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Survey of Bio Medical Waste with Special Reference to their Disposal and Management of Satna City

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Abstract
Biomedical waste poses significant environmental and public health risks due to its potential to spread infectious diseases and contaminate the environment. This paper presents a comprehensive survey and analysis of biomedical waste management practices in Satna City, aiming to identify existing challenges and propose effective strategies for disposal and management. Through a combination of field surveys, interviews with healthcare facility managers, and review of literature, the study assesses the generation, segregation, collection, treatment, and disposal of biomedical waste in Satna City. It examines the types and quantities of biomedical waste generated by healthcare facilities, including hospitals, clinics, laboratories, and research institutions. Furthermore, the study evaluates the compliance of healthcare facilities with biomedical waste management rules and regulations, highlighting areas of improvement. Special attention is given to the identification of barriers and challenges faced in the proper disposal and management of biomedical waste, such as inadequate infrastructure, lack of awareness, and insufficient training of healthcare personnel. Based on the findings, the paper proposes recommendations for enhancing biomedical waste management practices in Satna City, including the implementation of proper segregation techniques, provision of adequate training and resources, strengthening of regulatory enforcement, and promotion of sustainable waste treatment technologies. By addressing these issues, the paper aims to contribute to the development of effective strategies for the safe and environmentally sound management of biomedical waste in Satna City, ultimately protecting public health and the environment.

Keywords: Biomedical waste, Waste management, Healthcare facilities, Satna City, Environmental health, Waste disposal.

1. INTRODUCTION:

The management of biomedical waste has emerged as a significant issue, impacting not just hospitals and nursing homes, but also the environment at large. The volume of biomedical waste generated by healthcare institutions is shaped by a multitude of factors including waste management practices, facility types, healthcare specialties, the utilization of reusable items, and the accessibility of infrastructure and resources.

In 1998, the Biomedical Waste (Management and Handling) Rules of India outlined that any waste produced during research activities pertaining to the diagnosis, treatment, or vaccination of humans or animals, or during the testing of biologicals, falls under the category of biomedical waste. Furthermore, a notification issued by the Government of India in the same year emphasized that the management of waste in hospitals is integral to their sanitation and maintenance protocols.

For safe and scientific management of biomedical waste, handling, segregation, mutilation, disinfection, storage, transportation and finally disposal are vital steps vital steps are being adopted by all the institution related to the health problem (Acharya and Singh, 2000). Inadequate handling of biomedical waste leads to significant environmental issues, resulting in air, water, and soil pollution. These pollutants, including biological, chemical, and radioactive materials, pose serious threats. India has implemented various legislations and guidelines to combat environmental concerns effectively. Specifically, the classification of radioactive waste within biomedical waste is addressed. Additionally, the adverse effects of pollution on air quality, radioactivity levels, land degradation, and associated health hazards are thoroughly examined.

1.1. Air Pollution

Air pollution can originate from both indoor and outdoor environments. Biomedical waste generated by air pollution is categorized into three types: Biological, Chemical, and Radioactive. Pathogens contained within this waste can linger in the air for extended periods, either as spores or active pathogens. Measures such as waste segregation and pre-treatment at the source can significantly mitigate this issue. Additionally, sterilizing rooms can aid in combating indoor air pollution caused by biological factors. The inadequate ventilation of indoor spaces can lead to chemical-induced illnesses like Sick Building Syndrome (SBS). This can be addressed through proper building design and the maintenance of air conditioning systems. It's essential to adhere to prescribed norms when using chemicals and to avoid their overuse. (Askarian et al., 2004b; Baveja et al., 2000; Bdour, 2004).

The incineration of biomedical waste poses significant risks, primarily due to the release of toxic fumes. Inhalation of these fumes can lead to respiratory illnesses. It is imperative that the design specifications and upkeep of facilities for the treatment and disposal of such waste adhere strictly to prescribed standards (Bdour 2004).

2. The main objectives of the study ….

1. To classify BMW
2. To collect and transport BMW
3. To segregate BMW
4. To dispose BMW in hospitals

3. MATERIALS & METHODS

3.1 Description of study area

In the context of assessing and managing hospital waste, various types of hospitals including government and private ones in Satna, Madhya Pradesh, were chosen as the study locations. The study involved gathering data using a "self-assessment audit form" during the period of 2016-17.

The current investigation was conducted within Satna city, situated at longitude 80°21' to 81°23' east and latitude 23°58' to 25°12' north. As a pivotal business hub in Madhya Pradesh, Satna stands along the Mumbai-Howrah railway main line, positioned 187 kilometers from Allahabad (U.P.) and 190 kilometers from Jabalpur (M.P.). Renowned for its pilgrimage sites and industrial significance, Satna district boasts abundant resources including limestone, bauxite, white clay, geru, ramraj, and flagstones. The city hosts a diverse array of healthcare facilities, from small clinics to large hospitals, with plans for additional specialty hospitals and nursing homes in the foreseeable future. Predominantly agricultural, the district's economy sustains a rural population of 74.46% according to the 2011 census, with a total population of 282,977 individuals, comprising 149,415 males and 133,562 females.

3.2 SOURCE OF BIO MEDICAL WASTE: -

Biomedical waste, primarily generated from healthcare institutions including hospitals, nursing homes, veterinary hospitals, clinics, and general practitioners' offices, presents a notable environmental dilemma. This waste encompasses a wide array of materials including discarded items from medical procedures, laboratory experiments, blood banks, and animal research facilities. Moreover, bio-medical waste can also arise in home settings where healthcare is administered to patients, such as through injections or dressing changes.

Typically, a substantial portion of bio-medical waste—ranging from 75% to 90%—is categorized as nonhazardous, akin to standard municipal waste. However, the remaining 10% to 25% is hazardous, presenting risks to both human and animal health as well as environmental integrity. Importantly, when these two types of waste are intermingled, the entire waste stream becomes harmful, underscoring the critical need for proper segregation and disposal practices.

An acceptable common system should be in place which will provide regular supply of color-coded bags, daily collection of infectious waste, safe transportation of waste to offsite treatment facility and final disposal with suitable Technology (Rao et al. 2004, Chitins et al. 2003).

Additional origins of biomedical waste include: Household waste generated from healthcare practices at home. Waste from industries, educational institutions, and research centers involved in biomedical activities. Biomedical waste generated by blood banks and clinical laboratories during testing and medical procedures.

3.3 MAJOR SOURCES: -

1. Govt. hospitals / private hospitals
2. nursing home / dispensaries
3. Medical colleges and research center / paramedic services.
4. Veterinary colleges and animal research centers.
5. Blood bank / mortuaries / autopsy centers.
6. Biotechnology institutions.
7. Production units.

3.4 MINOR SOURCE: -

1. Animal houses / slaughter houses.
2. Blood donation camp.
3. Vaccination center.
4. Institution for disables person.

4. METHOD, TRANSPORT & MANPOWER: -

Upon inquiring about waste management practices in both government and private hospitals, researchers discovered contrasting approaches. In government hospitals, the waste is initially openly dumped around the premises until designated areas become filled, at which point it is collected by BMW vans and transported to a disposal plant. Conversely, in private hospitals, waste from each ward is collected and temporarily stored in separate containers and trolleys located outside the hospital building. Sweepers then dispose of the waste into designated "Blue" and "Yellow" color containers. Early mornings, BMW vans collect this waste from both government and private hospitals, where it is subsequently mixed with municipal waste and transported to the Satna disposal plant. Private hospitals revealed that they enlist the services of an agency to manage this waste on a monthly basis, with charges ranging from 7000 to 10,000 Rupees.

4.1 Collection

Biomedical waste management encompasses the utilization of diverse containers sourced from various facilities such as operating theaters, laboratories, wards, kitchens, and corridors. These containers must be strategically positioned to ensure the complete collection of waste. Specifically, sharps should be securely stored in puncture-proof containers at all times to prevent injuries and infections among the personnel handling them.

4.2 Storage

After the collection process, biomedical waste is appropriately stored. Segregated waste from various categories must be gathered in distinct containers that are easily identifiable. In large hospitals (with more than 250 beds), storage duration should not exceed 8-10 hours, while in nursing homes, it should not exceed 24 hours. Each container should be clearly labeled to indicate the ward or room where it is placed, facilitating easy traceability if needed. Additionally, the storage area must be marked with caution signs for safety purposes.

Table 1: -Segregation of Bio-Medical waste -

Category	Description of waste category	Treatment and disposal
Cat.1	Human Anatomical Waste: (human tissues, organs, body part)	Incineration / deep burial
Cat.2	Animal waste: (animal tissues, organs, body parts carcasses, bleeding parts fluid, blood and experimental animals used in research waste generated by veterinary hospitals colleges , discharge from hospitals ,animal houses)	Autoclaving/microwaving/ incineration
Cat.3	Microbiology and Biotechnology Waste :(waste from laboratory cultures stocks of specimens of microorganism, waste from production of biological, toxins, dishes ans divices used for transfer and cultures)	Disinfection (chemical treatment/autoclaving/microwaving) and mutilation/shredding
Cat.4	Waste Sharps (needles, syringes, scalpel, blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharpes)	Disinfection (chemical treatment/autoclaving/microwaving) and mutilation/shredding
Cat.5	Discarded Medicines and Cytoxic Druges (waste comprising of outdated contaminated and discarded medicine)	Incineration/destruction and drugs disposal in secured landfills

Cat.6	Solid Wastes (items contaminated with bloods and body fluids including cotton, dressings, solied paper casts, lines, beddings, other materials contaminated with blood)	Incineration/ Autoclaving/microwaving/
Cat.7	Solid Waste (wastes generated from disposable items other than the waste sharpes such as tubing, catheters, intravenous sets etc.)	Disinfection/ Autoclaving/microwaving/ and mutilation/shredding
Cat.8	Liquid Waste (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	Disinfection/discharge in to drains
Cat.9	Incineration Ash (ash from incineration of any bio-medical waste)	Disposal secured landfill
Cat.10	Chemical waste (chemical used in production of biologicals, chemicals, used in disinfection, as insecticides etc.)	Chemical treatments and discharge into drain for liquids and secures land fill for solids.

Source **https://www.researchgate.net/figure/Segregation-and-colour-coding-of-different-biomedical-wastes-with-treatment-options_tbl1_301920787**

4.3 TRANSPORTATION

To ensure utmost safety, it is imperative to take precautions when handling bags or containers containing BMWs. These containers must be securely tied or lidded prior to transportation. Additionally, before transporting such bags, a signed document by a Nurse or Doctor indicating the date, shift, quantity, and destination should accompany them.

Specialized vehicles should be employed to minimize access to and direct contact with the waste by transportation operators, scavengers, and the public. These transport containers must be properly enclosed to prevent any mishaps. Consideration must be taken into account for potential traffic accidents during the design phase, and it is imperative that drivers receive training on spillage procedures. Additionally, the interiors of the containers should be designed to be washable to facilitate comprehensive cleaning when required.

Table 02 - The use of protective gears should be made mandatory for all the personnel handling waste.

Colour coding	Types of containers 1 Waste category	Treatment options as per Schedule 1
Yellow	Plastic bag cat.1, cat.2, 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
Black	Plastic bag cat.5, cat.9, and cat.10, (Solid)	Disposal in secured landfill

Source: https://in.pinterest.com/pin/635852041147524935/

4.4 DISPOSAL OF BMW AT SATNA:-

- incineration
- Chemical disinfection
- Wet (autoclaving) and dry thermal treatment
- Microwave irradiation
- Land disposal
- Inertization

5. Disposal methods

Different methods are used for the disposal of bio medical waste and are discussed below:

5.1 Incineration:

It's a controlled combustion process where waste undergoes complete oxidation, effectively destroying harmful microorganisms under high temperatures. A recent study on plasma pyrolysis of medical waste revealed promising results. The authors highlighted that the operational expenses of the system would be 13 Indian Rupees per kilogram (kg), with energy recovery costing 8 Indian Rupees per kg, resulting in a net cost of Rs 7 per kg. The quantity and composition of hospital waste generated are detailed in Table 3. Incineration, widely practiced in countries like Japan where land is scarce, is favored due to its smaller spatial footprint compared to landfills. Sweden has notably utilized energy derived from incineration for the past two decades, while Denmark has integrated waste-to-energy incineration extensively into local combined heat and power facilities to support district heating schemes (Gupta, 1998).

Table 3. Machinery requirements for Common Waste Treatment Facility

1.	Incinerators	2 numbers
2.	Auto Claves	One
3.	Microwave equipment	(Optional)
4.	Shredders	2 nos
5.	Chimney	30 M
6.	Effluent Treatment Plant	1
7.	Vehicle Washing Equipments	1
8.	Water pumps, Storage, Air Compressors	1
9.	Generator for Electricity	1

Source: http://mpcb.mah.nic.in

The waste should be treated in a controlled manner and for an adequate duration to ensure disinfection. To ensure ease and safety during operation, the system should be of a horizontal type and specifically tailored for the treatment of bio-medical waste. For the best outcomes, a pre-vacuum-based system is preferred over a gravity-type system. It must include a tamper-proof control panel equipped with efficient display and recording devices to monitor critical parameters such as time, temperature, pressure, date, and batch number (Pruss et al., 1999).

5.2 Microwaving: Microbial inactivation arises from the thermal impact of electromagnetic radiation within the frequency range of 300 to 300,000 MHz. Microwave heating operates through an inter-molecular heating process, where heating transpires within the waste material amidst the presence of steam. Hydroclaving shares similarities with autoclaving, albeit with the distinction that indirect heating is applied to the waste by steam in the outer jacket. Throughout the process, the waste undergoes continuous tumbling within the chamber.

5.3 Shredder: Shredding is the method through which waste is reshaped or cut into smaller fragments, rendering them unrecognizable. This process serves to prevent the reuse of bio-medical waste and also serves as an indicator that the waste has been disinfected and is safe for disposal. A shredder is necessary for this purpose, meeting the minimum requirements for shredding bio-medical waste (Singh & Sharma, 2010; Rasheed et al., 2005)

6. Result and discussion

The current investigation was conducted in Satna city, situated at a longitude of 80°21' to 81°23' east and a latitude of 23°58' to 25°12' north. Located on the Mumbai – Howrah railway main line, Satna is a significant business hub in Madhya Pradesh, positioned approximately 187 kilometers from Allahabad (U.P.) and 190 kilometers from Jabalpur (M.P.). The district of Satna holds religious significance and serves as a national pilgrimage site, while also being recognized for its industrial activity and abundance of natural resources including limestone, bauxite, white clay, geru (ramraj), and flagstones.

Healthcare institutions are indispensable components of daily life, continuously generating waste that can pose potential health hazards to healthcare workers. In countries like India, where economic constraints drive impoverished and uninformed individuals to scavenge through discarded materials for survival, the proper management of waste becomes critically important.

Despite claims by hospitals to dispose of waste according to regulations, it is alarming to discover that a significant portion of infectious waste, including needles, syringes, and catheters, is being recycled and reintroduced into the market. Because of the inherent health risks associated with healthcare waste, even though it makes up a small portion of the overall waste stream, it needs special handling.

Waste demanding particular care includes potentially infectious materials, sharps such as needles and scalpels, as well as various chemically hazardous substances used in laboratories and pharmaceutical establishments. The safe and scientific management of biomedical waste in healthcare settings necessitates handling, segregation, mutilation, disinfection, storage, transportation, and final disposal—all of which require thorough training of healthcare workers.

Unfortunately, personnel responsible for biomedical waste disposal often lack adequate training, resulting in improper management and insufficient adherence to regulations. Employees frequently use colored bags without systematic segregation or treatment protocols. The current state of biomedical waste management in Indian hospitals is dire, highlighting the urgent need for healthcare establishments to ensure that waste is handled without adverse effects on human health.

6.1 CATEGORISATION OF BIOMEDICAL WASTE: -

Table 04 - Bio-medical waste have been categorised into ten different categories as mentioned in the table below.

Colour conding	Types of containers 1 Waste category	Treatment options as per Schedule 1
Yellow	Plastic bag cat.1, cat.2, 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
Black	Plastic bag cat.5, cat.9, and cat.10, (Solid)	Disposal in secured landfill

Source: http://mpcb.mah.nic.in

6.2 COLLECTION / PER DAY / ALTERNATE: -

Waste Generation Rate = Average waste production/patient/day ×Total no. of patients visited/day × Total no. of hospitals

Waste Generation in Government Hospitals = 150gms/patient/day × 250 patients/day × 1 Government hospitals

= 75000gms

In Kilograms = 75000/1000= **75kg/day** According

Table 5-Category wise Solid Waste Generation from JILA Hospital of Satna in 2022.

S. N	Months	Total number of beds	YELLOW	BLUE	PPS
01	January	250	189.00	36.000	30.000
02	February		176.00	39.000	35.000
03	March		193.00	35.000	37.000
04	April		188.00	31.000	40.000
05	May		196.00	25.000	30.000
06	June		187.00	25.000	25.000
07	July		195.00	36.000	36.000
08	August		199.00	37.000	40.000
09	September		202.00	30.000	37.000
10	October		206.00	29.000	34.000

11	November		198.00	33.000	40.000
12	December		187.00	36.000	34.000
MEAN			193.00 Kg	32.66 Kg	34.83 Kg
TOTAL			2316.00 KG	392.000 KG	418.000 KG

6.3 Treatment & Disposal Facilities for bio-medical waste:

According to the Biomedical Waste Management Rules (BMWM) of 2016, biomedical waste must be treated and disposed of by designated treatment and disposal facilities. The Central Pollution Control Board (CPCB) consistently urges State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) to ensure that biomedical waste from hospitals, nursing homes, and other healthcare units is scientifically disposed of, as outlined in the BMWM Rules of 2016.

These rules specify that biomedical waste should be treated and disposed of at Common Biomedical Waste Treatment Facilities (CBWTFs). However, the BMWM Rules of 2016 prohibit healthcare facilities from establishing on-site or captive biomedical waste treatment and disposal facilities if a CBWTF is available within a 15-kilometer radius.

Currently, there are 202 numbers of CBWTFs operated in the Country and 35 CBWTFs are under construction, with 18015 captive treatment facilities installed by healthcare facilities (HCFs). There has been a decrease in the use of captive treatment facilities by HCFs over the years. Specifically, the use of captive waste treatment incinerators decreased from 225 to 120 between 2007 and 2022, while the number of CBWTFs increased from 155 to 200 during the same period.

Although there was a decrease in captive treatment facilities from 2016 to 2022, the utilization of captive treatment facilities by HCFs increased again in 2022.

Research has been conducted on the disposal and management of both liquid and solid biomedical waste, emphasizing the necessity of best management practices for maintaining a healthy hospital environment, which is a fundamental right of all citizens. Hospitals can sometimes be sources of bacterial, viral, and chemical infections, not only within their premises but also potentially outside if hospital waste or contaminated liquid and solid waste is not safely disposed of and managed.

Liquid waste management requires particular attention, with effluent treatment facilities being of utmost importance for hospitals in general. Strategies for reduction, reuse, and recycling should be carefully considered, with proper waste segregation at the source being an essential first step.

Liquid waste generated from various hospital departments was collected and analyzed for parameters such as pH, suspended solids (SS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and oil and grease content. The permissible pH limit is 9.5, and pH values were observed to be within this limit. However, SS concentrations were found to be higher. Similarly, BOD values exceeded the permissible limit, while COD values mostly remained within the limit, with exceptions noted in June and November where COD levels surpassed the permissible limit

7. Conclusion

Ensuring the safe and efficient management of waste is not just a legal obligation but also a societal duty. Challenges such as lack of concern, motivation, awareness, and cost considerations hinder proper hospital waste management practices. Conducting thorough surveys to assess waste management procedures is essential. There is a clear need for educational initiatives to raise awareness about the hazards associated with improper waste disposal. Overcoming apathy towards waste management is crucial for effective waste disposal practices. Establishing an effective communication strategy is imperative, particularly given the low awareness levels among various staff categories in healthcare facilities regarding biomedical waste management.

Proper collection and segregation of biomedical waste are paramount. Additionally, the quantity of waste generated plays a significant role. Reducing the quantity of biomedical waste generated results in cost savings and a more efficient waste disposal system in addition to lessening the workload associated with waste disposal duties. Therefore, healthcare providers should consistently strive to minimize waste generation in their day-to-day operations within clinics or hospitals.

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