IDENTIFICATION OF HIGH - RISK ZONES OF BIO-MEDICAL WASTE GENERATION OF TAMIL NADU 2018 – 2021

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Abstract

The interplay between the microenvironment (internal) and macroenvironment (surrounding) of human beings plays a pivotal role in determining the health status of an individual or the broader community. Biomedical waste generation and disposal have become a pressing issue not only in India but globally on a daily basis. The everyday generation of biomedical waste is increasing due to the growth of healthcare facilities. Numerous of these difficulties can be lessened with efficient biomedical waste management. Biomedical waste must be separated, stored, processed, transported, and disposed of; these are all conventional procedures that are essential to healthcare waste management. Multidisciplinary cooperation is used in an all-encompassing strategy to address organizational, planning, administrative, financial, engineering, legal, and human resource issues. The management of medical waste demands unwavering commitment from healthcare providers across all tiers.

Biomedical waste can lead to the spread of diseases like Hepatitis B, C, E, dengue, and HIV because contaminated sharps are not properly contained. It can also cause pathogenic microbial populations to proliferate and mutate in municipal waste when biomedical waste is not properly disposed of. These repercussions also involve physical injuries and health hazards. Additionally, there are other ramifications, including the unsightly degradation of the environment due to careless disposal practices, which can have adverse effects on public health. This includes an elevated risk of nosocomial infections, alterations in microbial ecology, and the dissemination of antibiotic resistance. Furthermore, it leads to an increased density of vector populations, which can result in the spread of diseases among the public. Promoting awareness and sensitization among the public is crucial for the global protection of both the environment and public health.

In a system operated by inexperienced and irresponsible personnel, there is a concern about the risks and the value of their "contribution." Moreover, it is essential to educate trained medical professionals, including hospital administrators, as well as individuals from private and government institutions, clinics, and universities, about the proper protocols for biomedical waste disposal. Many aspects related to biomedical waste, including its significance, its interactions with the ecosystem, the environmental pollutants associated with the healthcare industry, and the impact of negligence on public health, remain largely unexplored. To achieve improved outcomes, it is imperative to expedite the enhancement of training and education in the management of biomedical waste and environmentally sustainable healthcare, all while adhering to relevant rules and regulations. This study explores the many forms of biomedical waste that are collected, separated, treated, and disposed of in Tamil Nadu between 2015 and 2020.

Keywords: Bio-Medical Waste (BMW), Source of BMW, Effective BMW Management

I. INTRODUCTION

The proliferation of medical advancements and the establishment of new hospital facilities aimed at enhancing healthcare have led to an increase in the volume of waste generated by healthcare establishments. "Health Care Waste" or "Bio-Medical Waste" is the collective term for waste resulting from medical practices in healthcare facilities, including testing centers and laboratories (Babu, Parande, Rajalakshmi, Suriyakala, & Volga, 2009; Manika & Arpita, 2015; Sunil Kumar, Manjunath, Badami, & Pradeep, 2012). Healthcare professionals, the general public, the surrounding environment, and wildlife are all at risk from hospital trash. As a result, worries about the removal of garbage from hospitals and other healthcare facilities have become an increasingly significant cause for concern.

Numerous countries worldwide, particularly those in the developing world, are grappling with a pressing issue: environmental pollution stemming from pathological waste generated due to expanding populations and the subsequent rapid proliferation of healthcare facilities (Manika & Arpita, 2015). Since the Union Ministry of Environment and Forests passed the Biomedical Waste (Management and Handling) Rules, 1998 in accordance with the Environment (Protection) Act, 1986, biomedical waste management has attracted a lot of attention in India. All organizations that produce, gather, receive, store, transport, manage, dispose of, or handle biomedical waste in any way are subject to these requirements (Sunil Kumar et al., 2012).

Effective and secure waste management is not merely a legal mandate but also a social responsibility. Issues such as negligence, apathy, lack of comprehension, and cost constraints can all surface in the context of proper hospital waste management. Public education on the risks connected to inappropriate garbage disposal procedures is desperately needed. An effective communication plan must be implemented because staff members at different healthcare facilities have a poor understanding of biological waste management (Kalpana, Sathya, Vinodhini, & Devirajeswari, 2016). A noteworthy accomplishment in India has been the mentality shift of healthcare facility managers, encouraging them to use private-sector waste management services and integrate good waste management techniques into their everyday operations (Praveen, Sangeeta, & Anand, 2012).

Biohazardous **Biomedical Waste**, when not appropriately managed and disposed of, biomedical waste has the potential to jeopardize the well-being of all organisms within the environment. It has the capacity to pollute water sources, harm wildlife, and pose health risks to individuals residing in communities near medical waste disposal sites. The consequences can manifest subtly, sometimes taking years to become evident, or they can be immediate, as seen in instances where improperly handled and discarded sharps cause injuries through cuts or needlesticks.

We often perceive the primary risk associated with improperly managed biomedical waste as the potential for pathogenic infections, which is indeed a significant concern. However, there are additional risks that should not be underestimated, some of which can have profound and enduring consequences. Therefore, it is imperative to comprehensively grasp the daily generation of biomedical waste to facilitate effective planning and management.

II. DEFINITION OF BIOMEDICAL WASTE

Biomedical waste (BMW) is defined as "Any waste generated during the process of diagnosis and treatment, immunization of human beings or animals, or in research activities contributing to biological production or testing" (Government of India, 1998) by the Biomedical Waste (Management and Handling) Rules, 1998. The effective attitude change among healthcare operators in India has been a noteworthy achievement, as it has motivated them to easily incorporate healthcare waste management into their daily activities (Bekir Onursal, 2003).Biomedical Waste Origins

One of the findings of Srishti (2010) was that the primary and secondary sources of healthcare waste generation, as described by Shaida and Singla (2019), are classified according to the quantities produced. This was discovered in the context of the 2018 training component of the "Environmentally Sound Management of Medical Wastes in India" Project. Primary sources encompass waste generated by institutions such as hospitals, medical colleges, nursing centers, dialysis centers, maternity homes, blood banks, research laboratories, immunization centers, and similar facilities. Conversely, secondary sources include the garbage produced by medical facilities, ambulances, funeral homes, slaughterhouses, colleges, and other associated organizations (Shaida & Singla, 2019; Srishti, 2010).

1. **Classification of Biomedical Waste:** Medical waste is divided into eight categories by the World Health Organization (WHO), which is supported by Srishti (2010) and described by Manika and Arpita (2015). These categories encompass General Waste, Pathological Waste, Radioactive Waste, Chemical Waste, Infectious Waste (including potentially infectious waste), Sharps, Pharmaceuticals, and Pressurized Containers.

   Different terminology have been used to describe infectious wastes over the years in research papers, laws, and guidelines. These include medical and biological wastes, hazardous and red bag wastes, contaminated waste, infectious medical wastes, and managed wastes in the medical industry, in addition to infectious and non-infectious wastes. In essence, all of these terminology refer to the same kinds of trash; but, as Chakraborty et al. (2014) and Singh et al. (2014) highlight, regulatory terminologies are often more precise.

2. **Categories of Biomedical Waste:** According to the regulations, the wastes are classified into ten distinct categories and should be segregated into four different color-coded containers or bags. These wastes must be managed using various methods outlined in Table 1, including deep burial, incineration, autoclaving, microwaving, mutilation, shredding, and chemical disinfection.

Table 1: Categories of Biomedical Waste

Option	Treatment & Disposal	Waste Category
Cat. No. 1	Incineration / deep burial	Human Anatomical Waste (human tissues, organs, body parts)

Cat. No. 2	Incineration / deep burial	Animal waste includes body parts, organs, corpses, bleeding portions, fluid, blood, and experimental animals used in research. It also includes garbage from veterinary clinics and colleges, hospital discharges, and animal houses.
Cat. No. 3	Local autoclaving/waving/ incineration	Wastes from laboratory cultures, stocks or specimens of live or attenuated microorganisms, vaccines, human and animal cell cultures used in research, infectious agents from research and industrial laboratories, wastes from the production of biological toxins, dishes, and culture-transfer devices are all considered microbiology and biotechnology wastes.
Cat. No. 4	Disinfections (chemical treatment autoclaving/ micro waving and mutilation shredding	Waste Sharps: Sharp objects that can pierce and cut, such as glass, syringes, scalpels, and needles. This covers both used and unused sharp objects.
Cat. No. 5	Incineration /destruction & drugs disposal in secured landfills	Cytotoxic drugs and abandoned medications (wastes consisting of wasted, contaminated, and out-of-date medications)
Cat. No. 6	Incineration / autoclaving/microwa ving	Soiled Waste: (items polluted with bodily fluids and blood, such as dressings, cotton, soiled plaster casts, line bedding, and other blood-contaminated materials)
Cat. No. 7	Disinfections by chemical treatment waving& mutilation shredding	Solid waste (debris produced from disposable equipment like tubing, catheters, intravenous drips, etc., other than waste sharps)
Cat. No. 8	Disinfections by chemical Treatment and discharge into drain	Liquid Waste (waste generated from laboratory & washing, cleaning, house-keeping and disinfecting activities)
Cat. No. 9	Disposal in municipal landfill	Incineration Ash (ash from incineration of any bio-medical waste)
Cat. No. 10	Chemical treatment is charge into drain for liquid &secured landfill for solids	Chemical Waste (chemicals used in production of biological, chemicals, used in disinfect ion, as insecticides, etc)

III. AIM AND OBJECTIVES OF THE STUDY

The current study's goal is to assess the generation and management of Bio-Medical Waste in Tamil Nadu from 2018 to 2021. To achieve this objective, the study has outlined the following specific goals.

1. To find the district wise Bio-Medical Waste Generation of Tamil Nadu from 2018 – 2021.
2. Categorise the generation of Bio-Medical Waste into High, Moderate and Poor.
3. Identification of High-Risk Zones of Bio-Medical Waste Generation.

IV. MATERIALS AND METHODS

The secondary information channels were the source of the materials and data used in this investigation. The study's foundation is also a review of prior studies, news stories, and reports that were compiled from official government and non-government agency websites as well as public reports. The Ministry of Health and Family Welfare (MoHFW) and the World Health Organization (WHO) websites are two among the many places from which the data reported in this study was gathered.

V. BIO-MEDICAL WASTE OF GENERATION OF TAMIL NADU 2018 –2021

During the COVID-19 pandemic, heightened attention to hygiene and sanitation practices has led to the presence of color-coded bags in many hospitals. Disposable supplies like masks, PPE kits, bed linens, and single-use medical equipment like glass vials and syringes are included in these packs. To guarantee that COVID-19 patients are treated safely, governments have been improving standard operating procedures (SOPs) on a regular basis. Tamil Nadu produced more than 6000 tonnes of COVID-19 biomedical waste between March 2020 and May 2021, according to the Central Pollution Control Board (CPCB) (see Table 2). Hospitals in cities with higher patient volumes, such Thanjavur and Tiruchi, have reported using a lot of disposable materials.

Hospitals' production of Bio-Medical Waste (BMW) has increased noticeably in a number of Tamil Nadu's central districts. The amount of disposed masks and PPE kits has certainly surged during the pandemic. Prior to COVID-19, our daily collection of BMW averaged around one and a half tonnes. "Before COVID, the winter season typically marked a peak in BMW generation due to flu and fever cases."

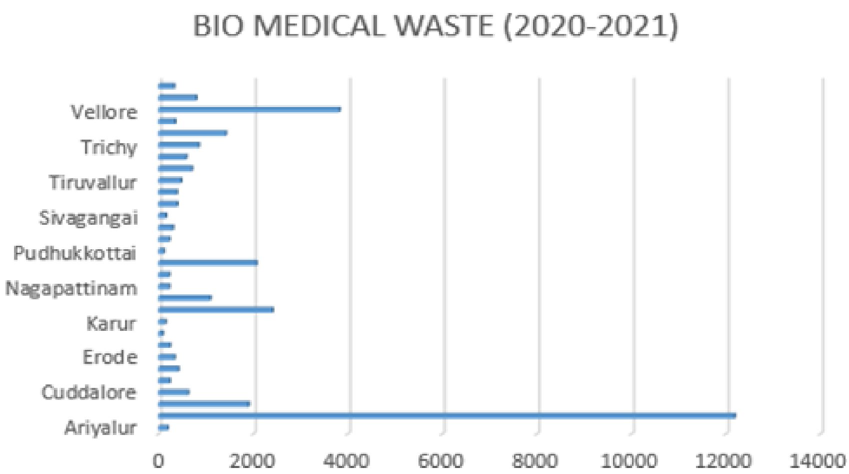

Figure 1

Table 2: Generation of Bio-Medical Waste (2020 – 2021)

S. No	District Office	Quantity of Generation of Bio-Medical Wastes (kg/ day)
Chennai Zone		
1	Ambattur	342.76
2	Chennai	9671.24
3	Maraimalainagar	2515
4	Sriperumbudur	1096
5	Gummidipoondi	37.5
6	Tiruvallur	537.5
Vellore Zone		
7	Vellore	3828
8	Vaniyambadi	476
9	Dharmapuri	237.27
10	Villupuram	795
11	Hosur	245
12	Tiruvannamalai	701
Salem Zone		
13	Erode	161.30
14	Namakkal	131.40
15	Perundurai	178.70
16	Salem	302.46
17	Karur	145.00
18	Kumarapalayam	93.60
Coimbatore Zone		
19	Coimbatore South	1550
20	Coimbatore North	1950
21	Tiruppur North	400
22	Tiruppur South	353
23	Ooty	120
Trichy Zone		
24	Ariyalur & Perambalur	194.2
25	Trichy	855
26	Pudhukottai	108.17
27	Thanjavur	393.86
28	Nagapattinam	224.17
29	Cuddalore	623
Madurai Zone		
30	Madurai	2406.92
31	Theni	385
32	Sivagangai	153.11
33	Ramanathapuram	230.16
34	Dindigul	421.24

Tirunelveli Zone		
35	Tirunelveli	1424
36	Thoothukudi	584.33
37	Nagercoil	1069.49
38	Virudhunagar	329.37
Total		**35269.74**

Source: Tamil Nadu Pollution Control Board - Annual report 2020-2021

Table 3: District wise Bio Medical Waste Categorization

S.No	District	2018	2021	Risk
1.	Ariyalur	Moderate	Low	Low
2.	Chennai	High	High	High
3.	Coimbatore	High	High	High
4.	Cuddalore	High	Moderate	Moderate
5.	Dharmapuri	Low	Low	Low
6.	Dindigul	High	Moderate	Moderate
7.	Erode	High	Moderate	Moderate
8.	Krishnagiri	Low	Low	Low
9.	Kanyakumari	High	Low	Low
10.	Karur	Low	Low	Low
11.	Madurai	High	High	High
12.	Kanchipuram	High	High	High
13.	Nagapattinam	Moderate	Low	Low
14.	Namakkal	Low	Low	Low
15.	Nilgiris	Low	High	High
16.	Pudukkottai	Low	Low	Low
17.	Ramanadhapuram	Low	Low	Low
18.	Salem	Moderate	Moderate	Moderate
19.	Sivagangai	Low	Low	Low
20.	Thanjavur	Moderate	Moderate	Moderate
21.	Theni	Low	Moderate	Moderate
22.	Tiruvallur	High	Moderate	Moderate
23.	Tiruvannamalai	Moderate	High	High
24.	Thoothukudi	Moderate	Moderate	Moderate
25.	Trichy	Moderate	High	High
26.	Tirunelveli	Moderate	High	High

27.	Tiruppur	Moderate	Moderate	Moderate
28.	Vellore	High	High	High
29.	Villupuram	Moderate	High	High
30.	Virudhunagar	Low	Moderate	Moderate

The Bio-Medical Waste generation of two different periods 2018- 2019 and 2020 – 2021is analysed (Table 3). From the 2018 - 2019 it is clearly understood that the districts Dindigul, Madurai, Vellore, Kanyakumari, Cuddalore, Erode, Kanchipuram, Coimbatore, Thiruvallur and Chennai comes under the High Generation of Bio-Medical Waste. The districts Thoothukudi, Tiruppur, Nagapattinam, Ariyalur, Villupuram, Thirunelveli, Thanjavur, Salem, Thiruvannamalai, Trichy comes under Moderate Generation of Bio-Medical Waste, the districts Ramanathapuram, Virudhunagar, Nilgiris, Karur, Krishnagiri, Sivagangai, Namakkal, Pudukottai, Dharmapuri, Theni comes under Low Generation of Bio-Medical Waste. (Table 2). By using the criteria table, the result was identified as High, Moderate and Low Risk zones of Bio-Medical waste. The maximum Bio-Medical Waste generation of 2019 is high in Chennai district. The minimum Bio-Medical Waste generation of 2019 is low in Theni district. In the same manner, the maximum Bio-Medical Waste generation of 2021 is high in Chennai district. The minimum Bio-Medical Waste generation of 2021 is low in Krishnagiri district.

VI. BIO-MEDICAL WASTE MANAGEMENT

The protocols and infrastructure set up for the proper treatment and disposal of biological waste are included in biomedical waste management. Waste generated during the diagnosis, treatment, or immunization of humans or animals, as well as during related research, is referred to as biomedical waste. This category includes infectious substances, sharp objects like needles and scalpels, laboratory waste, and other waste types that have the potential to pose risks to public health and the environment.

Proper biomedical waste management involves the segregation, collection, transportation, and treatment of this waste in a way that minimizes the risk of exposure to infectious materials and prevents contamination of the environment. This can be achieved through the use of proper handling and storage techniques, as well as the use of technologies such as incineration, autoclaving, and microwave treatment to sterilize and dispose of the waste. At the municipal, federal, and international levels, laws and regulations govern the handling of biomedical waste.

The management of bio-medical waste in India is regulated by the Bio-Medical Waste Management Rules, which were formulated in 1998 and amended in 2016. These rules provide guidelines for the segregation, collection, transportation, and treatment of biomedical waste. According to the rules, all healthcare facilities, including hospitals, nursing homes, clinics, and laboratories, are required to properly segregate biomedical waste and store it in designated containers.

VII. STRATEGIES FOR IMPROVING BIO-MEDICAL WASTE MANAGEMENT IN INDIA

Initially, healthcare facilities must prioritize the adoption of effective biomedical waste management protocols and ensure that their staff comprehends the significance of these measures. This may entail offering training in biomedical waste segregation and establishing secure procedures for the collection and transportation of such waste. Secondly, it is crucial to enhance public awareness regarding the proper disposal of biomedical waste. This objective can be accomplished through public campaigns and educational initiatives targeting both the general populace and healthcare professionals.

Finally, the use of available technologies for the treatment and disposal of biomedical waste can help to improve the management of this waste in India. Technologies such as incineration, autoclaving, and microwave treatment can effectively sterilize biomedical waste and make it safe for disposal.

VIII. PROCESS OF BIOMEDICAL WASTE DISPOSAL

In summary, the process of handling and disposing of biomedical waste begins with the collection and separation of waste materials at their point of origin. Subsequently, the gathered and sorted waste is transported to designated waste treatment facilities, where the final stages of disposal occur through methods such as disinfection and autoclaving. The following are the necessary steps for the correct management and disposal of biomedical waste:

1. **Collection and Segregation:** In order to prevent spills and other hazards, waste must be collected and separated on the producing site. Moreover, it guarantees efficient disposal of garbage. Keeping harmful and contaminated waste materials apart from non-contagious waste is the goal. Colored biomedical waste containers, like pedal bins and non-chlorinated plastic bags, are commonly utilized for simple segregation. Biomedical waste bins are color coded (yellow, red, blue, and black).

Color Coding & Type of Container for Disposal of Bio-Medical Waste

Color Coding	Type of Container -I Waste Category	Treatment Options as per Schedule I
Yellow	Plastic bag Cat. 1, Cat. 2, and Cat. 3, Cat. 6.	Incineration/deep burial
Red	Disinfected container/plastic bag Cat. 3, Cat. 6, Cat.7.	Autoclaving/Microwaving/ Chemical Treatment
Blue/White translucent	Plastic bag/puncture proof Cat. 4, Cat. 7. Container	Autoclaving/Microwaving/ Chemical Treatment and destruction/shredding
Black	Plastic bag Cat.5 and Cat. 9 and Cat.10. (solid)	Disposal in secured landfill

The yellow bags, which are devoid of chlorine content, are specifically designed for the transportation of human or animal tissues, organs, body parts, and solid contaminated materials like cotton, dressings, linens, and similar items. The disposal of garbage related to microbiology and biotechnology, as well as other laboratory waste products, is reserved for the red, non-chlorinated plastic bags.

They are also employed for the transportation of sharps, including items like needles and glass syringes, which have the potential to cause cuts or puncturesWhile the black non-chlorinated plastic bags are especially made for garbage like paper, kitchen scraps, food, and other non-infectious materials, the blue non-chlorinated plastic bags are meant for chemical waste. It is essential that biomedical waste handlers have sufficient training to guarantee proper waste management and to avoid mishaps and injuries. Additionally, it is essential to store the colored plastic bags within their designated biomedical bins.

2. **Storage and Transportation:** Rolling bin trolleys for biomedical waste are essential for moving garbage from the point of origin to the central storage area and then to the biomedical treatment plant. It is advisable to securely seal plastic bins, affix labels, and arrange for their disposal when they reach 75% capacity. Minimizing manual handling of these waste containers is essential to prevent injuries and the risk of infection from needle pricks. Equally vital is avoiding close contact with plastic bags or bins while they are being stored and during their transportation.

3. **Treatment**

Primarily, there are two steps involved in Treating Biomedical Waste

- **Pre-Treatment:** Waste materials made of rubber, plastic, and metal are disinfected before being burned to cut down on harmful emissions.
- **Final Disposal:** Incineration, secure landfilling, or even deep burial are used for final disposal. High temperatures are used for dry oxidation, which results in incineration.

Evaporating all volatile substances and moisture. This aids in lowering the waste's weight and volume as well. It is simple to submit dressing materials, human trash, and animal waste for burning.

Three types of incinerators are available: rotary kilns, double chamber pyrolytic incinerators, and single chamber furnaces. These incinerators are easy to construct, economical, and ecologically beneficial. Additionally, they work effectively in hospitals and other healthcare settings, even in remote areas.

IX. EFFECTS OF BIO MEDICAL WASTE ON ENVIRONMENT

When a healthcare professional begins their shift, one of the primary concerns they have is the potential exposure to biohazardous waste, which is also known as biomedical waste or infectious waste. This type of waste comprises infectious materials, including items like blood-soaked materials, scalpel blades, needles, and other waste contaminated with bodily fluids or substances like chemotherapy drugs. The impact of medical waste pollution is not limited to human health but extends to the environment as well.

X. CAUSES OF MEDICAL WASTE

The occurrence of medical waste is a result of inadequate segregation and disposal practices within medical facilities. In certain instances, the facility might not be responsible for the issue, as the fault could lie with the delivery service or the medical waste processing plant. Regardless of the source of the problem, the medical facility may still face fines. To avoid medical waste-related issues, medical facilities should diligently separate and store medical waste and ensure that the disposal service they engage complies with all state regulations. Every individual within the healthcare sector, irrespective of their role, bears the responsibility of guaranteeing the proper storage and disposal of medical waste, including those involved in its treatment.

Despite the current level of awareness regarding the impact of medical waste on both individuals and the environment, there are still instances where certain medical facilities and treatment companies improperly dispose of medical waste. This may occur due to inadequate training or, in some cases, deliberate improper disposal practices.

XI. HAZARDS ASSOCIATED WITH HOSPITAL WASTE

The impact of medical waste on human health and the environment is of immense magnitude, potentially leading to severe illnesses or even fatalities. When medical waste, particularly pharmaceuticals, ends up in proximity to wildlife refuges such as parks, lakes, and natural habitats, it has the potential to decimate entire wildlife populations. Medications, particularly those with vibrant colors, can be alluring to birds and other animals.

Medical waste that hasn't undergone proper treatment can easily contaminate groundwater. Once it infiltrates the groundwater, it becomes accessible to both animals and humans for ingestion. Landfills are specifically designed to contain all types of waste within a controlled environment. Some landfills incorporate liners to prevent waste from seeping into the surroundings. However, the disposal of sharps can puncture these liners, allowing liquids from waste, including household and improperly processed medical waste, to leach into the groundwater and soil.

At times, the diagnostic tools and devices employed by doctors contain radioactive elements. In the event that these disposable tools or devices are not correctly disposed of, radioactive materials can find their way into landfills and other areas. These radioactive particles pose significant risks to both humans and animals. Radioactive diseases represent just one category of illnesses that can result from improper medical waste management. Other diseases that humans may contract encompass AIDS, cholera, typhoid, Hepatitis B, and SARS.

Furthermore, certain pollutants present in medical waste may become airborne if the waste is not incinerated at the appropriate temperature. If these airborne pollutants happen to carry infectious agents, individuals exposed to the pollution through inhalation could be susceptible to these diseases.

XII. CONCLUSION

As per the findings outlined in this report, biomedical waste stands out as one of the most perilous types of waste generated by human activities. In India, addressing the challenges posed by biomedical waste has become a complex endeavor. Both governmental and non-governmental organizations have recognized the importance of biomedical waste management and have voiced concerns regarding it. It is imperative for any healthcare facility generating biomedical waste to establish the necessary treatment facilities to guarantee proper waste treatment and disposal, thereby mitigating the potential hazards associated with biomedical waste exposure for workers, patients, healthcare professionals, and the general public.

Several challenges and limitations such as a lack of awareness, insufficient concern, and cost-related factors currently hinder the proper management of biomedical waste. Nevertheless, it is crucial to emphasize that safe and effective biomedical waste management is not solely a legal obligation but also a societal responsibility. In the contemporary world, where the concept of "one health" prevails, the proper management of biomedical waste holds substantial significance. It plays a pivotal role in upholding ecological equilibrium, preserving biodiversity, and safeguarding the overall health of the global community. Prioritizing biomedical waste management is paramount in protecting public health, preserving the environment, and ensuring a safer and healthier future for all.

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