International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Biomedical waste management practices in selected hospitals of Bangalore urban

Bikash Debbarma[1], Dr. Hemanjali A.M[2]

[1] M.Sc. Student, Department of Environmental Science, Bangalore University
[2] Teaching Faculty, Department of Environmental Science, Bangalore University

Abstract

This study aimed to evaluate the quantities, compositions, and the methods employed for handling, treating, and disposing of waste in diverse healthcare settings. Biomedical waste management is of utmost importance due to its potential inclusion of infectious agents and hazardous materials, with inadequate management posing risks to healthcare workers, patients, communities, and the environment.

The safe and sustainable management of biomedical waste is a collective social and legal responsibility for those involved in supporting and funding healthcare activities. Effective biomedical waste management is not only a requirement for ensuring public health but also for maintaining a clean environment.

Proper handling, treatment, and disposal of biomedical waste are integral to hospital infection control programs. The objectives of biomedical waste management primarily revolve around preventing disease transmission among patients and healthcare workers, minimizing harm to those handling the waste, and averting general exposure to the adverse effects of cytotoxic, genotoxic, and chemical biomedical waste generated in healthcare facilities. When appropriately designed and implemented, waste management practices can be both effective and efficient in ensuring compliance. This review article provides insights into the collection, segregation, treatment, and disposal of various types of biomedical waste.

Chapter 1

Introduction

Health care as an enterprise is an essential foundation for every civilized community. Pharmaceutical products, clinical equipment and instruments assists in aiding patients in hospitals, naturally, steers the creation of diverse medical and non-medical wastes. Clinical waste generated from hospice processes carries a significant risk of infection and potential harm compared to other types of waste. Clinical waste created necessities in secure and consistent practices for continuous supervision and hence it is crucial. Defective and deficient managing of medical waste results in severe impact on both public health and environment. Effective and valid waste awareness campaigns play a vital role to moderate the extent and the amount of different waste forms, to curtail managing and disposal of wastes.

Medical waste includes materials generated during the treatment of infectious patients who can transmit diseases directly or indirectly through contact with the environment (Cheng et al., 2009; Hossain *et al.*, 2011). It is imperative to handle infectious waste with extreme care to prevent the spread of pathogens and safeguard environmental health. Such waste should be separated from other types of waste. The quantity of clinical waste produced by hospitals can vary due to several factors, including the hospital's size and type, patient-to-staff ratio, occupancy rate, geographic location, state and local waste management regulations, and hospital waste disposal policies. It is essential to handle hazardous waste with great caution to prevent the proliferation of pathogens and protect the surrounding environment while ensuring its segregation from other waste materials. Hospital waste generation is influenced by multiple factors, including hospital size, type, patient-to-staff ratio, occupancy levels, geographical location, local waste management regulations, and hospital waste disposal policies.

Several studies suggest that medical waste generally poses a minimal infectious risk to the public. However, the daily production of hazardous waste per patient varies significantly due to the absence of consensus on the definition of infectious waste. The generation of medical waste is expected to remain a persistent concern as society advances. Multiple studies have reported that hospitals in the United States produce approximately 2 to 4 pounds of infectious waste per patient per day, accounting for roughly 15% of the total waste generated by healthcare facilities (Berwick and Hackbarth, 2012).

Medical waste processing facilities alter the biological characteristics of clinical waste or reduce its disease-causing potential. Dismantling facilities break down clinical waste by either shredding or tearing it apart, making it less infectious and unidentifiable as medical waste. Once medical waste has undergone thorough treatment and destruction, there is no longer a need to monitor it. These treatment and destruction facilities encompass incinerators, and treatment procedures involve grinding, steam sterilization, or the application of disinfectants, heat, or radiation (USEPA, 2001).

Medical waste comprises all types of waste, both organic and inorganic, resulting from patient treatments and medical research activities (Rutala, 2005). Medical waste originates from various sources, including nursing homes, polyclinics, blood banks, research institutes, veterinary clinics, and more (Sharma, 2002).

The significant concerns associated with medical waste pertain to its toxicity and potential for spreading infections. Hospitals, akin to manufacturing industries, generate various types of waste as a result of diverse medical activities. Over the past decade, the increasing size and number of hospitals and healthcare services have led to a heightened consumption of disposable medical products, resulting in a notable upsurge in the quantity of medical waste (Licset *et al*., 1930).

Managing hospital waste poses challenges for both healthcare facilities and the environment. Various factors, including the methods employed, the types and specialties of medical facilities, occupancy rates within medical units, the ratio of reusable items, and other sources, have a significant impact on medical waste management. In the current context, waste management has evolved into a global humanitarian concern. It is well-established that the "medical waste" generated during patient care has numerous adverse and harmful effects on both the environment and human health.

1.1 Medical waste

Medical waste means any solid as well as liquid waste including its container and any moderate product, which is created during the diagnosis, treatment or immunization of human beings or animals or in research relating thereto or in the production or testing thereof. Some toxic waste comprises biological blood culture, body parts, tissues, blood, discarded bandages and gloves, sharps, and other laboratory wastes. The sharps involve probably infected utilized scalpels, needles, lancets and other devices capable of penetrating skin. Medical waste can also include waste obtained during the treatment or medication of both human beings and animals. Other wastes include derivatives of health care environment like radioactive wastes, plastics, devices containing mercury.

Clinical waste means any waste generated during diagnosis, treatment or immunization of human beings or animals. Management of healthcare waste is an integral part of infection control and hygiene programs in healthcare settings. These settings are a major contributor to community-acquired infection, as they produce large amounts of clinical waste. Clinical waste can be categorized based on the risk of causing injury and/or infection during handling and disposal. Wastes targeted for precautions during handling and disposal include sharps (needles or scalpel blades), pathological wastes (anatomical body parts, microbiology cultures and blood samples) and infectious wastes (items contaminated with body fluids and discharges such as dressing, catheters and I.V. lines). Other wastes generated in healthcare settings include radioactive wastes, mercury containing instruments and polyvinyl chloride (PVC) plastics. These are among the most environmentally sensitive by-products of healthcare (Askarain *et .al.,* 2004 ; Remy, 2001).

1.2 Biomedical Waste

Biomedical waste, also known as medical waste, refers to any waste that contains infectious or potentially infectious materials. This category of waste includes materials generated in healthcare facilities, research laboratories, and other medical or clinical settings.

Biomedical waste can encompass a wide range of items, such as used needles, syringes, soiled bandages, cultures, and various discarded medical equipment. Due to its potential to carry infectious agents like bacteria, viruses, or other pathogens, proper disposal and management of biomedical waste are essential to prevent the spread of disease and protect public health and the environment.

Handling and disposing of biomedical waste typically involve following specific regulations and guidelines to minimize health and environmental risks. These guidelines often include methods like incineration, autoclaving (sterilization), and using specialized containers for safe storage and transportation. Regulations for biomedical waste management can vary by location and are typically set by government authorities or agencies responsible for public health and environmental protection.

Biomedical waste handling rules are regulations and guidelines designed to ensure the safe and proper disposal of biomedical waste generated by healthcare facilities, research laboratories, and other institutions where medical and biological materials are used. These rules are crucial for preventing the spread of infections and protecting the environment. While the specific rules may vary by country and region, here is an overview of some common principles and practices related to biomedical waste handling:

1.3 Sources of Biomedical waste

Hospital waste refers to all waste, biologic or non-biologic that is discarded and not intended for further use. Medical waste is a subset of hospital waste; it refers to the material generated as a result of diagnosis, treatment or immunization of patients and associated biomedical research. Biomedical waste (BMW) is generated in hospitals, research institutions, health care teaching institutes, clinics, laboratories, blood banks, animal houses and veterinary institutes.

Table 1. The sources of Biomedical wastes are listed below:

MAJOR SOURCES	MINOR SOURCES
Hospitals	Clinics
Research center	Dental clinics
Labs	Home cares
Animal research	Paramedicals
Blood banks	Institutions
Nursing homes	Pet clinics
Autopsy centers	Funerals services

Most medical waste is incinerated, a practice that is short-lived because of environmental considerations. The burning of solid and regulated medical waste generated by health care creates many problems. Medical waste incinerators emit toxic air pollutants and toxic ash residues that are the major source of dioxins in the environment. The toxic ash residues sent to landfills for disposal have the potential to leach into groundwater.

Medical waste has been identified by US Environmental Agency as the third largest known source of dioxin air emission and contributor of about 10% of mercury emissions to the environment from human activities. The air emissions affect the local environment and may affect communities hundreds or thousands of miles away. Dioxin is one of the most toxic chemicals known to humankind. Dioxins have been linked to cancer, immune system disorders, diabetes, birth defects and disrupted sexual development.

International Agency for Research on Cancer (IARC), an arm of WHO, acknowledged dioxins cancer causing potential and classified it as human carcinogen. To avoid dioxin production, no chlorinated plastic bags (and preferably no other chlorinated compounds) should be introduced into the incinerator. Red bags must not be incinerated as red color contains cadmium, which causes toxic emissions. If mercury-containing items are put into a red bag for infectious waste and sent to an incinerator or other waste treatment technology, mercury will contaminate the environment. Airborne mercury then enters a global distribution cycle in the environment, contaminating fish and wildlife. Mercury is a potent neurotoxin that can cross the blood-brain barrier as well as the placenta.

World Health Organization report 2019 states that 85% of hospital wastes are actually non-hazardous, whereas 10% are infectious and 5% are non-infectious but they are included in hazardous wastes. This range is dependent on the total amount of waste generated. These wastes now threaten the public since, the health care foundations are situated in heart of city and therefore medical waste, if not properly managed can cause dangerous infection and possess a potential threat to the surrounding environment, persons handling it and to the public. Health and environmental effects, uncertainty regarding regulations and negative perceptions by waste handles are some important concerns in health care waste management in a country.

Globally this issue has been seriously considered and appropriate waste management systems are being developed and installed. A number of difficulties are being faced at many places in implementation of this plan in practice. The waste disposal is governed by the Government agencies and regulations including private organizations.

At present, there is no available information that describes the actual practice of handling the health care waste products. The proposed hospital waste management plan is consistent with the biomedical waste (management and handling) (second Amendment) Rules, 2000, Ministry of environment, forests and climate change. As a result, this study aims to assess the biomedical waste handling and treatment in different health care settings.

1.4 Overview of Biomedical Waste Handling Rule, 2016

The Biomedical Waste Management Rules in India, as of 2016, include a comprehensive schedule that provides detailed guidelines for the segregation, collection, packaging, transportation, treatment, and disposal of various categories of biomedical waste. The schedule helps healthcare facilities and other biomedical waste generators understand how different types of waste should be managed. Below is an overview of the schedule of the Biomedical Waste Management Rules 2016 in India:

Schedule I:

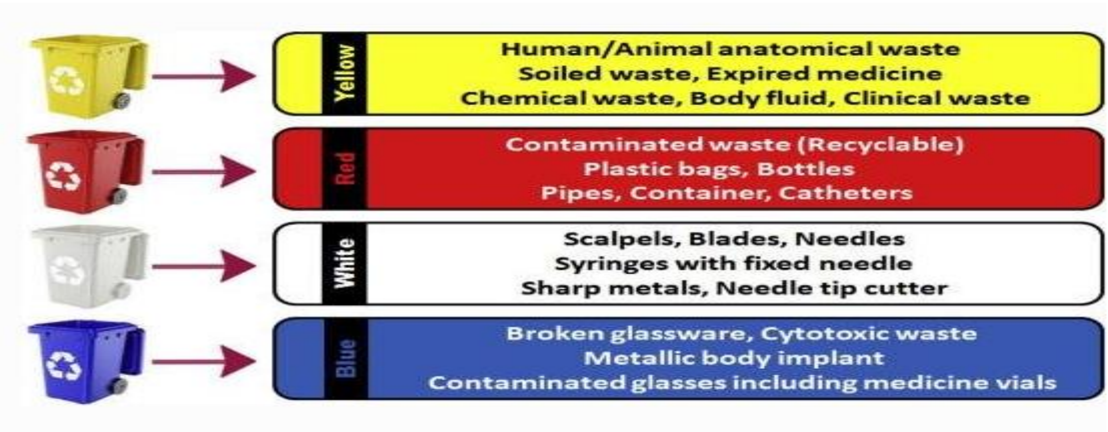

Figure 1: Categories of Biomedical Waste

Schedule II: Segregation of Biomedical Waste

Schedule II of the Biomedical Waste Management Rules 2016 outlines essential guidelines for the segregation of biomedical waste at its source of generation. Biomedical waste is categorized into nine distinct categories, including human anatomical waste, animal waste, microbiology and biotechnology waste, sharps waste, discarded medicines and cytotoxic drugs, soiled waste, solid waste, liquid waste, and incineration ash. Each category is assigned a specific color code, facilitating easy identification and proper disposal. Containers used for waste collection must be marked with the biohazard symbol and labeled to indicate the waste category. Training and education of healthcare personnel and waste handlers are emphasized to reduce the risk of errors and accidents. Ultimately, it is the responsibility of waste generators to ensure the correct segregation of biomedical waste at the source, promoting a safer and more efficient waste management process.

Schedule III: Packaging Requirements

Schedule III of the Biomedical Waste Management Rules, 2016, outlines the packaging requirements for the safe handling of biomedical waste. These requirements are essential to prevent the risk of infection and contamination associated with biomedical waste. They specify the types of containers and methods for packaging different categories of biomedical waste, ensuring that waste is securely contained and labeled for proper handling and disposal. Adhering to these packaging requirements is crucial for the safe and responsible management of biomedical waste, reducing the potential health and environmental hazards associated with it.

Schedule IV: Transportation of Biomedical Waste

Schedule IV of the Biomedical Waste Management Rules, 2016, focuses on the transportation of biomedical waste. It provides guidelines and requirements for the safe and responsible transportation of biomedical waste from the point of generation to the treatment and disposal facilities. This schedule lays out specific rules for packaging, labeling, and the vehicles used for transporting biomedical waste. It also addresses the need for trained personnel to handle the transportation process and the necessary permits and documentation for tracking the waste's movement.

The regulations outlined in Schedule IV are designed to prevent spillage, contamination, and the spread of infections during the transportation of biomedical waste. Proper adherence to these rules is critical to maintaining the safety of both the personnel involved in waste transportation and the general public while minimizing the environmental impact of biomedical waste.

Schedule V: Record Maintenance

Schedule V of the Biomedical Waste Management Rules, 2016, pertains to the record maintenance requirements for the handling and management of biomedical waste. This schedule outlines the necessary documentation and records that must be maintained by healthcare facilities and other generators of biomedical waste.

The records typically include details related to the quantity and categories of biomedical waste generated, the transportation and disposal processes, and the treatment methods employed. Maintaining these records is crucial for transparency, accountability, and regulatory compliance. It allows authorities to monitor and ensure that biomedical waste is being managed in accordance with the established guidelines, reducing the potential risks to public health and the environment associated with improper waste management.

The schedules is a crucial component of the Biomedical Waste Management Rules 2016 in India, as it helps healthcare facilities and other waste generators adhere to proper waste handling procedures, maintain records, and promote the safe and responsible management of biomedical waste. It is essential for compliance with the regulations to prevent health risks and environmental harm.

1.5 Scope of the study

Despite of the fact stated by the (WHO, 2014) 10% to 20% of healthcare wastes are hazardous and healthcare activities lead to the production of wastes that may also lead to adverse health related and environmental pollution effects. Healthcare wastes, whether produced at smaller rural clinics or larger facilities, can be managed where adequate well-operated infrastructures exist. Until countries are in transition and developing countries do not have access to healthcare waste management options that are safer to the environment and health, incineration may be an acceptable response when used appropriately as stated by the (UNEPA, 2006). Although major improvements made in medical waste management, current strategy and practices in Bangalore city still requires modification and progress.

This assessment addresses multiple facets of medical waste management. It identifies existing challenges and proposes solutions, assesses the awareness of waste segregation among staff and beneficiaries, and determines necessary inputs for safe waste management. The insights provided are intended to inform policymakers, healthcare stakeholders, and government officials for the betterment of waste management practices. Additionally, it serves as a valuable starting point for future research by offering potential research directions to scholars and researchers in the field. The ultimate goal is to enhance healthcare waste management for the safety of all involved.

1.6 Objectives

- To evaluate hospital practices with the Biomedical Waste Management Rules of 2016 for the comprehensive management of biomedical waste.
- Developing a Standard Operating Procedure (SOP) to enhance hospital workers' understanding and implementation of biomedical waste management practices.

Chapter- 2

Review of literature

Sharma *et al.*, (2020) studied the challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic and focus area for this study was Bio medical waste, plastic, food waste management during COVID-19. They found that contamination from virus laden

BMW and health risks of sanitation workers, increased plastic waste and food waste. Need of building resilience to ace future catastrophe.

Radha and Lavanya (2019) conducted study work on challenges and actions to the environmental management of Bio-Medical Waste during COVID-19 pandemic in India and their focus area of study was Biomedical waste, Waste disposal, Waste management, Infectious waste, Segregation, Health care unit, Regulation, Hazard. They found that medical facilities in urban centers are improving faster than those in the rural areas due to rapid urbanization. Waste management systems in the urban areas are already overburdened. Hence, an additional load due to mixing of infectious waste from HCUs aggravates the problem. Separate systems for disposal of HCU waste are available in only a few establishments. The shortcomings in the existing system are: The segregation of waste in almost all hospitals is not satisfactory.

Pasupathi *et al*., (2011) studied the biomedical waste management for health care industry and fucus area was proper handling, treatment and disposal of biomedical waste management role in hospital and to control infection. Preventing transmission of disease from patient to patient, from patient to health worker and vice versa, to prevent injury to the health care worker. Their finding are the quantity of hospital waste and proportion of infection waste is definitely higher than one would expect in India due to extensive use of medical and non-medical disposals. Most of hospital wastes are nonhazardous in nature like food waste from admitted patients. The century witnessed the rapid mushrooming of hospitals in the public and private sector, dictated by the need of the expanding population, and the advent and acceptance of "disposable" has made the generation of hospital waste a significant factor in present hospitals.

Rajan *et al*., (2019) studied the Biomedical waste management in Ayurveda hospitals and focus area of study was identification and classification of biomedical wastes in Ayurvedic hospitals, current practices of its management in Ayurveda hospitals and its future prospective. They found from this study it is found that the major waste material coming out of an Ayurveda hospital is the used kizhi (a material used for fomentation process) and medicated oil discarded after use. Large quantities of this oil are available and many unscrupulous elements misuse this spent oil. An eco-friendly way should be found out to make use of or to destroy this waste oil. Ayurveda creates less waste with blood or body parts, except in the case of Rakthamoksham (bloodletting), where blood-filled leech may be considered as a bio medical waste.

Datta *et al.,* (2021) studied the biomedical waste management in India: Critical appraisal and focus area of study was on Biomedical waste in India, International agreement and convention in relation with bio medical waste management. The importance of rules in managing biomedical waste. Their found from this study it is found that there is major challenge in implementation the rules properly and effectively due to lack of financial. To phase out chlorinated plastic bags, gloves, blood bags and to establish a bar code system for bags/ containers the cost will be high.

Goswami *et al*., (2021) conducted study work on the problem associated with handling of biomedical waste during covid-19 period and its safe disposal without harming environment and general public. They found from this study that there are apparent challenges and gaps in implementing the guidelines due to inadequate infrastructure across the states and inconsistent operational efficiency of implementing agencies. Though there have been many revisions in regulatory guidelines for better management of BMW during this pandemic, no significant improvement of management efficiency has been observed over the study period.

Shalini *et al*., (2012) conducted study work on evaluation of bio-medical waste management practices in a government medical college and hospital. The study was conducted for biomedical waste management practices in sixteen hospitals of Indore city and found that hospital authorities think that their basic responsibility is to take care of the health of the patients whereas the waste disposal in an environmentally compatible manner has been given a low priority.

Kulkarni and Anantharam (2020) conducted study work on repercussions of COVID-19 pandemic of MSW management: challenges and opportunities. Fron this study it was found that increased burden on MSW, mixing of BMW and risk of disease transmission through solid waste handling, impact of increasing BMW on MSW management system.

Ramteke and Sahu (2020) studied on novel coronavirus disease 2019 pandemic: considerations for the biomedical waste sector in India and his study focus area was about potential impact of COVID-19 on BMW administrations, focuses where option working methodology or extra moderation measures might be fitting. He highlights the need for considerations for further measures towards BMW management.

Somani *et al.,* (2020) conducted study on indirect implications of COVID-19 towards sustainable environment: an investigation in Indian context and fucus area of their study was about effects of COVID -19 restrictions on the environment in India: Investigate the impact of COVID-19 on waste management. They highlight the need for automation and mechanization of waste management is required.

Kumar *et al.,* (2020) study was done on life cycle assessment of PPE kits under two disposal scenarios, namely landfill and incineration (both centralized and decentralized) for six environmental impact categories. They found that disposal of overall has the maximum impact, followed by gloves and goggles, in term of GWP. The incineration process showed high GWP but significantly reduced impact w.r.t other environmental and health impacts. High overall impact of landfill disposal compared to incineration. The decentralized incineration has emerged environmentally sound option.

Vanapalli *et al., (*2020) studied about the challenge and strategies for effective plastic waste management during and post COVID-19 pandemics and study was focus on plastic waste management during pandemic. They found from the study that proper segregation and safety measures for plastic waste in BMW should not be part of MSW.

Rume and Islam (2020) studied positive and negative environmental impacts of the COVID-19 pandemic. They found that negative consequences of COVID-19, such an increase of medical waste, haphazard use and disposal of disinfection, mask and gloves.

Sangkham (2020) work on a rapid estimation of face mask and medical waste generation and environmental consequences related with the COVID-19 pandemic and study was focus on face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. He discussed on reducing impacts of waste management through standardization, procedures, guidelines and strict implementation of medical waste management related to COVID-19.

Salve and Jungari (2020) conducted study on socioeconomic status and vulnerability of sanitation workers and sanitation workers at the frontline work and vulnerability in response to COVID-19. Their study highlights that the policy to safeguard sanitation workers by providing them adequate protective equipment, ensure regular and good payment and health insurance.

Parvathamma, *et al.*, 2014 done study of biomedical waste management in sustainable method and study focus on proper transportation of Biomedical waste from sources to disposal. The study found that the function of primary collection and transport are effectively carried out in Bangalore city for solid waste management. Greater sustainability can be provided by decentralized system.

Sharad Chand (2021) conducted a study of Hygiene and Sanitation Biomedical Waste Disposal and Hospital Pharmacy Management in a Tertiary Care Hospital and study focus area was on bacteriology biomedical waste compliance dispensing errors dispensing time drinking water patient safety Clinical Pre-Clinical and Health quality care. His found was ensuring the patient safety parameters is an on-going process and needs to be carried out in healthcare institution using the scientific methodologies. The identification of various sensitive and resistant micro-organism can be carried out for the better understanding of the hospitals. Microbiology.

Chapter 3

Materials and methods

3.1 Study area

The Bangalore city was selected as study area. Bangalore, officially Bengaluru is the capital and largest city of the southern Indian state of Karnataka. It has a population of more than 8 million and a metropolitan population of around 11 million, making it India's third most populous city and fifth most populous urban agglomeration, as well as South India's second-largest urban agglomeration, and the 27th largest city in the world. Located on the Deccan Plateau, at a height of over 900 m (3,000 ft) above sea level.

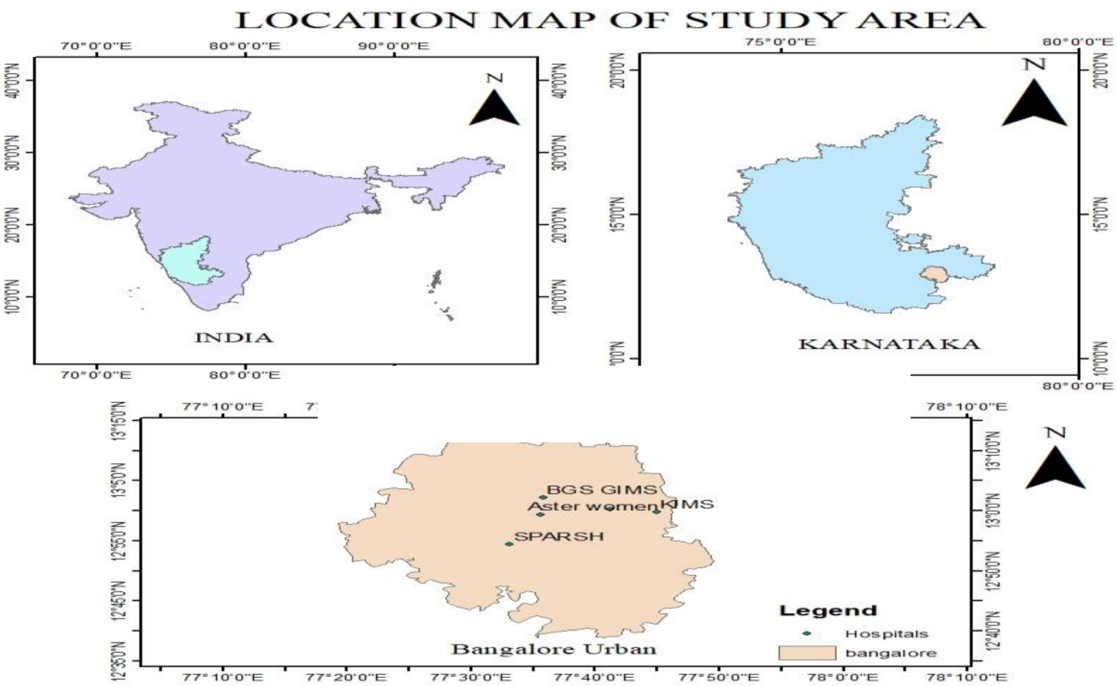

Figure 2: Location map of study area

3.2 Methods for Biomedical Waste Assessment and Data Collection

The data collection methods employed in this research on biomedical waste management included comprehensive fieldwork in hospitals within Bangalore city. Bangalore was chosen due to its concentration of healthcare facilities providing clinical services. The study utilized a combination of qualitative and quantitative techniques to gather data.

Qualitative methods were instrumental in assessing and gaining an understanding of the hospital's biomedical waste management processes, uncovering any underlying issues or shortcomings in the system. On the other hand, quantitative methods involved the administration of structured questionnaires. These questionnaires were designed to assess the knowledge, attitudes, and practices of hospital employees regarding biomedical waste management. To ensure the reliability of the information collected through the questionnaires, personal observations were carried out as a means of verification.

3.3 Assessment of Biomedical Waste Management Facilities

The research utilized consented questionnaires for data collection, involving both hospitals and staff responsible for biomedical waste management. Complementary data were acquired through on-site visits as part of the survey process. These visits provided valuable insights into prevalent waste management practices. The collected information encompassed various aspects, including waste generation, segregation, storage, treatment, transport, and disposal. The survey took place in hospitals within Bangalore Urban city from July 2023 to September 2023.

3.4 Questionnaire Design

The questionnaires were specifically designed to gather data from healthcare professionals working in hospitals and clinics, with a focus on their roles in waste segregation, treatment, handling, and disposal. These questionnaires also delved into the behavioral, medical, and cultural aspects of clinical staff. To tailor the questionnaires effectively, they were customized to suit the various hospital facilities. This customization took into account the number of beds, the volume of Outpatient Department (OPD) services provided, and the quantity of Inpatient Department (IPD) services offered in each hospital. The resulting questionnaires played a vital role in collecting data on the generation of biomedical waste from healthcare facilities within the study area.

Ensuring Clarity in Data Collection the questions were clear and easily comprehensible, special attention was given to explaining technical terms and utilizing accessible language in the questionnaire’s design. This clarification process was conducted with all participants, including hospital staff, nurses, doctors, and other medical personnel. The aim was to ensure that every respondent fully understand the questionnaire, thus facilitating accurate responses regarding their knowledge and practices related to biomedical waste management in their daily hospital duties.

Data collection involved both physical (hard copy) and digital (soft copy, via Google Forms) methods, allowing for a comprehensive and efficient approach to gather the necessary information.

Table 2 Hospitals selected for study

Sl no	Name of hospitals
1	BGS GIMS medical college and hospital
2.	Sparsh Hospital
3.	KIMS Hospital
4.	Bangalore Baptist Hospital
5.	Aster Children and Women Hospital

Chapter 4

Result and discussion

4.1 Assessment of Biomedical Waste Generation in Hospitals within Bangalore City

The responsibility for biomedical waste management falls solely under the purview of the Pollution Control Board, as mandated by the Environment Protection Act of 1986. Each state is tasked with regulating healthcare waste within its boundaries through its respective State Pollution Control Board. In alignment with the guidelines set forth in the Bio-Medical Waste (Management & Handling) Rules, 2016, healthcare establishments are mandated to carry out pre-treatment (for specific items) and segregation (for all categories of clinical waste) at the facility level.

Final disposal and recycling, which should be carried out by government-approved recyclers, are central processes that occur at a dedicated Central Bio-Medical Waste Treatment Facility as specified by the regulations.

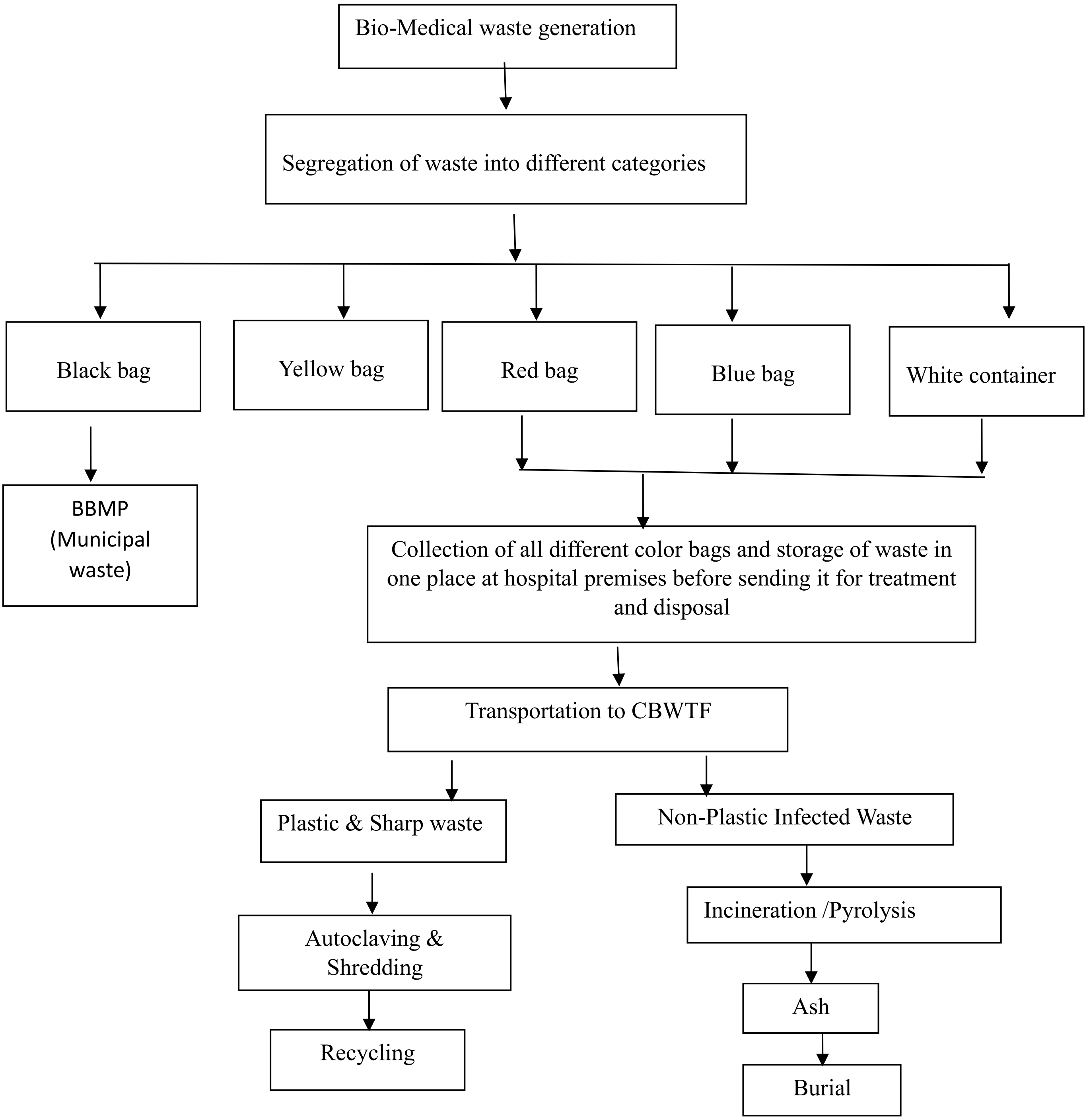

Figure 3: Current Biomedical Waste Management System in Hospitals of Bangalore City

4.2 Analysis of Survey Responses from Hospital Staff

The survey was conducted on hospital working staffs which involved nursing staffs, cleaning staff, doctors and staffs. The survey was conducted by using google form and virtual interview in hospital. The main focus of survey was to know the attitude of segregation of biomedical waste and their knowledge about bio medical waste management in hospital. The Survey results are below:

Table no 3: Biomedical waste generation and handling practices survey analysis

Tenure of Employment at the Hospital	No. of Respondents	Percentage (%)
Tenure of Employment at the Hospital		
0- 12 months	6	15%
1-2 years	25	62.50%
2-5 years	5	12.50%
Above 5 years	4	10%
Are you familiar with the Biomedical Waste (Handling and Management) Rules of 2016?		
YES	36	90%
NO	4	10%
Do you consider it crucial to have knowledge about biomedical waste generation, associated risks, and relevant legislation?		
YES	40	100%
NO	0	0%
Have you undergone any training programs related to biomedical waste management during your tenure at the hospital?		
YES	38	95%
NO	2	5%
Is the individual responsible for waste handling equipped with protective clothing?		
YES	30	75%
NO	6	15%
NOT SURE	4	10%
Are you conscious of the potential health hazards associated with biomedical waste		
YES	40	100%
NO	0	0%
Do you agree that biomedical wastes should be segregated into different colour coded categories?		
YES	38	95%
NO	0	0%
NOT SURE	2	5%

Do you concur that it is necessary to separate biomedical waste into distinct color-coded categories?		
YES	40	100%
NO	0	0%
Do you know about colour-coding segregation of Bio-Medical waste?		
YES	38	95%
NO	2	5%
Do you adhere to the color-coding system for biomedical waste segregation		
YES	40	100%
NO	0	0%
Is the existence of legal provisions instrumental in ensuring the safe management of biomedical waste?		
YES	28	70%
NO	3	7.50%
NOT SURE	9	22.50%
Awareness Deficiency as a Contributing Factor to Healthcare Waste Mismanagement		
YES	40	100%
NO	0	0%
NOT SURE	0	0%

4.3 Production of Biomedical Waste

The study reveals that human anatomical waste, soiled waste, expired medicine, and chemical waste collectively constitute the highest volume of waste generated, surpassing the other three waste categories. Following this, Contaminated Waste (Recyclable) ranks next in terms of quantity, succeeded by glassware waste. Container waste is the category with the lowest waste generation volume.

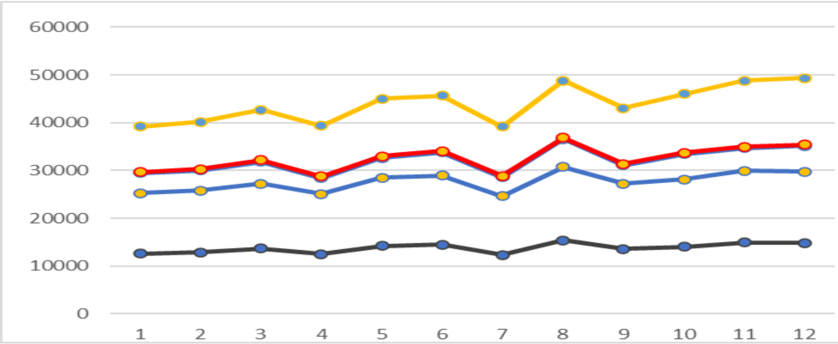

Figure.4: Different categories of biomedical waste generation rate

Table 4: Comparison of Biomedical waste generation with patients volume

Sl no.	Month	Total number of patients in both OPD and IPD	Total medical waste production(kg)
1	Aug-22	15099	1370.52
2	Sep-22	12130	1400.64
3	Oct-22	11713	1472.36
4	Nov-22	11691	1404.6
5	Dec-22	12842	1455.09
6	Jan-23	20680	1526.58
7	Feb-23	20847	2058.59
8	Mar-23	21169	2104
9	Apr-23	17190	1362.31
10	May-23	15251	1412.6
11	Jun-23	12270	1582.98
12	Jul-23	11370	1422.55

(Source: BGS GIMS hospital)

International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

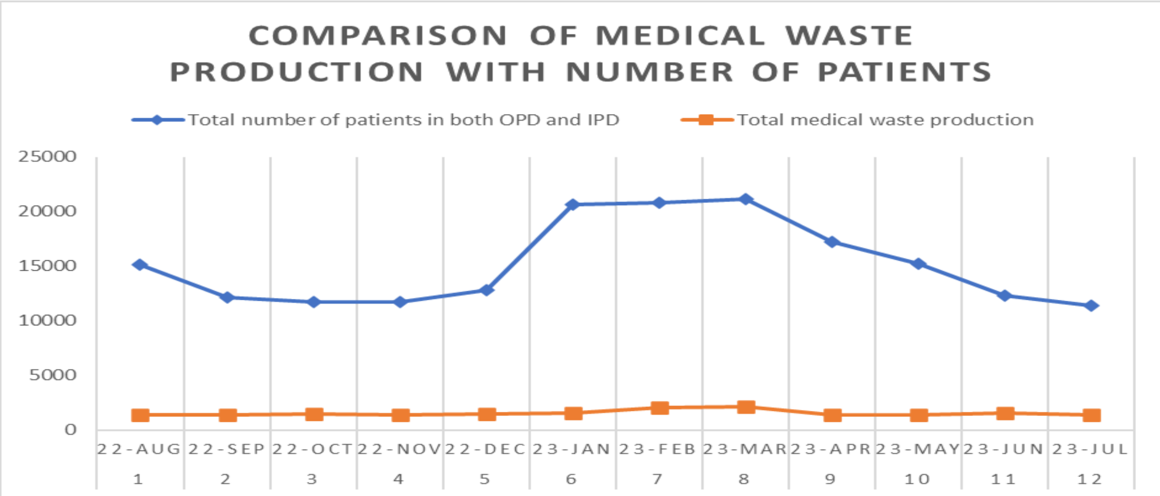

Figure 5: Comparison of medical waste production with number of patients

The survey findings highlight a direct correlation between the number of patients and the quantity of biomedical waste generated. It's evident that waste generation is notably higher in hospital wards compared to the Outpatient Department (OPD). Various hospital departments generate waste in accordance with the types of patients they serve. Notably, the Surgery OPD generates the highest amount of waste, while the Psychiatry department generates the least waste in comparison to other departments.

Furthermore, the research underscores that waste production varies not only among different healthcare facilities but also in accordance with the type of facility and regional regulations.

The study's data indicates that the total waste generated in these five hospitals amounts to approximately 4,344.09 kg per month, averaging about 144.80 kg per day. The specifics of medical waste production for each of the five hospitals are detailed in Tables 6, table 7, table 8 , table 9 and table 10

Table 5: Amount of waste generated by BGS GIMS hospital

BGS GIMS HOSPITAL							
Quantities of BMW							
Sl No.	**MONTH**	**BLUE BAGS(kgs)**	**RED BAGS (kg)**	**YELLOW BAGS (kg)**	**WHITE CONTAINERS (kg)**	**TOTAL (kg)**	**Cost of expenditure (Rs.7.25 per kg)**
1	22-Aug	168.70	649.22	535.41	17.19	1370.52	9936.27
2	22-Sep	157.30	601.01	611.31	31.02	1400.64	10154.64
3	22-Oct	142.03	745.49	558.81	26.03	1472.36	10674.61
4	22-Nov	156.38	672.31	539.18	36.73	1404.60	10183.35
5	22-Dec	120.12	726.92	574.20	33.85	1455.09	10549.40
6	23-Jan	161.30	773.08	574.00	18.20	1526.58	11067.71
7	23-Feb	204.33	992.56	813.20	48.50	2058.59	14924.78
8	23-Mar	100.40	609.10	657.50	37.00	2104.00	10179.00
9	23-Apr	104.70	552.00	636.00	69.61	1362.31	9876.75

10	23-May	161.10	680.20	512.18	59.12	1412.60	10241.35
11	23-Jun	107.72	821.06	612.90	41.30	1582.98	11476.61
12	23-Jul	105.20	772.00	510.10	35.25	1422.55	10313.49
TOTAL		**1689.28**	**8594.95**	**7134.79**	**453.8**	**17872.8**	**129577.95**

(Source: Manually collected from BGS GIMS Hospital)

Table 6**:** Amount of waste generated by Aster women and children hospital

ASTER WOMEN AND CHILDREN HOSPITAL							
Quantities of BMW							
Sl No.	**MONTH**	**BLUE BAGS(kg)**	**RED BAGS (kg)**	**YELLOW BAGS (kg)**	**WHITE CONTAINERS (kgs)**	**TOTAL (kg)**	**Cost of expenditure (Rs.7.25 per kg)**
1	22-Aug	125.34	601.25	892.00	25.86	1644.45	11922.26
2	22-Sep	83.97	581.70	855.75	19.63	1541.05	11172.61
3	22-Oct	83.97	481.31	895.33	18.53	1479.14	10723.77
4	22-Nov	113.56	474.54	916.12	17.85	1522.07	11035.01
5	22-Dec	110.75	524.35	904.93	16.37	1556.40	11283.90
6	23-Jan	158.77	611.91	935.92	19.33	1725.93	12512.99
7	23-Feb	142.64	560.81	811.45	21.73	1536.63	11140.57
8	23-Mar	187.23	744.14	1159.88	23.28	2114.53	15330.34
9	23-Apr	130.61	768.13	1105.73	55.02	2059.49	14931.30
10	23-May	103.54	919.18	1257.48	34.05	2314.25	16778.31
11	23-Jun	131.88	1059.98	1277.47	26.89	2496.22	18097.60
12	23-Jul	160.06	1126.29	1090.15	35.25	2411.75	17485.19
TOTAL		**1532.32**	**8453.59**	**12102.21**	**313.79**	**22401.91**	**162413.85**

(Source: Manually collected from Aster Women and Children Hospital)

Table 7: Amount of waste generated by Bangalore Baptist hospital

Bangalore Baptist Hospital							
Quantities of BMW							
Sl No.	**MONTH**	**BLUE BAGS (kg)**	**RED BAGS (kg)**	**YELLOW BAGS (kg)**	**WHITE CONTAINERS (kg)**	**TOTAL (kg)**	**Cost of expenditure**
1	22-Aug	3687.80	6280.50	8740.80	157.90	18867.00	136785.75
2	22-Sep	3821.80	7027.02	8770.90	241.21	19860.93	143991.74
3	22-Oct	3974.10	6882.80	9912.60	287.95	21057.45	152666.51
4	22-Nov	2697.58	7000.04	8837.45	271.45	18806.52	136347.27
5	22-Dec	3374.97	7767.03	9552.99	329.29	21024.28	152426.03

6	23-Jan	4054.00	7007.30	9619.94	141.00	20822.24	150961.24
7	23-Feb	3169.98	5601.08	7678.31	115.00	16564.37	120091.68
8	23-Mar	5057.82	7777.46	10306.00	197.00	23338.28	169202.53
9	23-Apr	3182.00	6548.02	8339.82	136.00	18205.84	131992.34
10	23-May	4614.25	7187.31	9183.43	159.00	21143.99	153293.93
11	23-Jun	4189.40	8097.85	9787.80	137.00	22212.05	161037.36
12	23-Jul	4623.00	8098.00	9843.00	149.00	22713.00	164669.25
TOTAL		**46446.70**	**85274.41**	**110573.04**	**2321.80**	**244615.95**	**1773465.64**

(Source: https://bbh.org.in/bmw-report/)

Table 8: Amount of waste generated by KIMS Health hospital

KIMS Health Hospital							
Quantities of BMW							
Sl No.	**MONTH**	**BLUE BAGS (kg)**	**RED BAGS (kg)**	**YELLOW BAGS (kg)**	**WHITE CONTAINERS (kg)**	**TOTAL (kg)**	**Cost of expenditure**
1	22-Aug	309.33	1140.00	1230.00	17.3	2370.00	17182.50
2	22-Sep	245.35	1264.00	1252.00	25.3	2516.00	18241.00
3	22-Oct	155.21	1112.60	633.40	14.60	1915.60	13888.10
4	22-Nov	226.12	1190.00	882.00	19.00	2317.00	16798.25
5	22-Dec	308.26	1582.22	1667.26	32.88	3590.62	26032.01
6	23-Jan	338.07	1727.29	1714.16	38.10	3817.62	27677.75
7	23-Feb	331.02	1520.33	1331.75	33.42	3216.52	23319.77
8	23-Mar	432.66	1575.00	1472.41	40.66	3520.73	25525.29
9	23-Apr	388.74	1830.70	1695.58	42.20	3957.22	28689.85
10	23-May	326.17	1417.01	1232.46	32.24	3007.88	21807.13
11	23-Jun	366.56	1570.36	1322.36	33.10	3292.38	23869.76
12	23-Jul	462.21	1548.15	1425.21	29.30	3464.87	25120.31
TOTAL		**3334.69**	**17477.66**	**15858.59**	**315.50**	**36986.44**	**268151.70**

(Source: www.kimshealth.org)

Table 9: Amount of waste generated by SPARSH hospital

SPARSH HOSPITAL							
Quantities of BMW							
Sl No.	**MONTH**	**BLUE BAGS (kg)**	**RED BAGS (kg)**	**YELLOW BAGS (kg)**	**WHITE CONTAINERS (kg)**	**TOTAL (kg)**	**Cost of expenditure**
1	22-Aug	272	846	1219	9	2337	16943.25
2	22-Sep	138	997	1409	6	2544	18444.00
3	22-Oct	230	1242	1642.5	12	3114.5	22580.13
4	22-Nov	176	1211.5	1356	7	2743.5	19890.38
5	22-Dec	155	1409.5	1567.75	8	3132.25	22708.81
6	23-Jan	135.4	1543.65	1632.2	12	3311.25	24006.56

7	23-Feb	115.8	1677.8	1696.65	28	3490.25	25304.31
8	23-Mar	96.2	1811.95	1761.1	7	3669.25	26602.06
9	23-Apr	76.6	1946.1	1825.55	5	3848.25	27899.81
10	23-May	57	2080.25	1890	17	4027.25	29197.56
11	23-Jun	37.4	2214.4	1954.45	18	4206.25	30495.31
12	23-Jul	17.8	2348.55	2018.9	37	4385.25	31793.06
TOTAL			**2482.7**	**2083.35**	**166**	**4584.05**	**33234.36**

(Source: www.sparshhospital.com/bio-medical-waste-reports)

4.4 Expenditure Associate with Biomedical Waste Management

A considerable portion of the budget must be allocated to adhere to the stipulated regulations for Biomedical Waste (BMW) management. The costs associated with BMW management can be categorized into two main types: capital costs and recurring costs. Capital costs represent one-time or fixed expenses, including:

- The acquisition of plastic bins for the safe disposal of waste.
- Investment in transport trolleys utilized to move waste from its point of generation to the internal storage area.
- The procurement of sharp containers designed for the safe disposal of sharps.
- Provision of personal protective equipment, such as rubber shoes, for waste handlers to wear during the packaging and transportation of waste.

Recurring costs are ongoing expenses that are incurred regularly over a defined period. This category encompasses various items, such as the cost of consumables like color-coded bags, personal protective equipment including plastic aprons, face masks, and gloves, expenditures related to employee training, salaries for waste handlers, and outsourcing expenses.

To facilitate an informed decision-making process, administrators can analyze these costs and make comparisons across various cost categories. This evaluation enables administrators to prioritize expenditures effectively in order to achieve compliance with Biomedical Waste (BMW) management regulations.

The cost data was obtained through a comprehensive review of hospital records. Additionally, informal discussions were held with administrators and departmental heads to determine cost allocations. Given that housekeeping staff perform tasks beyond waste handling, an appropriate cost apportionment was carried out. The costs associated with BMW management were classified into capital costs and recurring costs.

The figures number 5, 6 , 7 , 8 and 9 provide a comprehensive overview of the total outsourcing costs for Biomedical Waste Management (BMW). Notably, in all five hospitals, the majority, ranging from 70% to 80%, of these costs were allocated to recurring expenses. An effective metric for comprehending the cost-of-service provision is the cost per kilogram (kg) of all categories of BMW, excluding the black bag waste, which is considered regular solid waste.

Data gathered from various private hospitals indicates that the cost of biomedical waste per kg stands at Rs. 7.25 for all categories of BMW. This amount is disbursed to waste collection agencies. During the study and interviews with hospital authorities, it became apparent that these expenditures significantly impact hospital budgets, as they entail substantial payments to waste collection agencies.

In addition to payments to waste collection agencies, hospitals are compelled to allocate funds for various other expenses within their premises. These include hiring personnel to handle waste, acquiring dustbins and buckets, and procuring bags of different colors, among other related costs. The data in the table below delineates the expenditure distribution across different categories of Biomedical waste originating from private hospitals.

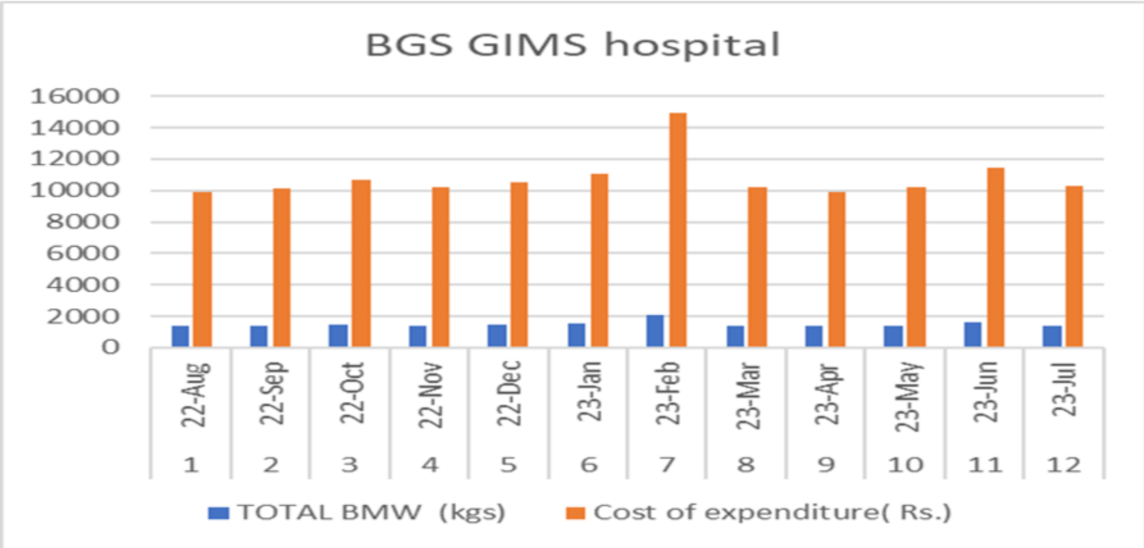

Figure 6: Biomedical waste expenditure of BGS GIMS hospital

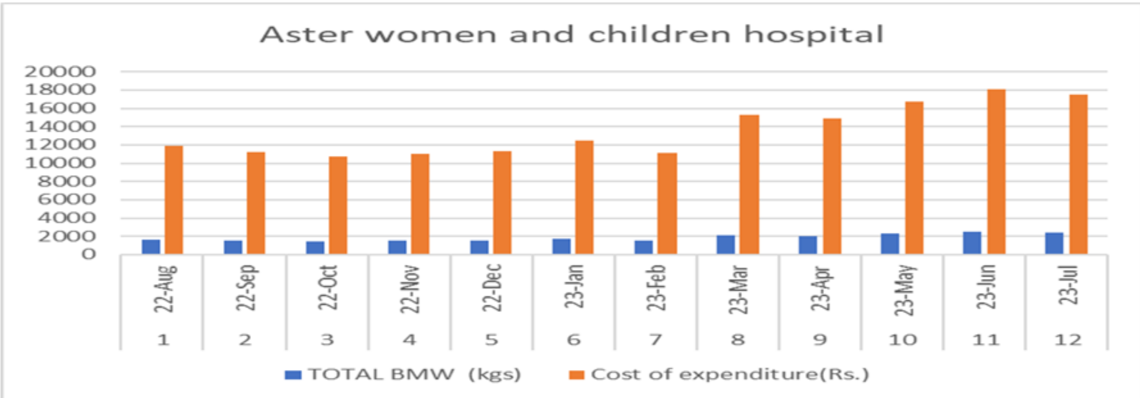

Figure 7: Biomedical waste expenditure of Aster women and children hospital

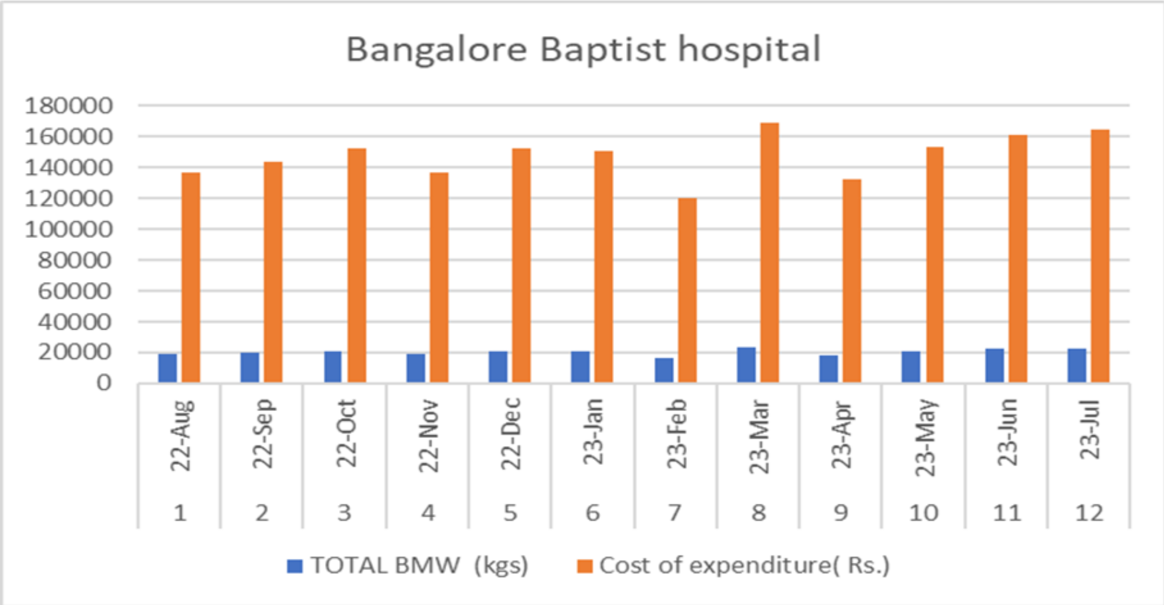

Figure 8: Biomedical waste expenditure of Bangalore Baptist hospital

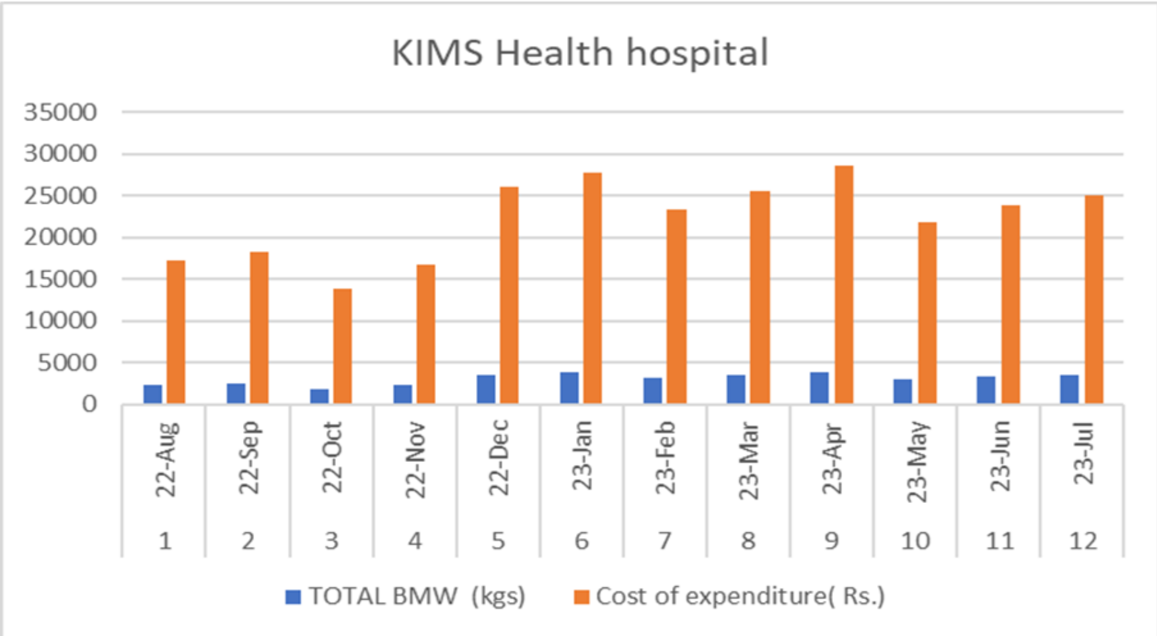

Figure 9: Biomedical waste expenditure of KIMS Health hospital

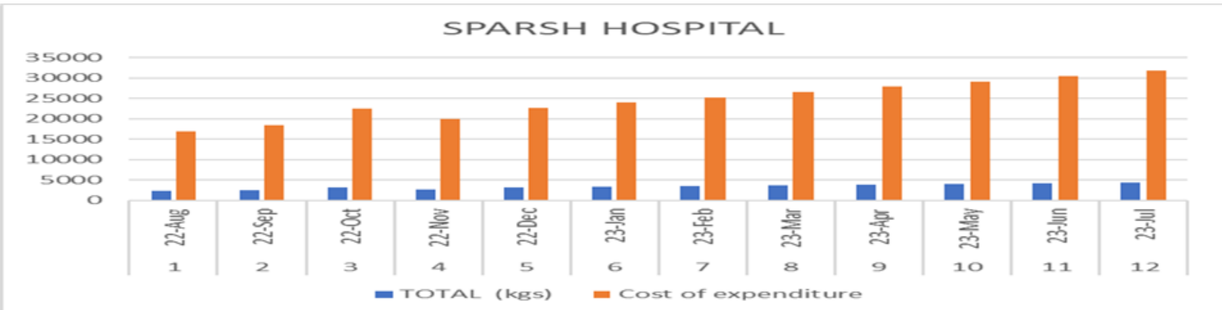

Figure 10: Biomedical waste expenditure of SPARSH HOSPITAL

International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

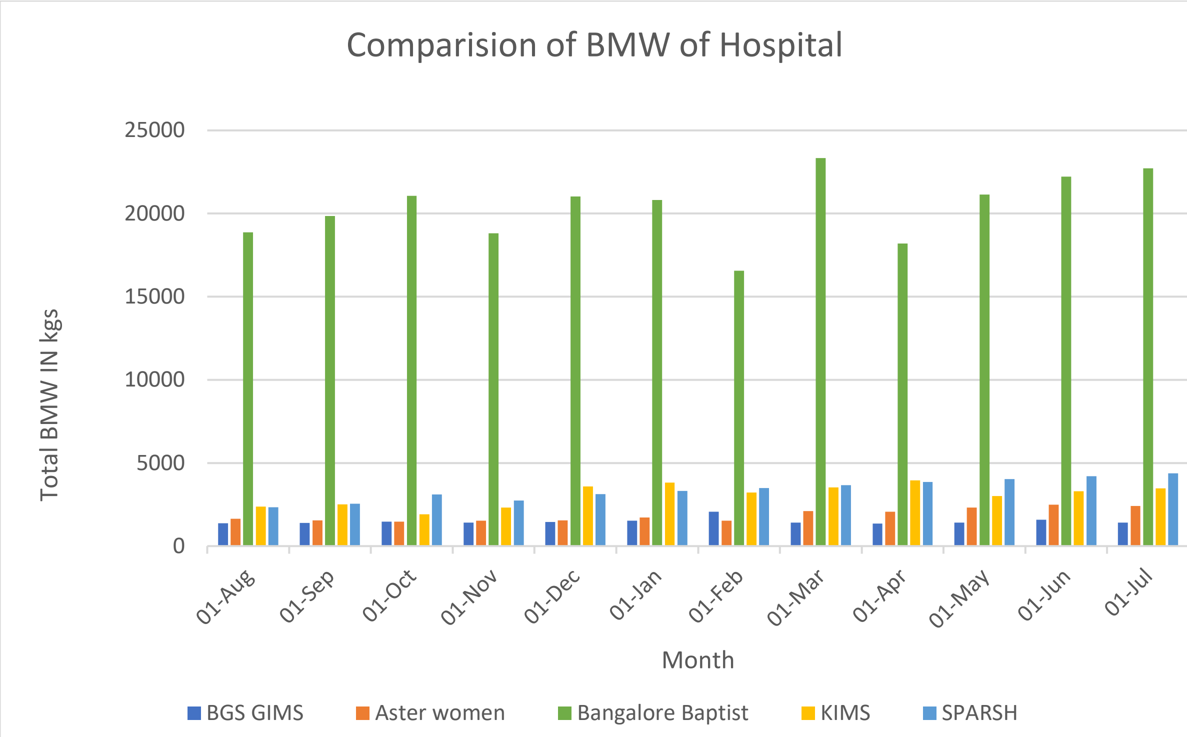

Figure 11: Comparative Analysis of Biomedical Waste Management Among Hospitals

Among the five hospitals under analysis, Bangalore Baptist Hospital stands out due to its notably higher biomedical waste generation. This discrepancy highlights substantial variations in the waste management practices across these facilities.

Upon conducting a comprehensive assessment of biomedical waste management practices, it becomes evident that larger medical facilities, such as Bangalore Baptist Hospital, generate a significant volume of biomedical waste on a daily basis. This surplus waste production is influenced by several factors, including a higher patient turnover rate and a broader spectrum of medical services offered, which collectively contribute to increased waste output.

The excess waste production at Bangalore Baptist Hospital raises concerns regarding the effectiveness of their current waste management practices. This situation not only strains the resources allocated for waste disposal but also gives rise to environmental and health risks. In contrast, the other four hospitals serve as exemplars of efficient waste management. They underscore the importance of tailoring strategies for biomedical waste handling in accordance with the size and scope of a healthcare facility.

4.5 Key Observations from the Study

Survey responses were moderately favorable, with most participants having received clinical waste management training during their training programs. A positive aspect was the availability of colored waste bins for waste segregation. However, some discontent was observed, indicating mismanagement of hospital waste by certain employees, as evidenced in oral interviews and Google Form responses.

In terms of awareness campaigns conducted by different hospital departments about medical waste, the responses were generally positive, suggesting that personnel are well-informed by their respective departments. Nevertheless, there was some dissent among participants regarding the existence of monitoring and control of waste management within each department.

Some unexpected responses revealed a lack of actions taken against staff mishandling medical waste, as well as a dearth of specialized staff in medical waste management. Participants also reported a lack of knowledge about any framework or policy related to waste management, along with a sense of a gap compared to developed countries. Additionally, the need for increased investments in recycling medical waste was expressed.

These findings shed light on the primary issues associated with the current state of medical waste management in the city, underscoring the necessity for establishing a new framework to govern medical waste treatment in Bangalore

4.6 Insights of the observation

The research took place in five hospitals situated in Bangalore Urban District, Karnataka. Prior authorization to carry out the study was secured from the hospital administrators. However, it was noted that the practice of segregating waste at its source and sorting it into color-coded bags was not consistently adhered to in all five hospitals.

Despite the presence of color-coded bags, it was observed that waste sorting was not consistently aligned with the guidelines outlined in Schedule II. This discrepancy appeared to stem from a combination of factors, including a lack of awareness and insufficient training among the staff.

The internal transport of biomedical waste within the hospital premises was found to be in accordance with regulations in all five hospitals. The waste was safely conveyed in closed trolleys marked with the Biohazard symbol.

Figure 13: BGS GIMS Hospital Storage room

All waste handlers were provided personal protective equipment to handle waste. Immunization of employees was 100% in all five hospitals, immunization was provided by the hospital at discounted price; however, it was not documented in any of hospitals. In BGS GIMS Hospital, waste handlers were not aware of immunization and record of immunization provided by hospital was not available. Common storage area within the premises where waste is collected before final disposal was present in all the five hospitals. However, the storage area in BGS GIMS hospital did not have proper management as it was observed that many BMW was scattering in front of store door. All the five hospitals have outsourced final disposal of waste to common BMW treatment facility. All wastes are weighed before transportation. Regular training programs were conducted for housekeeping workers and nursing staff in every hospital. It consisted of lecture classes and onsite demonstration. Every new employee was provided training during the orientation program. Retraining for staff was provided once in 2 years. Nursing superintendent/Ward in-charge brief staff regarding segregation of waste.

During the observation, it was noticed that the sorting of waste into designated color-coded bags was not done as per Schedule II of BMW Rules. Compliance to BMW management is directly related to the knowledge and awareness about process and this attitude and knowledge is updated with the help of periodic training in the subject. It is evident from various studies that training should be an essential part of the hospital employee's daily activity so as to have proper and scientific management of the BMW generated in the hospital.

4.7 Reflective Analysis

In all the hospitals, a level of partial compliance with the segregation of biomedical waste (BMW) was noted. Effective segregation of BMW at its source is a fundamental and crucial aspect of the overall biomedical waste management system. Notably, this practice led to a significant reduction in BMW generation, even as the number of inpatients increased.

Regular training sessions were consistently provided to all personnel responsible for waste handling within the hospital. It is essential that these training programs be conducted routinely in all hospitals, covering nursing staff, waste handlers, and other hospital personnel. These training initiatives play a pivotal role in enhancing awareness and fostering a deeper understanding of biomedical waste management, ultimately facilitating proper BMW management.

A study conducted by Mathur et al., 2011 highlighted the vital importance of comprehensive knowledge in biomedical waste (BMW) management, particularly in ensuring the adoption of appropriate disposal practices. This underscores the critical need for prioritizing training programs aimed at instilling correct BMW waste management practices. The study also revealed a prevalent lack of awareness regarding proper practices, particularly among sanitary waste handlers.

Another research project conducted in tertiary care hospitals in India revealed an intriguing disparity: individuals with higher education levels, including consultants, residents, and scientists, exhibited a strong understanding of biomedical waste management rules but did not consistently translate this knowledge into their practical actions. This underscores the pivotal role of employee training and awareness in establishing optimal biomedical waste (BMW) management procedures.

In all five hospitals examined, a shared storage area for waste was observed. In accordance with World Health Organization (WHO)2019 guidelines, waste should be stored in bags or containers within a dedicated area, room, or building. The size of this storage area should correspond to the volume of waste generated and the frequency of collection. Additionally, adherence to specified storage time limits, based on local climate conditions, is crucial for safe and effective BMW management:
In temperate climates: 72 hours in winter and 48 hours in summer.
In warm climates: 48 hours during the cool season and 24 hours during the hot season.

In summary, effective management of biomedical waste (BMW) is indispensable in healthcare settings. Even individuals with higher education levels may not consistently put their knowledge into practice. Therefore, employee training and awareness play a pivotal role in ensuring optimal BMW practices. The presence of a shared storage area in the hospitals studied aligns with World Health Organization (WHO) guidelines, which recommend appropriate storage areas based on waste quantities and collection frequencies. Adherence to storage time limits, as influenced by local climate conditions, is essential for maintaining safe and effective BMW management practices.

Chapter 5

Standard operating procedures (sops)

The document delineates a comprehensive set of procedures focusing on the systematic gathering, segregation, and transportation of generated medical waste within the designated facility. It intricately details the protocols for each stage, emphasizing the critical aspects of proper handling and transport to the on-site storage area. The primary oversight and implementation of these procedures lie within the domain of the Sectional Head, tasked with ensuring adherence to standards and efficient execution. Supporting this role, the Safety Officer and Deputy Quality Manager hold secondary responsibilities, contributing to the smooth coordination and compliance of the outlined protocols. Their roles encompass assistance, monitoring, and reinforcing the adherence to safety and quality standards in tandem with the Sectional Head's directives. This hierarchical division of responsibilities ensures a structured and accountable approach to medical waste management within the facility.

Facility/ Laboratory	
SOP title: collection and segregation medical waste	
Document number: 01	Version Number:

Issue date	Amendment date	Description of changed	Reviewed and approved by	issue by

5.1 Introduction

Within the hospital setting, biomedical waste comprises both hazardous and non-hazardous categories. Inadequate management of this waste poses risks such as injuries, infections, and exposure to harmful toxins. Common challenges encompass a lack of awareness regarding the health hazards associated with healthcare waste (HCW), insufficient training in proper waste management, the absence of an effective waste management and disposal system, limited financial and human resources, and a low priority accorded to the issue.

Biomedical waste encompasses any waste produced during the diagnosis, treatment, immunization of human beings or animals, as well as in research activities related to these, and in the production or testing of biological substances.

5.2 Objectives

- Establish and execute a robust system for the secure and proper management of medical waste.
- Guide all hospital personnel in the proper classification, storage, segregation, transportation, treatment, and disposal of waste.
- Conduct regular training sessions for hospital staff to enhance awareness regarding the significance of medical waste management.

5.3 Waste Segregation Responsibility in Healthcare

Every individual generating healthcare waste, regardless of their organizational role, bears the responsibility for the proper segregation of each waste item. The healthcare facility management is tasked with ensuring the existence of an effective system for segregation, transportation, and storage, and with overseeing staff compliance with the prescribed procedures.

5.4 Key Definitions in Waste Categorization

- **Hazardous Waste**: Any waste with the potential to pose a significant threat to human health or the environment. Approximately 15-25% of healthcare waste generated in hospital facilities falls within this category, according to a WHO report.

- **Non-Hazardous Waste**: Waste not contaminated with blood, body fluids, or chemicals. This category constitutes about 75-85% of generated waste, encompassing items like packaging, boxes, and wrappings.
- **Infectious Waste**: Medical waste identified by medical practitioners as capable of transmitting infectious agents to humans or animals. This includes microbiological laboratory waste, carcasses of sick animals, and waste from infected patients in isolation or dialysis departments.
- **Pathological Waste**: Comprising tissues, organs, body parts, aborted fetuses, and other biofluids recognized by the public or healthcare personnel. Special handling is ethically required.
- **Sharps Waste**: All biomedical waste containing sharp instruments or pointed parts capable of causing wounds or penetrating the skin.
- **Pharmaceutical Waste**: Waste resulting from the production, preparation, and use of expired pharmaceutical products.
- **Chemical Waste**: Generated from chemical use in sanitary procedures during sterilization, cleaning, and research. Characterized by toxicity, corrosiveness, flammability, volatility, and/or reactivity.
- **Radioactive Waste**: Substances contaminated with radioactive isotopes from the use of radionuclides in medicine or research.
- **Genotoxic Waste**: Toxic cellular waste produced during oncology treatment preparation, requiring special attention due to its severity.
- **Heavy Metal Waste**: Highly toxic waste with elevated levels of heavy metals such as cadmium, lead, mercury, and silver.
- **Compressed Packs**: Encompasses empty or damaged gas cylinders, cartridges, and aerosols.

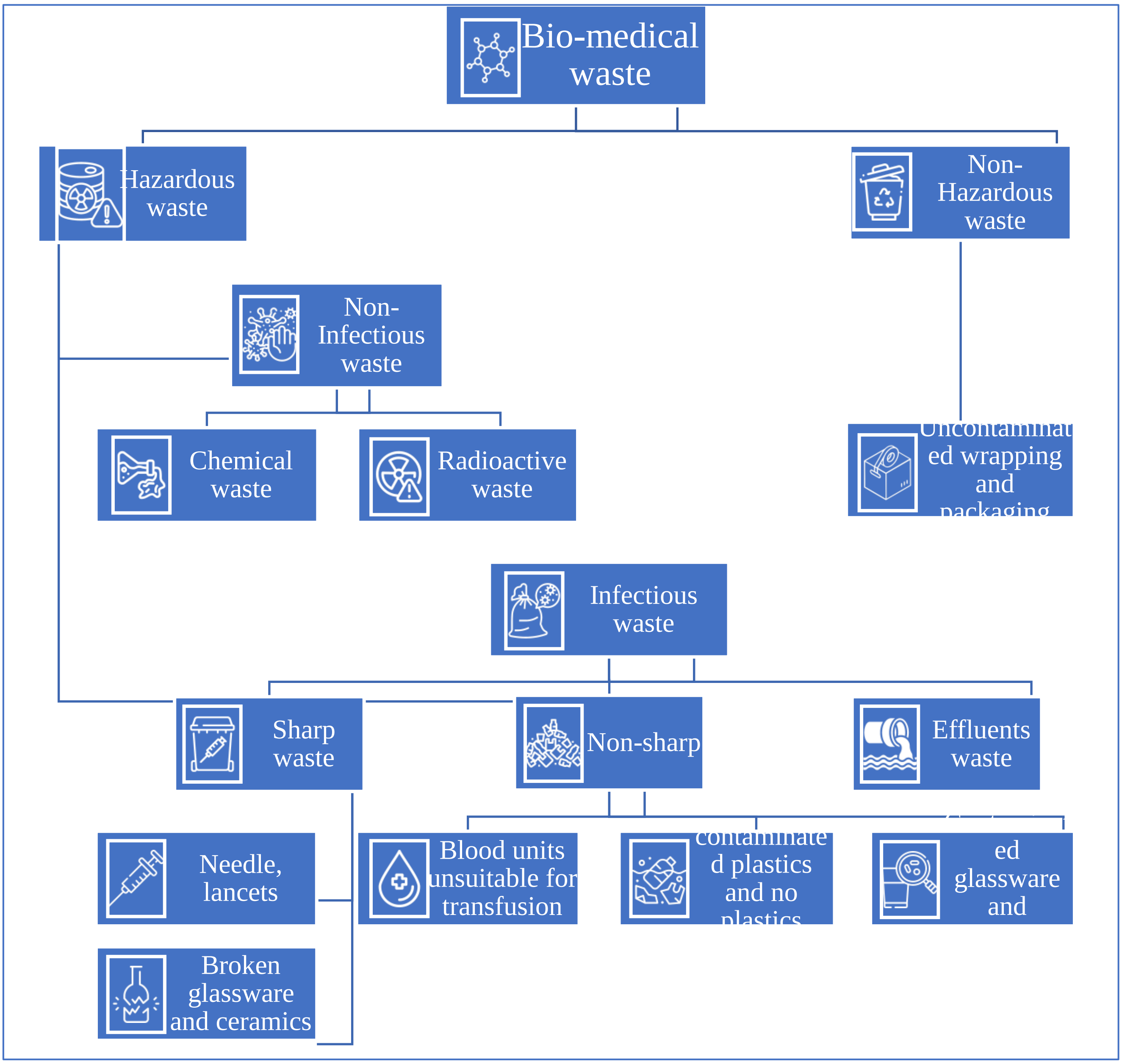

Figure 14: Different categories of Biomedical waste.

5.5 Hospital and Healthcare Center Waste Handling Process

Managing healthcare waste (HCW) generated during the diagnosis, treatment, and immunization of humans carries an inherent infection risk. Therefore, quality managers and safety managers should:

- Evaluate the risks associated with HCW and establish a secure working environment for staff.
- Ensure that staff members are well-informed about the proper management of HCW, offering comprehensive training and supervision.
- Equip staff with the necessary tools and suitable personal protective equipment (PPE) based on the anticipated risks during the handling process.
- Develop guidelines and standard operating procedures for HCW management that align with infection control and occupational health and safety requirements.

The comprehensive handling of healthcare waste (HCW) involves a series of distinct steps:

- Firstly, waste minimization is a pivotal goal, and this is accomplished through reduction, re-use, and recycling. The emphasis lies on curbing the generation of waste at its source.
- The subsequent steps in the process include waste segregation, collection, storage, transportation, treatment, and disposal. Each stage is crucial in ensuring the systematic and safe management of healthcare waste, contributing to both environmental sustainability and the protection of human health.

5.6 Optimal Conditions for Medical Waste Collection

A. Daily organization of methods for collecting medical waste bags and containers, along with their transportation to the temporary collection point.

B. Implementation of a unified classification system, as outlined in Annex 1, to mark and code waste containers, ensuring safety and averting potential hazards.

C. Provision of personal protective clothing and necessary tools to male and female workers involved in the medical waste collection process. This includes supplying bags and boxes for medical waste, as well as materials for cleaning and sterilization.

D. Mandatory sterilization of waste from communicable diseases departments, medical laboratories, and similar sources at the origin before transportation to the collection point.

5.7 Requirements for the Designated Collection Point (Storage Area)

A. Criteria for the Designated Collection Point

- Ensure the area size aligns with the volume of waste generated in the facility.
- Place the storage area at a considerable distance from supply rooms or food preparation zones.
- Guarantee easy accessibility for healthcare cleaners within the facility.
- Construct a solid, easily cleanable, and sterilizable floor with adequate water sources and sewage facilities.
- Restrict access to authorized personnel only by maintaining the area as closed.
- Facilitate convenient access for waste transport vehicles located outside the health facility.
- Implement measures to prevent access by animals and insects, including dogs, cats, birds, and mosquitoes.
- Provide effective lighting, ventilation, and temperature control (15-18 °C) through suitable air conditioning.
- Strategically position the storage area in proximity to the housekeeping room containing cleaning materials.
- Clearly mark the area as a designated collection point for hazardous and infectious wastes using internationally recognized symbols.
- Strictly prohibit the storage of any materials other than waste in the temporary storage area.
- Establish a routine cleaning and sterilization schedule for the floor, walls, and surfaces.

B. Interim Storage Guidelines for Healthcare Facilities with Limited Capacity and Infrequent Waste Collection"

Waste storage necessitates cooled environments with temperatures between 2-8 °C, accompanied by clear warning signs. The stipulated storage periods are a maximum of 72 hours in winter and 48 hours in summer. In freezing conditions (below -5 °C), waste can be stored for up to one week, with the requirement of prominent warning signs on storage locations and freezers.

5.9 Framework for Sorting Medical Waste

In establishing an effective medical waste sorting system, health facility directors must ensure the following:

A. Collaborate with the health facility director and administrative affairs departments to ensure comprehensive understanding and awareness among medical, paramedical, and nursing staff regarding their responsibilities in sorting and classifying medical waste at its source. This involves the initial treatment areas, preventing its mixture with general waste (household waste) within the health facility.

B. Guarantee that the responsibilities of collection workers and cleaners are confined to the collection and transportation of waste. These personnel should not participate in the sorting process to mitigate the risk of accidents arising from a potential lack of comprehensive knowledge about the various types of medical waste.

5.10 Optimal Procedures for Separating and Collecting Medical Waste in Healthcare Settings

- Separation is the pivotal procedure within health facilities that involves isolating medical waste from household waste. It serves as an efficient management strategy for medical waste, ensuring proper disposal methods, prioritizing worker safety, and minimizing environmental impact.

- Producers are mandated to adhere to the specific requirements outlined in this regulation for the separation and collection of medical waste. This process should be carried out based on the waste types specified in the definitions section of this policy.

- The separation process is to be implemented seamlessly, starting from the point of waste generation and extending across all waste streams until final disposal.

- Waste categories should be distinctly collected in plastic bags and containers, following color-coded and type-specific recommendations for easy identification and proper disposal.

Foundational Guidelines Governing Medical Waste Collection Procedures

The medical waste collection unit assumes responsibility for overseeing the medical waste management unit within the health facility. Daily collections from laboratories and medical wards are imperative, and the collected waste is subsequently transported to the temporary collection point.

A critical aspect of this process is ensuring that no bags are transported without the internationally recognized biohazard signs. These signs not only indicate the type of waste but also specify its origin within the health facility.

Once the collection of medical waste is complete, the next step involves storing it in the interim (temporary) storage area. This serves as a holding point until the waste is ready for transportation for treatment and eventual disposal.

Types of Waste Containers and Bag

Table 10: Colour coding of Biomedical Waste Management rules, 2016

Colour	Description
Yellow	**Waste which requires disposal by incineration** Indicative treatment/disposal required is incineration in a suitably permitted licensed facility
Orange	**Waste which may be 'treated'** Indicative treatment/disposal required is to be 'rendered safe' in a suitably permitted or licensed facility, usually alternative treatment plants (ATP's). However this waste may also be disposed of by incineration
Purple	**Pharmaceutical including Cytotoxic and cytostatic waste** Indicative treatment/disposal required is incineration in a suitably permitted or licensed facility
*Black/Orange	**Offensive/hygiene waste*** Indicative treatment/disposal required is landfill or municipal incineration/energy from waste at a suitably permitted or licensed facility
Red	**Anatomical waste for incineration** Indicative treatment/disposal required is incineration in a suitably permitted facility
Black	**Domestic (municipal) waste** Minimum treatment/disposal required is landfill, municipal incineration/energy from waste or other Municipal waste treatment process at a suitably permitted or licensed facility. Recyclable components Should be removed through segregation
White	**Amalgam waste** For recovery
Clear	**Recyclables** Separated at source or Indicative recovery from Domestic Waste Stream in a suitably permitted or licensed facility
Brown	**Compostables and food waste** Separated at source for Recovery

SUMMARY AND RECOMMENDATION

Conclusion

In a comprehensive analysis across multiple hospitals of Bangalore, partial compliance with biomedical waste (BMW) segregation was observed, emphasizing the pivotal role of proper waste segregation at its source. This practice notably reduced BMW generation despite increased inpatient numbers. Consistent training sessions for personnel involved in waste handling were implemented, highlighting the crucial need for routine training across all hospitals to enhance awareness and understanding. Studies underscored the necessity for in-depth knowledge in BMW management to ensure correct disposal practices and revealed gaps in awareness among waste handlers. Interestingly, higher-educated individuals showed theoretical knowledge but lacked consistent practical implementation. The presence of shared waste storage areas in the hospitals aligned with WHO, 2019 guidelines, stressing the importance of storage based on waste volume and collection frequency. Adhering to specific storage time limits based on local climate conditions emerged as crucial for safe BMW management. Overall, optimal BMW practices necessitate not just knowledge but consistent training, awareness, and adherence to guidelines for effective waste management in healthcare settings.

Recommendations

- Regular Comprehensive Training Programs: Implement routine training sessions across hospitals, covering all personnel involved in waste management, emphasizing the importance of proper BMW segregation and disposal. These sessions should target not only waste handlers but also nursing staff and other relevant hospital personnel.

- Enhanced Awareness Initiatives: Develop awareness campaigns to bridge the gap in understanding among waste handlers, ensuring they grasp the significance of proper BMW management practices and the potential impact on healthcare environments.

- Practical Implementation Emphasis: Emphasize the translation of theoretical knowledge into practical actions, especially among individuals with higher education levels. Tailored training programs could focus on aligning theoretical understanding with on-ground practices.

- Storage Area Compliance: Ensure hospitals adhere to WHO, 2019 guidelines regarding dedicated storage areas for waste. Tailor these areas based on waste volume and collection frequency, and strictly adhere to specified storage time limits as influenced by local climate conditions.

- Ongoing Monitoring and Compliance: Establish monitoring mechanisms to ensure continued compliance with BMW management protocols. Regular assessments and audits can help sustain effective waste management practices across healthcare facilities.

Reference

1. Cheng, Y. W., Sung, F. C., Yang, Y., Lo, Y. H., Chung, Y. T., & Li, K. C. (2009). Medical waste production at hospitals and associated factors. Waste Management
2. Hossain, M. S., Santhanam, A., Norulaini, N. N., & Omar, A. M. (2011). Clinical solid waste management practices and its impact on human health and environment–A review. Waste management,
3. Berwick, D. M., & Hackbarth, A. D. (2012). Eliminating waste in US health care. Jama,
4. Sharma, A., Sharma, V., Sharma, S., & Singh, P. (2013). Awareness of biomedical waste management among health care personnel in Jaipur, India. Oral Health Dent Manag
5. Zimlichman, E., Kreiss, Y., Mandel, D., Wartenfeld, R., Ohana, N., Cohen-Rosenberg, G., ... & Afek, A. (2003). Evaluating delivery of primary health care to military personnel during low-intensity conflict using a patient satisfaction survey. Military medicine,
6. Babu, B. R., Parande, A. K., Rajalakshmi, R., Suriyakala, P., & Volga, M. (2009). Management of biomedical waste in India and other countries: a review. Journal of International Environmental Application & Science,

7. Letho Z, Yangdon T, Lhamo C, Limbu CB, Yoezer S, Jamtsho T, Chhetri P, Tshering D. Awareness and practice of medical waste management among healthcare providers in National Referral Hospital.
8. Abah, S. and Ohmain, E. (2011). Healthcare waste management in Nigeria: A case Study:Journal of Public Health and Epidemiology
9. Acharya DB, Meeta S, (2000) Hospital Waste Management. Minerva Press, New Delhi 2000,
10. Al-Azzawi, S. A. (2012). Hospital Waste and Cleaning Workers in Baquba Teaching Hospital Diyala: Journal of Medicine Vol. 2, Issue 1
11. Almuneef M, Memish Z, (2003) Effective medical waste management: it can be done. American Journal of Infection Control,
12. Anon, 1988. Integrated hazardous waste management facility opens near Swan Hills, Alberta.The Hazardous Waste Consultant. 6 (1)
13. Anonymous (1998). Biomedical waste (management and handling) rules, The Gazette of India, Extraordinary, Part II, Section 3(ii), dated 27th July, pp. 10-20, 460. Ministry of Environment and Forests, Notification N.
14. Askarian M, Vakili M, Kabir G, (2004) Hospital waste management status in university hospitals of the Fars province, Iran. Int. J. Environ. Health Res.
15. Askarian M. Vakili M, Kabir G (2004b) Results of a hospital waste survey in private hospitals in Fars province, Iran. Waste Manage.
16. Bagchi, A. and Sopcich, D. (1989). Characterization of municipal solid waste incineration ash. J. Envi. Engineer.
17. Baum, Bernard; charles, H. Parker Debell and Richardson, 1973. Solid Waste Disposal. Vol. 1 Incineration and landfill. 1973. Michiguan: Ann Arbor Science Publishers.
18. Baveja A., G. Feichtinger, R.F. Hartl, J.L. Haunschmied, and P.M. Kort, 2000. “A Resource Constrained Optimal Control Model for Crackdown on Illicit Drug Markets,” Journal of Mathematical Analysis and Applications, Vol. 249, No.1, pp. 53-79; In the Centennial Issue honoring Richard Bellman (the founding editor of the journal) for his lifetime achievement in the field of Operations Research
19. Belevi, H., Stapfi, D. M. and Baccini, P. (1992). Chemical behavior of municipal solid waste incinerator bottom ash in monofill. J. Waste Management &Research.
20. World Health Organization (WHO). 2011. 34. Aide-Memoire for a national strategy for healthcare waste management.
21. United States Environmental Protection Agency. (2001a). Medical Waste Regulation
22. United States Environmental Protection Agency. (2001b). Test Methods for Evaluation Solid Waste, Physical/Chemical methods
23. World Health Organization. "Safe Management of Wastes from Health-Care Activities.", 2nd ed, 2014
24. Kulkarni BN, Anantharama V. Repercussions of COVID-19 pandemic on municipal solid waste management: Challenges and opportunities. Sci Total Environ.
25. Shobhana Ramteke, Bharat Lal Sahu, Novel coronavirus disease 2019 (COVID-19) pandemic: Considerations for the biomedical waste sector in India, Case Studies in Chemical and Environmental Engineering, Volume 2, 2020,
26. Mathur V, Dwivedi S, Hassan M, Misra R. Knowledge, Attitude, and Practices about Biomedical Waste Management among Healthcare Personnel: A Cross-sectional Study. Indian J Community Med. 2011