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A Review of Biomedical Waste and Management, Maharashtra, India

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Abstract: Biomedical Waste (BMW) is one of the most hazardous waste generated from biological and medical sources and activities, such as the diagnosis, prevention, or treatment of diseases. Proper management of this waste is an environmental concern. If it is not dealt with in a certain fashion, the waste may cause infections and other dangers to humans and other living organisms that are exposed to it. This study investigates the urgent need for raising awareness and education on medical waste issues and the cost effective system for providing better medical waste treatment facilities along with generation of awareness to reduce and recycle the waste necessary to sustain the environment.
Index Terms: BMW, Awareness, Environment.

I. INTRODUCTION

Healthcare is a never dying industry in any country. Hospitals, which are at the center of this industry, have immense scope for continual expansion, in terms of their infrastructure and services. As in any other industry, hospitals also generate waste. However, this waste is different in terms of content. Hospitals generate biomedical waste, the handling of which is one of the major concerns of hospitals across the globe, in particular, those of the developing countries (Sagaonkar et al, 2014). Biomedical waste includes a wide range of materials: sharps, human and animal tissues, blood soaked materials, microbiological cultures, discarded medicines, cytotoxic drugs, chemical waste, and materials contaminated with body fluids. A large portion of biomedical waste is non-hazardous, but a significant percentage- estimated to be around 15-25%- is considered hazardous and requires specialized handling.

The improper handling, storage, transportation, and disposal of biomedical waste can lead to grave consequence. These include the transmission of infectious diseases such as HIV/AIDS, hepatitis B and C, tuberculosis, and other blood borne pathogens. Waste handlers, healthcare workers, patients, and the general population are at risk if biomedical waste is not managed according to established safety protocols.

In response to the health and environmental threats posed by biomedical waste, numerous countries have enacted stringent regulations and guidelines. For instance, the Biomedical Waste Management Rules, 2016 in India provide a comprehensive framework for the segregation, collection, storage, transport, treatment, and disposal of biomedical waste. Similar regulations exist globally, governed by organization such as the world Health Organization (WHO) and national environmental protection agencies.

Effective biomedical waste management (BMWM) is a multidisciplinary task that requires collaboration among hospital authorities, healthcare workers, environmental engineers, waste handlers, and government regulators,

The core principles of BMWM include:

1) Segregation at source- Categorizing waste at the point of generation using color- coded bins.
2) Safe Collection and Transportation- Ensuring that waste is handled using protective measures and moved securely to treatment facilities.
3) Appropriate Treatment- Employing techniques such as incineration, autoclaving, microwaving, and chemical disinfection based on the type of waste.
4) Environmentally Safe Disposal- Final disposal through landfilling, shredding, or other methods that minimize environmental impact.
5) Monitoring and Training- Regular audits, staff training, and public awareness campaigns to ensure compliance and safety.

In recent years, the COVID-19 pandemic has underscored the importance of robust BMWM systems,with exponential increases in medical waste such as masks, gloves, PPE kits, and test kits. This crisis revealed the gaps in existing systems, especially in developing countries, and highlighted the urgent need for capacity building, investment in infrastructure, and adoption of ecofriendly and sustainable waste management practices.

II. LITERATURE REVIEW

Sunil Kumar VC and his team (2012) pointed out that biomedical waste, if not managed properly, can lead to serious diseases like hepatitis, TB, and HIV/AIDS. Although many national and international organizations have shown concern about this issue, most hospitals still don't have proper systems in place to handle and dispose of this waste. This leads to major hygiene and cleanliness problems in hospitals.

Using disposable medical items has helped lower infection risks, but it has also created a lot more waste, which needs to be dealt with carefully. The authors say that proper waste disposal can only happen if we look at all the parts of the waste management process – from how the waste is collected and separated, to how it's treated and finally thrown away safely.

A.K. Jindal and colleagues (2013) did a study to analyze how biomedical waste (BMW) is currently being managed, especially in service hospitals and healthcare establishments (HCEs). Their goal was to understand how much and what type of waste is being produced, what equipment is available or needed, and whether outsourcing BMW disposal is a good and practical option.

The study used both direct methods (like observation, interviews with key staff, group discussions, and surveys from users) and existing data to get a full picture. Most of the people involved in managing biomedical waste agreed that outsourcing waste disposal could be a good solution, as long as there are reliable, government-approved local agencies available to do it.

Anurag V. Tiwari and his team (2013) reviewed different biomedical waste management practices followed in India and other countries. They looked at around 60 research papers, which included topics like general information, laws and regulations, hospital experiences, and how waste is managed in different cities and countries.

In India, biomedical waste makes up only 1 to 1.5% of the total solid waste generated in a city, but 10–15% of that is infectious, meaning it can spread diseases if not handled properly. The main goal of their study was to raise awareness about the dangers of biomedical waste.

The authors stressed that the most important step to reduce the risk from biomedical waste is to segregate it properly at the source—in other words, sorting the waste right where it's generated (like in hospital wards or labs) before it gets mixed with other garbage.

1. Title: *A Case Study on Municipal Solid Waste Management in Solapur City, Maharashtra, India*

B.L. Chavan and team (2013) carried out a detailed study to understand how municipal solid waste (MSW) is currently managed in Solapur city, Maharashtra. The study involved surveys of the city's solid waste facilities, including the available manpower and waste management systems. They looked at everything from how much waste is generated to how it's collected, transported, treated, and disposed of. The information was gathered from Solapur Municipal Corporation records and through direct visits to different sites. Their findings showed that the city's solid waste management system has several gaps and weaknesses, especially when compared to the standards outlined in the Municipal Solid Waste (Management and Handling) Rules, 2000.

2. Title: *Biomedical Waste and Its Impact of Mismanagement – A Study of Maharashtra, India*

Sravanthi Karnata and her team (2020) explored how mismanagement of biomedical waste can impact both the environment and public health. Their study focused on Maharashtra, India's third-largest state with a population of over 11 crore (110 million). Using secondary data collected from pollution control boards, published research, and news reports, the article pointed out that Maharashtra alone produces about 10% of India's total biomedical waste. The study highlights how improper disposal can lead to pollution, disease outbreaks, and other serious consequences, and emphasizes the urgent need for strict control measures and effective waste management systems

3. Title: *Biomedical Waste Management in India – A Review*

This review by Deepika and Lata Kanyal (2021) focused on the key aspects of biomedical waste (BMW) in India—its definition, classification, handling, and disposal methods. They explained that BMW includes hazardous materials like:

- Human and animal body parts
- Sharps (needles, blades, etc.)
- Infectious lab waste
- Expired medicines
- Soiled materials
- Chemical and liquid waste
- Incineration ash

These wastes are generated from hospitals, clinics, labs, blood banks, veterinary and medical colleges, funeral homes, and more. Even though some waste types may not be infectious (like radioactive or chemical waste), they still pose environmental and health risks if not handled properly.

The World Health Organization (WHO) estimates that 10% of hospital waste is infectious and 5% is hazardous but non-infectious. WHO classifies medical waste into eight categories:

1) General
2) Pathological
3) Radioactive
4) Chemical
5) Infectious
6) Sharps
7) Pharmaceuticals
8) Pressurized containers

In India, biomedical waste is governed by the Biomedical Waste (Management & Handling) Rules, 1998, along with later amendments. These rules include:

- Waste categories
- Colour-coded segregation
- Labeling requirements
- Transport and treatment standards
- Facility guidelines for incinerators, autoclaves, and microwaves

A. Steps in Biomedical Waste (BMW) Management

Proper management of biomedical waste is crucial because even one mistake can put people's lives at risk. There are six main steps involved in managing BMW:

1) Surveying the Waste – Understanding how much and what type of waste is being produced.
2) Segregating the Waste – Separating different types of waste (like sharps, plastics, liquids) at the point where it is generated.
3) Collecting the Waste – Gathering waste in the right type of containers or bins.
4) Categorizing the Waste – Sorting it according to hazard levels and waste type.
5) Storing the Waste – Keeping waste safely in marked areas for a limited time.
6) Transporting and Treating the Waste – Moving it carefully to treatment or disposal sites and processing it properly.

Segregation is the most important step. When waste like needles (sharps) gets mixed with general waste, it increases the risk of injury or infections like HIV or Hepatitis B. Improper segregation can also lead to the reuse of syringes, which is very dangerous. When done correctly, segregation also allows recycling of non-infectious plastic and metal waste.

As per Schedule 2 and 3 of the Biomedical Waste Rules, waste must be separated at the source using color-coded bins and properly labeled containers. Initially, there were 10 schedules under the BMW rules (1998), but now there are 4.

BMW should be stored only:

- 8–10 hours in large hospitals (250+ beds)
- 24 hours in smaller nursing homes

Storage areas must be clearly marked with biohazard signs to avoid any confusion or danger.

B. Methods for Treating Biomedical Waste

There are several treatment methods used to make biomedical waste safe:

1. Incineration
    - Involves burning waste at very high temperatures (1800°F to 2000°F)
    - Reduces waste volume by converting it into ash and gas
    - Chlorinated plastics and metals should not be incinerated – they release dioxins, which are toxic and can cause cancer and respiratory problems.
2. Autoclaving
    - Uses steam and heat (121°C for 20–30 minutes) to sterilize waste

- Safe and cost-effective
- Best for sharps and disposables
- Not suitable for anatomical, radioactive, or chemical waste

3. Chemical Treatment
   - Chemicals like chlorine, hydrogen peroxide, and Fenton's reagent are used
   - Mainly for liquid waste (e.g., blood, urine, stool), but can also be used for solid surfaces and instruments
   - Disinfects waste and kills pathogens
4. Thermal Inactivation
   - Uses high heat to kill microorganisms
   - Temperature depends on the type of germs present
   - Treated waste is often released into sewers

C. Health and Environmental Risks of Poor BMW Management

When biomedical waste is mixed with general garbage**, it creates** major health and environmental hazards**:**

- Needle stick injuries from improperly discarded sharps can transmit HIV or Hepatitis B
- Medical waste handlers and waste pickers are at high risk of infection
- Sharps should always be disposed of in rigid, puncture-proof, translucent white bins
- Thin plastic bags are unsafe for sharps – they can tear and cause injuries

Environmental risks include:

- Air Pollution: Incineration releases biological spores and toxic gases
- Water Pollution: Waste with heavy metals can contaminate water bodies and even drinking water
- Land Pollution: Poorly constructed landfills and open dumping can spread disease and pollution
- Rodent Threat: Rats and mice can spread infections from waste to nearby communities

III. CONCLUSION

Safe and effective management of waste is not only a legal necessity but also a social responsibility. Lack of concern, motivation, awareness and cost factor are some of the problems faced in the proper hospital waste management. Proper surveys of waste management procedures in dental practices are needed. Clearly there is a need for education as to the hazards associated with improper waste disposal. Lack of apathy to the concept of waste management is a major stymie to the practice of waste disposal. An effective communication strategy is imperative keeping in view the low awareness level among different category of staff in the health care establishments regarding biomedical waste management.

Proper collection and segregation of biomedical waste are important. At the same time, the quantity of waste generated is equally important. A lesser amount of biomedical waste means a lesser burden on waste disposal work, cost-saving and a more efficient waste disposal system. Hence, health care providers should always try to reduce the waste generation in day-to-day work in the clinic or at the hospital. Biomedical Waste management programme cannot successfully be implemented without the willingness, devotion, self-motivation, cooperation and participation of all sections of employees of any health care establishment. Therefore, it becomes the responsibility of this group to segregate and manage the waste in such a way, that it is no longer hazard for them, public and environment. Keeping in view, inappropriate management of biomedical wastes, the Ministry of Environment and Forests notified the "Biomedical Waste (Management and Handling) Rules 1998." These rules are meant to protect the society, patients and health care workers. The most imperative component of the waste management plans is to develop a system and culture through education, training and persistent motivation of the health care staff.

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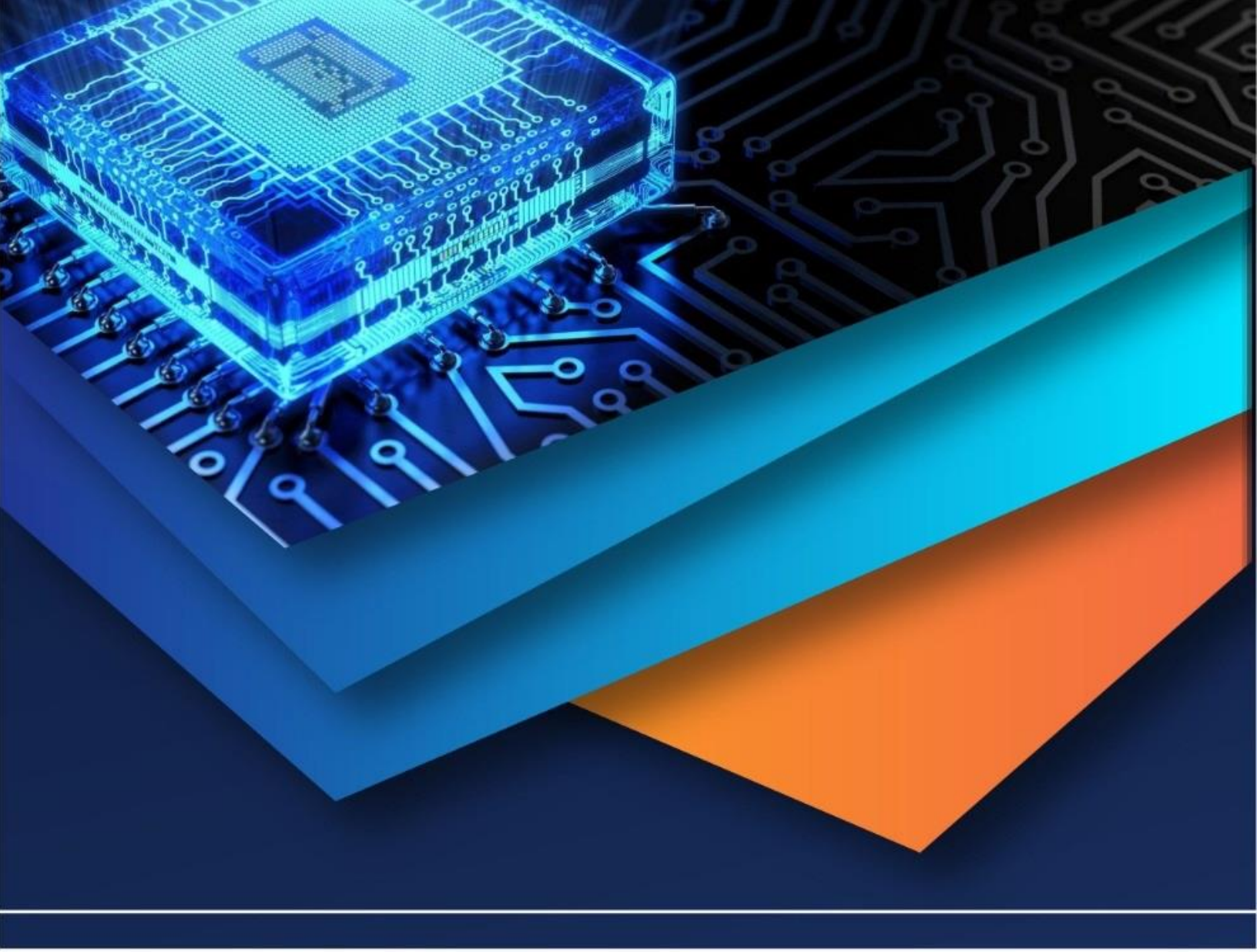

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