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Biomedical Waste Management in India: Post COVID 19 Trends & SDG Alignment[1][2]

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ABSTRACT
All healthcare facilities generate biomedical waste during the diagnosis and treatment of patients, both human and animal. Biomedical waste can exist in both solid and liquid forms, encompassing microbiological and biological waste, expired or discarded medicines, cytotoxic drugs, contaminated substances, infected solid and liquid waste, animal carcasses, human anatomical remains, ash from incineration, chemical by-products, and sharp instruments. This type of waste carries inherent risks and demands careful handling and proper disposal. The management of biomedical waste involves four essential stages: 1) its production, 2) separation, 3) accumulation and storage, and 4) processing and final disposal. It is a best practice for healthcare facilities to disinfect any waste before disposal. Improper handling of this waste can have significant adverse effects on the environment, humans, and other living organisms. Worldwide, medical facilities routinely generate substantial amounts of hazardous waste. Many developed countries have recently adopted advanced technologies to neutralize toxicity and ensure proper disposal in designated locations. Conversely, in countries like India, which are still developing, biomedical waste is frequently disposed of in open areas due to insufficient awareness, inadequate infrastructure, limited financial resources, and weak enforcement of national disposal regulations. This study seeks to examine the challenges associated with biomedical waste management, its effects on the environment, the legal provisions regulating waste disposal, and the extent of compliance across different state post COVID 19. Additionally, it proposes innovative solutions and best practices that can be standardized nationwide to enhance the efficiency of waste management.
Keywords: Biomedical Waste Management, Hazardous Waste Disposal, Environmental Impact, Sustainable Development, Waste Segregation.

INTRODUCTION
Medical care is essential for preserving life, yet it also produces dangerous waste that poses risks to both the environment and living organisms. Healthcare facilities, such as hospitals and clinics, generate different types of waste, including used cotton, syringes, needles, gloves, liquid waste, and outdated medicines. This biomedical waste, created during medical procedures, testing, and research, is more dangerous than household or industrial waste because of its infectious nature. Common sources of this waste include hospitals, laboratories, dental and veterinary clinics, and research centers.[3] To address these dangers, the Indian government established the Bio-medical Waste (Management and Handling) Rules in

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[3] See The Bio-Medical Waste Management Rules, 2016, schedule I.

1998, updated in 2016 to incorporate the latest standards. These rules outline national guidelines for handling various categories of biomedical waste, such as anatomical waste, sharps, contaminated materials, and discarded medicines.[4] Researchers, NGOs, and environmental advocates have called for stricter regulations due to the severe impact of improper waste disposal on the environment and sustainable development. While environmental concerns have existed for a long time, legal frameworks have traditionally addressed environmental protection only when deemed necessary. Earlier, no specific laws governed biomedical waste disposal. However, with technological advancements, the dangers posed by hazardous waste from healthcare facilities can no longer be ignored. The human environment relationship has changed over time and varies across regions, influencing India's environmental conservation policies. Notably, environmental protection was not incorporated into the Indian Constitution until 1976, and India's environmental initiatives began in 1972 following the Stockholm Conference.

HISTORICAL DEVELOPMENT OF ENVIRONMENTAL PROTECTION IN INDIA

India's historical relationship with environmental protection is deeply rooted in its ancient traditions and philosophies. Environmental consciousness has been a part of Indian culture for centuries, often intertwined with religious and ethical teachings:

1. Buddhism: Gautam Buddha, seen as both an environmentalist and humanitarian, attained enlightenment under the Bodhi tree, symbolizing a deep connection to nature. His teachings emphasized nonviolence (ahimsa) and simplicity, advocating for respect towards all living beings and the natural world. In Buddhism, humans, trees, and forests are viewed as interconnected, where trees are valued for providing sustenance and shelter.
2. Jainism: Jain philosophy also promotes environmental protection, forbidding animal sacrifices during religious festivals and condemning cruelty towards animals. Jainism stresses environmental harmony, urging care for all life forms, and discourages harm to nature. Lord Mahavira, a key figure in Jainism, taught that ignoring the elements—earth, air, fire, water, and plants—is equivalent to disregarding one's own existence.
3. Kautilya's Arthashastra: Arthashastra written by Kautilya (also known as Chanakya), includes specific penalties for environmental violations.[5] Fines were imposed for activities like dumping dirt on streets, obstructing pathways, or polluting reservoirs. The severity of the penalties varied depending on the infraction, highlighting the importance of cleanliness and environmental care.[6]

Such historical teachings and laws illustrate India's longstanding commitment to environmental stewardship, which has influenced contemporary conservation efforts.

INTERPRETATION FROM MODERN HISTORY

During the colonial era, British rule had a profound influence on India's legal and administrative frameworks. However, their governance also resulted in extensive exploitation of natural resources, with minimal efforts toward forest conservation. Despite this, the British implemented certain laws to curb pollution affecting water, air, and wildlife. Among the earliest was the Shore Nuisance (Bombay & Kolaba) Act of 1853, which aimed to control water pollution. Similarly, the Oriental Gas Company Act

[4] Capoor, M., & Bhowmik, K. (2017). Implementation challenges in bio-medical waste management rules, Indian Journal of Medical Microbiology, 2016, 35
[5] Kangle, R. P. (1986). The kautiliya Artha sastra (No. 1-3). Motilal Banarsidas Publication IPC 1860
[6] Francis, E. (2012). King, Governance, and Law in Ancient India: Kautilya's Arthasastra, A New Annotated translation.

of 1857 was enacted to regulate emissions from the Oriental Gas Company.
The Indian Penal Code of 1860 also included provisions related to environmental protection. For example, Section 268 defined actions causing public harm or inconvenience as public nuisances, which could be punished under Sections 290 or 291. Section 269 imposed penalties for negligence likely to spread harmful diseases. Further sections, such as 426, 430, 431, and 432 penalized actions causing damage or reducing the value of property.[7] These laws provided a legal framework for dealing with environmental offenses even if they weren't explicitly focused on pollution.
While British-era laws addressed some environmental concerns, they lacked a structured and comprehensive approach to environmental protection. After independence, India recognized the need for stronger environmental safeguards, making it a priority under **Article 21** of the Constitution, which guarantees the Right to life. Over time, the judiciary expanded its interpretation of this right to include ecological justice, setting the foundation for stronger environmental policies. To address growing environmental challenges, the government introduced various laws. The Factories Act of 1948 established basic guidelines for waste management, while the River Boards Act of 1956 empowered states to control pollution in inter-state rivers.[7]
India's Constitution, particularly Part III, contains key provisions related to environmental protection. **Article 21**, interpreted by courts to include the right to a clean environment, became a legal tool for environmental justice, a cause championed by activist lawyer M.C. Mehta. Additionally, **Article 47** highlights the state's responsibility to improve public health, **Article 48A** mandates government efforts to protect and enhance the environment, and **Article 51A(g)** places a fundamental duty on citizens to contribute to environmental conservation.

INTERNATIONAL CONVENTIONS

Three major international agreements play a vital role in regulating biomedical waste management, environmental protection, and sustainable development: the Basel Convention, the Stockholm Convention, and the Minamata Convention. The Basel Convention on Hazardous Waste is among the most extensive agreements, with **participation from 170** countries. Its main objective is to safeguard human health and the environment from the risks posed by hazardous waste generation. handling, and disposal of hazardous waste, including medical waste generated by healthcare facilities. The Stockholm Convention on Persistent Organic Pollutants (POPs) aims to safeguard both human health and the environment from persistent organic pollutants—dangerous chemicals that can accumulate in living organisms and cause significant harm.[8] The treaty sets out standards for reducing these pollutants, often generated through waste disposal methods like incineration. In 2006, guidelines for best environmental practices were issued, emphasizing waste reduction, proper sorting, recycling, recovery, education, and efficient collection and transport. The Minamata Convention on Mercury, established in 2013, focuses on protecting human health and the environment from the toxic effects of mercury, a natural element used in many everyday products.[9] The treaty addresses the reduction of mercury emissions into the air, soil, and water, highlighting the importance of limiting its widespread use and controlling its impact on ecosystems.

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[7] Divan, S. & Rosencranz, A. (2022). Environmental Law and Policy in India: Cases and Materials. Oxford University Press. 579-601
[8] Revised Draft Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices of the Stockholm Convention on Persistent Organic Pollutants.2006
[9] United Nations Environment Program. (2013). Minamta Convention on Mercury. United nations environment Program. See also, Kessler, R. (2013). The Minamata Convention on Mercury: a first step toward protecting future generations

Biomedical waste refers to any type of waste that contains potentially infectious materials, which can harm public health and the environment. This type of waste is generated during medical procedures, including diagnosis, treatment, and immunization of both humans and animals. Unlike regular waste, biomedical waste requires special handling, segregation, and treatment to reduce its potential hazards. Its safe disposal is crucial to prevent the spread of infections and protect both healthcare workers and the general public. Biomedical waste can exist in both solid and liquid forms. Some common examples of biomedical waste include:

- **Sharps**- Items like needles, syringes, lancets, scalpels, and broken glass that can cause injury or transmit infections.
- **Human Tissues and Body Parts**- These are often generated from surgeries or amputations and may be identifiable.
- **Animal Tissue-** Waste generated from veterinary hospitals or animal testing.
- **Used Medical Supplies**- This includes items such as bandages, gloves, dressings, and other disposable medical products that may be contaminated with infectious materials.
- **Liquid Waste**- Fluids from infected areas or patients that require safe disposal.
- **Laboratory Waste**- Materials like test tubes, cultures, and chemicals used in medical laboratories.

TYPES OF BIOMEDICAL WASTE MANAGEMENT

The **World Health Organization (WHO)** classifies **biomedical waste into eight categories**, each requiring specific handling and disposal methods due to the risks they pose. Proper management of these waste types is essential to prevent harm to both humans and the environment. Below is an overview of these categories:

1. **Infectious Waste** – This includes waste contaminated with infectious agents, such as materials from patients with contagious diseases. If not managed correctly, it can pose significant health risks.
2. **Sharps** – Items such as needles, scalpels, broken glass, and razors fall under this category. These objects are particularly hazardous due to the risk of injuries and infections.
3. **Pathological Waste** – This consists of human or animal tissues, body parts, organs, blood, and bodily fluids. Due to potential pathogens or toxins, it must be handled with extreme caution.
4. **Pharmaceutical Waste** – Expired, unused, or discarded medications, including drugs and ointments, belong to this category. Improper disposal of such waste can have harmful effects on health and the environment.
5. **Geno toxic Waste** – This includes hazardous chemicals and drugs capable of causing genetic mutations or cancer. Due to its toxicity, specialized precautions are necessary when handling this waste.
6. **Radioactive Waste** – Any waste containing radioactive substances, often from medical treatments or diagnostic procedures, falls under this category. It requires strict safety protocols to prevent exposure.
7. **Chemical Waste** – This includes waste from disinfectants, cleaning agents, and batteries used in healthcare settings. If not disposed of properly, these substances can be dangerous to both humans and the ecosystem.
8. **General/Other Waste**- This is the category for non-hazardous waste that doesn't fall into any of the above groups. While not dangerous, it still needs to be disposed of properly to avoid unnecessary environmental impact.

JUDICIAL INTERVENTIONS IN BIOMEDICAL WASTE MANAGEMENT

The Supreme Court and High Courts of India have consistently emphasized the importance of biomedical waste management, particularly concerning environmental protection. Several landmark cases have shaped the legal framework in this domain:

- Subhash Kumar v. State of Bihar[10]: This Public Interest Litigation (PIL) sought directives to prevent coal washery sludge from polluting the Bokaro River. The case questioned whether the right to a healthy environment is covered under the right to life. The Court ruled that Article 21 of the Constitution includes the right to clean air and water.
- K.C. Malhotra v. State of Madhya Pradesh (1993)[11]: The Court addressed a cholera outbreak linked to improper waste disposal, highlighting the failure of state authorities in managing waste and protecting public health. The ruling reaffirmed that the right to life extends to basic necessities such as food, water, and healthcare, reinforcing the state's responsibility to ensure public well-being.
- Vellore Citizens Welfare Forum v. Union of India[12]: This case established the principles of Sustainable Development and the Polluter Pays Principle as fundamental to India's environmental laws.
- Research Foundation for Science, Technology, and National Resource Policy v. Union of India: The Supreme Court played a crucial role in addressing hazardous waste disposal, forming a committee to recommend proper waste management measures.
- Environment Monitoring Forum & Anr. v. Union of India[13]: The ruling mandated that all institutions generating biomedical waste must follow prescribed disposal methods to prevent environmental hazards.
- Haat Supreme Wash tech Pvt. Ltd. v. State of Haryana[14]: The National Green Tribunal (NGT) ruled that any facility handling biomedical waste must secure Environmental Clearance (EC) to minimize environmental risks.
- D. Swami v. Karnataka State Pollution Control Board[15]: The Supreme Court ruled that if a facility meets pollution norms and holds the necessary permits, it may be granted ex post facto EC in exceptional cases, prioritizing pollution control over strict procedural compliance.

These judicial interventions have reinforced the importance of strict biomedical waste management, ensuring environmental sustainability and public health protection.

IMPLEMENTATION OF BIOMEDICAL WASTE MANAGEMENT RULES

The Biomedical Waste Management Rules are applicable to all individuals and organizations involved in the generation, collection, transportation, storage, treatment, disposal, or handling of biomedical waste in any capacity. However, these rules do not apply to the following categories:

- Radioactive waste, which falls under the Atomic Energy Act, 1962
- Waste managed under the Municipal Solid Waste Rules, 2000
- Lead-acid batteries
- Hazardous waste governed by specific regulations

[10] AIR 1991 SC 420
[11] AIR 1994 MP48
[12] 1996(5)SCC 647
[13] 2003
[14] 2022 SCC OnLine SC 1278
[15] 2022

- Electronic waste (E-waste)
- Hazardous microorganisms that are regulated separately

These exclusions ensure that different types of waste are managed under appropriate frameworks to maintain environmental safety and public health standards.

CURRENT LEGAL FRAMEWORK FOR BIOMEDICAL WASTE MANAGEMENT

The legal definition of biomedical waste is provided under the Biomedical Waste Management and Handling Rules, 1998, introduced by the Government of India. As per these regulations, biomedical waste includes any solid, liquid, or fluid waste, along with containers and by-products, that arise from diagnosis, treatment, or immunization of humans and animals. It also encompasses waste generated from research activities, as well as the production and testing of biological products. However the recent rules which are followed are of 2016 BMW rules.

BIOMEDICAL WASTE MANAGEMENT PROCESS AND REGULATIONS

The management of biomedical waste involves multiple crucial steps/ stages to ensure its safe handling, disposal, and treatment in healthcare facilities.

- Generation: Waste is produced during medical procedures, diagnostics, and daily operations in healthcare institutions.
- Accumulation: The waste is then sorted and categorized based on its type to ensure proper handling.
- Handling: This phase involves the careful management of waste to prevent contamination, accidents, or exposure to hazardous substances.
- Storage: Before final disposal or treatment, the waste is temporarily stored in designated, secure locations.
- Treatment: The waste undergoes processing methods like sterilization or incineration to minimize health risks and environmental damage.

These systematic steps ensure responsible waste management, reducing its impact on public health and the environment.

Hospitals generate a variety of hazardous and non-hazardous waste, including:

- Infectious materials (e.g., blood, organs, tissues)
- Sharps (e.g., needles, scalpels)
- Chemical waste (e.g., toxic substances, heavy metals)
- Microbiological cultures

Since biomedical waste may contain highly contagious pathogens, improper disposal can lead to severe environmental and health hazards. If not managed properly, it can cause air, water, and soil pollution, produce foul odors, and attract vectors like insects and rodents, increasing the risk of diseases such as typhoid, cholera, hepatitis, and HIV/AIDS— particularly through contaminated needles or syringes.

To mitigate these risks, the Biomedical Waste (Management and Handling) Rules, 1998, were introduced, establishing regulations for waste collection, segregation, treatment, and disposal. Over time, these rules have been updated and strengthened to ensure safe waste management in healthcare settings.

In 2016, the Ministry of Environment, Forest, and Climate Change revised these regulations under the

Environment (Protection) Act, 1986[16] introducing the Biomedical Waste Management Rules, 2016. These updated rules align with India's Clean India initiative, making it mandatory for healthcare facilities to categorize biomedical waste into color-coded bins (yellow, red, blue/white, and dark-colored bins) for effective waste segregation and disposal in colored bags or bins. These wastes can be stored for up to 48 hours before being safely disposed of or collected by professionals from a Common Biomedical Waste Treatment Facility (CBMWF). The treatment of waste is based on the ***color-coded bags***, with each color requiring specific disposal methods, such as cremation, deep burial, autoclaving, destruction, chemical treatment, or landfill disposal.

Healthcare facilities are also responsible for pre-treating certain types of waste, such as laboratory and microbiological waste, blood samples, and blood bags, by disinfecting and sanitizing them in accordance with guidelines from the World Health Organization (WHO) or the National AIDS Control Organization (NACO). In an effort to prevent the release of harmful dioxins and furans, healthcare facilities are mandated to phase out the use of chlorinated plastic bags, gloves, and blood packs within two years.

A study by the Government of India revealed that 484 tons of biomedical waste are generated daily by 168,869 healthcare facilities in India, although only 447 tones are processed before disposal. There is a significant issue with informal waste disposal, where 15% of the waste is hazardous or toxic, and the remaining 85% is non-hazardous. However, when mixed, the entire waste becomes dangerous, making segregation and proper treatment crucial for public health and environmental safety.

IMPACT OF COVID 19

The rising volume of biomedical waste has become a significant concern, particularly with the surge in Covid-19 cases. According to data from the Covid-19 Biomedical Waste Management (BWM) authorities, over 56,000 tons of Covid-19 contaminated waste were generated between June 2020 and June 2021. This sharp increase in waste has sparked widespread concern, especially regarding the safety of frontline health and sanitation workers who are responsible for collecting biomedical waste from the homes of Covid-19 patients. These workers face heightened risks due to the potential exposure to infectious materials.[17] These rules aim to regulate and streamline the process of biomedical waste segregation, helping to ensure safer management practices across the country. These guidelines are vital for the effective handling of the waste generated by healthcare facilities and the general public during the pandemic. The COVID-19 pandemic highlighted significant systemic flaws, particularly in areas such as data management, inadequate reporting, and a lack of awareness regarding proper segregation of biomedical waste. Even after the pandemic, numerous reports have surfaced about healthcare facilities (HCFs) and Common Biomedical Waste Treatment Facilities (CBWTFs) across the country continuing to violate established waste management rules. These ongoing issues emphasize the need for stricter enforcement and enhanced awareness regarding the proper handling and disposal of biomedical waste.

The Central Pollution Control Board (CPCB) recently compiled data submitted by State Pollution Control Boards and Committees in response to the National Green Tribunal’s order dated January 12, 2024. The report provides insights into the current state of healthcare facility (HCF) management across India.

According to data from 36 pollution control bodies, India has a total of 393,242 healthcare facilities (HCFs). Of these, approximately 67.8% are non-bedded facilities, which include clinics, laboratories,

[16] Biomedical waste management rules 2016 published in gadget of India extraordinary part 2 section 3 sub section (1) Government of India ministry of environment forest and climate change

[17] Sarkodie, S.A , P.A.(2021). Impact of code 19 pandemic on waste management environment and development sustainability

blood banks, dispensaries, and veterinary institutions. Inadequate biomedical waste disposal poses serious risks, such as:

- Contamination of the environment, leading to potential health hazards.
- Reuse of prohibited medical disposables, increasing the risk of disease transmission.
- Unintentional cultivation of harmful microorganisms, which can threaten public health.

This highlights the urgent need for stricter enforcement of biomedical waste management rules to ensure proper disposal, minimize contamination, and protect public health and the environment.

SEGREGATION, PACKING STORAGE AND TRANSPORT OF MEDICAL WASTE

Biomedical waste is classified into four categories based on the appropriate treatment and disposal methods. These categories help in ensuring safe and efficient waste management while minimizing environmental and health hazards. As per regulations, no untreated biomedical waste should be stored for more than 48 hours. If there is a need to extend the storage period, the occupier must ensure that it does not pose any risk to human health. Additionally, they must inform the State Pollution Control Board (SPCB), providing a valid reason for the extended storage duration.

These guidelines play a crucial role in preventing contamination, disease transmission, and environmental pollution, reinforcing the importance of timely and proper biomedical waste disposal. Proper segregation of biomedical waste is the first and most crucial step in its management. Waste must be separated at the point of generation into designated color-coded bins—yellow for infectious and pathological waste, red for contaminated recyclable waste, white for sharp objects like needles and scalpels, and blue for glassware and metallic body implants. Each category undergoes specific treatment methods, such as incineration, autoclaving, or chemical disinfection, before final disposal. Proper packing and labeling of waste bags prevent accidental exposure and ensure safe handling during transportation. Additionally, dedicated storage areas should be used to keep biomedical waste until it is transported to authorized treatment facilities, ensuring compliance with safety and regulatory standards.

A message to always remember for the segregation, storage and disposal of the waste is that: "YELLOW has blood, drugs and tissues dead, Plastics tubes and syringe now go in RED, Sharps in Containers lockable & white, Black is for garbage; BMW not by right, Card boards shall carry bottles and Glasses, We must remember these four classes."

The Recyclable materials must either be repurposed through proper recycling methods or disposed of safely in a secured landfill after undergoing necessary treatment. As per the Biomedical Waste Management (BMWM) Rules, occupiers are restricted from setting up on-site or captive biomedical waste treatment and disposal facilities if a public treatment facility is available within a 75-kilometer radius.

STATUS OF COMPLIANCE BY THE STATE

India currently consists of 28 States and 8 Union Territories. As per Rule 13 of the Bio-Medical Waste Management Rules, 2016, State Pollution Control Boards must submit an annual report by July 31 each year. This report includes details on the collection, treatment, and disposal of biomedical waste in each state and is submitted to the Ministry of Environment, Forest and Climate Change (MoEF&CC). Table 1 outlines the compliance status of various states regarding biomedical waste management. The most recent data available on the Central Pollution Control Board's website pertains to the year 2022 and is based on the Annual Report on Biomedical Waste Generation.

The MoEF&CC serves as India's primary government authority overseeing environmental policies, regulations, and forestry programs. It plays a crucial role in shaping the country's environmental governance by formulating and implementing policies aimed at sustainable waste management. Under Section 12 of the Environment (Protection) Act, 1986, the central government has the authority to designate Environmental Laboratories responsible for conducting environmental assessments. Additionally, Section 13 of the same Act empowers the government to appoint Government Analysts to ensure compliance with environmental standards and regulations.

The compliance gaps highlight the varying effectiveness of states in managing biomedical waste disposal. States like Assam, Bihar, Karnataka, and Kerala require significant improvements in their waste disposal mechanisms, while Jharkhand, Jammu & Kashmir, Madhya Pradesh, and Uttarakhand also need to enhance their management strategies. Furthermore, states such as Goa, Ladakh, Manipur, Odisha, and Rajasthan need slight improvements to ensure effective biomedical waste disposal.

Table 1: Annual Report on Biomedical Waste Generation by Central Pollution Control Board.[18]

S. No.	**Name of (State/Union Territory)**	**Cumulated Quantity of BMW generated**	**Cumulated Quantity of BMW Treated and Disposed**	**Gaps in treatment and Disposal of BMW (kilogram/day)**
1.	Andaman Nicobar	734.79	734.79	0
2.	Andhra Pradesh	16512.02	16512.02	0
3.	Arunachal Pradesh	464.6	464.6	0
4.	Assam	8229.32	5208.93	3020.39
5.	Bihar	28246.3	13949.3	14297

[18] Central pollution control Annual Report 2022 on bio medical waste generation by Central pollution control board

6.	Chandigarh	5710	5710	0
7.	Chhattisgarh	7504.9	7504.9	0
8.	Daman & Diu and Dadra Nagar Haveli	324	324	0
9.	Delhi	29155	29155	0
10.	Goa	2128.4	2128.44	0.04
11.	Gujrat	47843	47843	0
12.	Haryana	20590	20590	0
13.	Himachal Pradesh	3769.51	3769.51	0
14.	Jharkhand	9694.5	9011.22	683.28
15.	J & K	8651.42	8418.53	232.89
16.	Karnataka	78441	70018	8423
17.	Kerela	62122.78	29175	32947.78
18.	Ladakh	86.35	86.34	0.01
19.	Lakshadweep	86	86	0
20.	Madhya Pradesh	15631.86	15450.77	181.09
21.	Maharashtra	74248	74248	0
22.	Manipur	1442.92	1442.42	0.50
23.	Meghalaya	2840.66	2840.66	0
24.	Mizoram	958.06	958.06	0
25.	Nagaland	1076.43	1076.43	0
26.	Odisha	16677.6	16677.64	0.04
27.	Puducherry	4706.4	4706.4	0
28.	Punjab	19841	19841	0
29.	Rajasthan	19564.9	19564.91	0.01
30.	Sikkim	562	562	0
31.	Tamil Nadu	49721.43	49721.43	0
32.	Telangana	25306	25306	0
33.	Tripura	1975.87	1975.87	0
34.	Uttarakhand	7113.37	7101.60	11.77
35.	Uttar Pradesh	89210.65	89210.65	0
36.	West Bengal	38886.14	38886.14	0
37.	DGAFMS	5152.3	5152.3	0
	TOTAL	705209.569	645411.851	59797.718

INTERPRETING GAPS THROUGH SUSTAINABLE DEVELOPMENT GOALS

The United Nations introduced the Sustainable Development Goals (SDGs) in 2015 as a strategic framework for promoting human development and enhancing quality of life. Proper healthcare waste management is directly linked to achieving key SDGs, particularly **SDG 3 (Good Health and Well-being)** and **SDG 6 (Clean Water and Sanitation)**. Ensuring public health and a clean environment is a fundamental aspect of the right to life. The Supreme Court has consistently upheld that Article 21 of the Indian Constitution, which guarantees the right to life, encompasses the right to health and a pollution-free environment. As previously discussed, discrepancies between the quantity of biomedical waste generated and the amount safely disposed of pose serious risks to public health and environmental sustainability. To bridge these gaps and mitigate their negative consequences, Common Bio-medical Waste Treatment and Disposal Facilities (CBWTFs) have been established to enhance waste management efficiency and ensure proper treatment and disposal.

CHALLENGES IN LEGAL REGULATIONS ON BMW MANAGEMENT

Despite significant advancements in biomedical waste management in India, several obstacles persist, preventing full regulatory success. The Bio-Medical Waste Management Rules have empowered local self-governments, state authorities, and national pollution control boards to monitor and regulate waste disposal. Hospitals that violate these guidelines face strict penalties, including potential closure. Additionally, State Pollution Control Boards (SPCBs) are responsible for conducting surprise inspections to ensure compliance.

However, practical challenges remain, particularly in urban hospitals, which produce vast amounts of biomedical waste. If not managed properly, this waste can adversely impact surrounding communities, increasing health risks for residents. Smaller healthcare facilities and clinics also face difficulties, as they often rely on private contractors for waste disposal, resulting in additional financial burdens.

Illegal dumping of biomedical waste is another pressing issue, with widespread noncompliance in several regions. A key challenge is effectively monitoring and enforcing waste management regulations, especially when dealing with unauthorized waste disposal practices. Addressing these challenges requires stricter enforcement, improved infrastructure, and greater financial support for smaller healthcare institutions establishments. Unauthorized disposers often mix biomedical waste with regular household trash and dispose of it in public bins, making it hard to identify and prosecute offenders. This lack of accountability presents a significant hurdle for the government in enforcing regulations effectively. Moreover, issues such as bribery and undue influence sometimes protect those who violate the rules, allowing them to avoid facing consequences. This corruption further complicates efforts to ensure proper disposal practices are followed. Strengthening public awareness, ensuring efficient waste segregation at the source, and expanding affordable waste treatment options can significantly improve compliance. government bodies, private stakeholders.

CONCLUSION

To ensure effective BMW practices, healthcare personnel and HCFs must obey strict legislation, cooperate with government authorities, and undergo continuous monitoring. legislature has established strict standards for managing biomedical waste in healthcare facilities, state agencies must closely monitor them to prevent biohazards from entering the environment. BMW 2016 suggestions improve segregation, transportation, and disposal operations, reducing pollution and ensuring safety for workers, patients, and the public. Therefore, medical waste should be classified based on their origin, typology, and potential risks for management, capacity, and disposal. The main step is to minimize waste at source and consider reuse, recycling it. To address the alarming situation of municipal disregard for healthcare facilities and state government adherence to minimal regulations, we need to consider radical and innovative solutions. The generation of waste, especially biomedical waste, has significant immediate and abnormal costs for society. This will test our abilities to handle excessive biomedical waste and to conduct and regulate ourselves with respect to achieve India's biomedical waste management industry is projected to grow at an annual rate of 7-8%, making it crucial to address existing inefficiencies to prevent future challenges. Without effective interventions, the increasing volume of waste could pose significant environmental and health risks.

SUGGESTIONS

State Pollution Control Boards (SPCBs) must conduct comprehensive gap assessments to identify weaknesses in the system and ensure proper waste management. Establishing additional Common Biomedical Waste Treatment and Disposal Facilities (CBWTFs) based on demand and geographic requirements will help optimize waste processing and minimize operational overload.

A detailed audit comparing actual versus reported capacities of treatment facilities is necessary to ensure compliance with regulatory guidelines. Healthcare facilities (HCFs) should be strictly monitored, and Online Continuous Emission Monitoring Systems (OCEMS) must be rigorously enforced to prevent violations. Every stakeholder—from waste generators to handlers and recyclers—should be systematically tracked to eliminate intentional or accidental breaches in the disposal process.

Current loopholes in the system, including illegal waste transfers, improper incineration, and inefficient disposal methods, demand immediate action. Some CBWTFs serve an excessive number of HCFs, leading to bottlenecks in waste treatment. However, constructing a facility in each of India's 806 districts is neither practical nor financially viable. SPCBs must determine the optimal number of treatment centres and the most efficient strategies to manage biomedical waste effectively.

Expanding barcoding systems to include biomedical waste recyclers can enhance traceability and prevent the misuse of recycled medical products. Additionally, hospitals generate significant quantities of non-medical waste, including plastics, paper, and food waste, which are often mixed with biomedical waste. Strengthening the implementation of Solid Waste Management Rules, 2016, specifically for HCFs, can ensure proper segregation at the source.

Addressing these challenges is essential to establishing a robust, sustainable, and legally compliant biomedical waste management system in India, ensuring that no hazardous medical waste reaches the country's landfills or informal dumping grounds.

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