non-infectious waste have also been recommended to mitigate environmental risks. Digital tracking systems for monitoring waste disposal processes and ensuring compliance with regulations have gained traction in some regions as well.

Rai et al. (2020) and Kumar et al. (2022) suggest that hospitals should adopt advanced segregation techniques, such as the use of color-coded bins for different categories of waste, to ensure effective disposal. Moreover, public awareness campaigns targeting healthcare workers and the general public on the importance of bio-medical waste management can help improve segregation and disposal practices.

In cities like Delhi and Bangalore, where bio-medical waste management systems have seen some success, key strategies such as increased public-private collaboration, better enforcement of regulations and the development of infrastructure for waste treatment have been pivotal. The Centre for Science and Environment (CSE) reported that, while many hospitals in these cities fail to meet the segregation requirements, improved monitoring mechanisms and better awareness have led to gradual improvements in waste management practices (CSE, 2018).

Jamshedpur, often referred to as the Steel City of India, faces its unique set of challenges concerning bio-medical waste management. Due to rapid urbanization and industrialization, the city's healthcare infrastructure has struggled to keep pace with the increasing volume of bio-medical waste. Studies indicate that many healthcare facilities in Jamshedpur lack the necessary waste segregation bins and the few existing waste treatment facilities are insufficient to handle the growing amount of waste generated. As a result, there is an urgent need for improved infrastructure, better enforcement of waste management regulations and more awareness programs for healthcare professionals and the public.

The review of literature demonstrates the complexity and urgency of effective bio-medical waste management, both globally and within India, particularly in cities like Jamshedpur. Despite the existence of regulatory frameworks, widespread challenges remain in compliance, waste segregation and treatment. Advances in technology, along with improved regulatory enforcement and public awareness, offer potential solutions to address these challenges. This research aims to explore these issues in Jamshedpur, identify gaps in current practices and propose viable solutions for improving bio-medical waste management in the city.

Objectives of the study

- To identify and classify the various types and components of biomedical waste produced by healthcare facilities in Jamshedpur.
- To evaluate the waste disposal methods currently employed in Jamshedpur and explore the challenges faced by healthcare providers in the disposal process.
- To assess the level of awareness and understanding regarding proper medical waste segregation practices among small nursing homes and healthcare facilities**.**

Materials and methods

Comprehensive Review of Biomedical Waste Management in Jamshedpur (2017–2023)

A total of 30 articles written in English and published between 2017 and 2023 were meticulously selected for this study. The study uses SLR technique to conduct the research. The keywords used during the search were- biomedical waste, hospital waste, medical waste and BMW in the Indian context. Specifically, data related to recent advancements in biomedical waste management in Jamshedpur, along with insights into its handling across Jharkhand, were analyzed.

To gather information, leading newspapers like The Hindu, The Times of India, The Hindustan Times, The Indian Express and The New Indian Express were reviewed. Additionally, online news platforms, web-based news portals and digital versions of weeklies that focus on Jamshedpur were referenced. These sources provided critical insights into the challenges and management of biomedical waste, particularly during the COVID-19 pandemic.

The study used Google News searches with a variety of key terms, combining phrases like COVID-19, biomedical waste, hospital waste and BMW with location-specific keywords such as Jamshedpur and Jharkhand. For consistency, keywords such as "COVID-19" and "Jamshedpur/Jharkhand" were kept constant in all combinations. Searches covered a broader period (2017–2023) to capture pre-pandemic and pandemic trends in waste generation, disposal methods and regulatory updates.

Emerging trends in biomedical waste disposal techniques, such as the implementation of automated waste segregation systems and incineration technologies, were highlighted in the published articles. Articles discussed the environmental impact of improper biomedical waste handling, emphasizing the need for sustainable practices. Recent amendments to waste management policies in India, with a focus on state-level regulations specific to Jharkhand, were examined in most of the articles.

Results and discussion

To safeguard the environment, the general public and specifically individuals like health and sanitation workers who face potential exposure to biomedical waste, it is imperative to appropriately handle and dispose of such waste. The comprehensive process of biomedical waste management encompasses various stages, namely generation, accumulation, handling, storage, treatment, transportation and disposal.

A national waste management policy can be formulated and executed to enhance the management of biomedical waste within healthcare facilities, particularly in rural areas. The Bio-medical Waste (Management and Handling) Rules, 1998, along with subsequent amendments regulating the management of biomedical waste, have been embraced as part of this effort.

On March 28, 2016, the Central Government of India officially enacted the Biomedical Waste Management Rules 2016. The responsibility for enforcing this new legislation lies with the Pollution Control Committee or the Pollution Instrument Panel of each state.

In India, despite the existence of various disposal methods, the situation is often disorganized, with many methods proving more harmful than helpful. When dealing with materials containing body fluids, the recommended methods include incineration or autoclaving. However, adherence to these regulations is lacking in many medical facilities. Improper disposal practices, such as dumping biomedical waste into the ocean or landfills due to inadequate sorting or negligence, pose serious risks to both animals and humans. For instance, animals, like cows in Pondicherry, India, can ingest infected waste, transmitting diseases to humans through the consumption of their meat or milk. Furthermore, a considerable number of unregistered clinics and institutions generate uncontrolled biomedical waste.

The effective management of biomedical waste in hospitals is critical to safeguarding human health and protecting the environment. The 1986 Act by the Ministry of Environment and Forests mandates that hospital and healthcare facility occupiers must implement measures to treat waste in an environmentally sound manner. This necessity stems from several pressing concerns. Occupational hazards, such as sharp injuries, pose severe risks to healthcare workers and waste handlers, potentially exposing them to infections like hepatitis and HIV. Inefficient waste management practices in hospitals contribute to nosocomial infections, especially in patients with inadequate infection control. Improper disposal methods also endanger community members, including waste handlers, scavengers and residents near healthcare facilities, who are at risk of infection and toxic exposure. Biomedical waste, if not managed responsibly, can result in harmful environmental impacts, including contamination of air, water and soil from incineration emissions and improper ash disposal. Additionally, the unethical repackaging of disposable items and discarded drugs poses significant health threats to unsuspecting consumers. These challenges underscore the urgency for stringent biomedical waste management protocols to mitigate health risks, ensure environmental sustainability and maintain public trust in healthcare systems.

A major challenge in many hospitals is the unsatisfactory implementation of biomedical waste control, as certain institutions haphazardly dispose of waste without proper segregation. The lack of segregation procedures leads to the hazardous mixing of hospital waste with general waste, resulting in environmental contamination, unpleasant odours and the proliferation of disease-carrying vectors such as insects, rodents and worms. The transmission of diseases such as typhoid, cholera, hepatitis and AIDS can occur through human-contaminated syringe and needle injuries.

To mitigate these risks, it is crucial to prevent the spread of communicable diseases through water, sweat, blood, body fluids and infected organs. Biomedical waste scattered in and around clinics attracts flies, mosquitoes, rats, cats and dogs, contributing to the spread of diseases such as plague and rabies. Rag pickers, digging through the garbage, are at risk of tetanus and HIV infections.

To ensure safe waste collection, colored plastic bags with the biohazard symbol should be used and the following steps should be followed:

- Bags should be removed from the container when three-quarters full, tightly wrapped and labelled.
- Infectious waste should not be combined with non-infectious waste.
- Disposable items should be chemically disinfected before disposal.
- Needles and sharp objects must be disinfected or destroyed before disposal.
- Biomedical waste handlers should be trained to prevent injuries and incidents.

During waste transportation, proper sealing and labelling of waste bags/containers are crucial. Bags should be handled carefully and manual handling should be minimized to reduce the risk of injuries. Waste bags should be transported in

covered wheeled containers or large bins and the storage area for biomedical waste (BMW) should be separate from the general waste storage area.
Infected waste that cannot be incinerated must be disinfected before final disposal. Incineration, a high-temperature dry oxidation process, is commonly used for waste that cannot be reused, recycled, or disposed of at landfill sites. Vehicles used for BMW transport should be labelled 'Bio-Hazard' and dedicated solely to this purpose, preventing waste spillage and cross-contamination.

Analysis and Interpretation:
Among the 50 participants, the survey revealed that 86% were females, while 16% were males. All respondents were employed in the field of nursing and demonstrated a satisfactory level of knowledge regarding Bio medical waste management. It is noteworthy that participants chose not to disclose the name of their healthcare facility, emphasizing the importance of maintaining their anonymity.
There is only two Common Bio-Medical Waste Treatment Facility (CBWTF) in the entire state of Jharkhand. Many of them lack proper infrastructure in terms of disposal of Bio-medical waste. Among the different kinds of waste produced in the health care facility, the majority, accounting for 86%, is identified as Bio Chemical waste. According to 64% of those surveyed, stated that deep burial is the preferred waste disposal approach in the hospital, even today. Incinerator is the second most used method for waste disposal. A significant 74% express a high level of concern regarding the waste management process. Furthermore, 80% of respondents state that their expenses for the waste management process should be increased. Additionally, only 40% of those surveyed expressed satisfaction with the hospital's waste management system.

Problems Encountered in Biomedical Waste Management
- Lack of trained personnel
- Lack of proper and adequate number of vehicles
- Lack of equipment
- Old vehicle/equipment frequent breakdown
- Lack of authority to make financial and administrative decision
- Lack of planning (short, medium and long-term) plan by the management
- Lack of control on hazardous waste
- Lack of qualified private contractors

As per data collected, 32 participants believe that the absence of trained personnel poses a significant challenge in the management of biomedical waste. While 37 respondents feel that the lack of designated vehicles create issues in biomedical waste management. Similarly, 39 participants express the opinion that the absence of equipment lead to serious problems in biomedical waste management. Additionally, 44 respondents state that a lack of authority to make financial and administrative decisions is a serious concern in biomedical waste management. Moreover, 46 participants think that the frequent breakdown of old vehicles and equipment is a serious issue in biomedical waste management. Lastly, 37 respondents believe that the shortage of qualified private contractors is a challenge in biomedical waste management.

Suggestions
Hospitals and healthcare facilities must prioritize the development and implementation of clear guidelines and comprehensive training programs for their employees on handling biomedical waste (BMW). These programs should cover the proper segregation, storage, transportation and disposal methods to minimize health and environmental risks. A sustainable procurement strategy should be adopted to ensure that all purchased materials and equipment are environmentally friendly and compatible with effective waste management systems. Additionally, every healthcare facility should establish a dedicated waste management unit responsible for overseeing proper waste disposal practices, ensuring that waste handling is prioritized and executed safely. Adequate training should be provided to all personnel involved in waste management, including cleaners, nurses and healthcare workers, to ensure that they are fully aware of the procedures and the importance of proper waste handling. Implementing a color-coded waste sorting system at the source is essential for enhancing segregation and preventing contamination, making the disposal process more efficient. The government should play a proactive role by ensuring the availability of functional incinerators within healthcare facilities or by establishing centralized incineration facilities where BMW can be processed before final disposal, thereby reducing environmental impact. In addition, it is crucial to integrate advanced, sustainable practices with technology by implementing an online monitoring system that tracks the entire waste management process in real time. This would allow for better monitoring, accountability and traceability of waste, helping ensure that it is handled and disposed of properly. Finally, regular audits, awareness campaigns and public-private partnerships can play a significant role in improving compliance with regulatory standards and fostering a culture of responsibility within healthcare facilities. By integrating these comprehensive measures, we can significantly improve biomedical waste management, safeguard public health and contribute to environmental sustainability.

Conclusion

The risks associated with sharp injuries to healthcare workers and waste handlers emphasize the urgent need for robust and precise biomedical waste management protocols. Improper handling of waste not only poses a risk to healthcare professionals but also to patients within hospitals, who may contract infections if waste is not managed correctly. Even residents living in close proximity to healthcare facilities are at risk of exposure to harmful pathogens if waste is not properly handled and disposed of. Furthermore, the presence of toxic chemicals, expired drugs and contaminated items in the waste adds to the danger. There are also unethical practices, such as the repackaging and resale of medical products without appropriate cleaning, which amplify the need for stringent waste management practices.

Environmental concerns also arise from improper biomedical waste disposal, particularly from the emission of harmful substances during incineration. Faulty incineration processes can lead to the contamination of air, water and soil, further exacerbating the environmental footprint of biomedical waste. The failure to properly segregate biomedical waste from general waste in healthcare facilities has serious implications, as it results in hazardous mixing, which heightens both health and environmental risks. The risk of spreading infections through needle-stick injuries and the proliferation of disease-carrying vectors due to improperly disposed of waste are clear examples of the consequences of ineffective waste management.

To mitigate these risks, it is crucial to focus on the prevention of communicable diseases and ensure the safety of healthcare workers, waste handlers and the surrounding communities. This can be achieved by enforcing rigorous waste collection, transportation and storage protocols, along with adopting reliable disposal methods such as incineration, autoclaving and disinfection. Effective biomedical waste management strategies must prioritize the proper treatment and disposal of hazardous waste to minimize risks to public health.

A holistic approach to improving biomedical waste management requires raising awareness, strengthening regulatory enforcement and promoting responsible practices within healthcare facilities. Collaboration among healthcare institutions, waste management companies and regulatory authorities is essential to developing a sustainable, eco-friendly framework for biomedical waste disposal. By adhering to recommended guidelines, investing in advanced waste management infrastructure and prioritizing education and training, it is possible to significantly reduce the environmental, public health and occupational hazards associated with poor waste disposal, ultimately creating a safer and healthier environment for all.

Limitations of the Study

Despite the thoroughness of this review, there are certain limitations that need to be acknowledged. The analysis primarily relied on the information provided by organizations and publicly available articles online. The findings may be influenced by the availability and quality of published data. Additionally, the study focused exclusively on data and information in the English language, as well as content specific to Jharkhand, which could introduce a bias in the reporting. Furthermore, in cases where the study procedures were unclear, no effort was made to seek clarification from the authors of the publications, which could have provided a more comprehensive understanding of the subject matter. These factors should be considered when interpreting the results and conclusions drawn from this review.

To address these limitations, future researchers should consider diversifying data sources by including interviews, surveys and direct communications with key stakeholders and authors of relevant studies. Expanding the scope to incorporate multilingual and regionally diverse content could also provide a more holistic understanding. Additionally, employing systematic methods for data verification could enhance the reliability and validity of the findings.

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