GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

Spatial Analysis and Environmental Impact of Biomedical Waste Management in Chamarajanagar District: A Geographical Perspective

R Shiva Kumar[1]*, **P Surendra**[2]

1 *Faculty, Department of Geography, Bangalore University, Jnanabharathi Campus, Bengaluru, Karnataka, India*
2 *Assistant professor, Department of Geography, Bangalore University, Bengaluru, Karnataka, India*

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* **Corresponding author**.
drshivakumarrajendra@gmail.com

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Abstract

Managing Bio-Medical Waste (BMW) is an essential part of running a healthcare facility; it involves following strict guidelines to avoid contaminating the environment and endangering public health. Using information gathered from many Health Care Establishments (HCEs) via the Common Biomedical Waste Treatment Facility (CBMWTF), run by Shree Consultants, this study seeks to evaluate the trends and effectiveness of biomedical waste treatment in Chamarajanagar District. The analysis looks at how biomedical waste is classified, how much of it is produced, and how it is disposed of. It also identifies areas that need to be improved and offers workable solutions to improve current management techniques. In addition to offering suggestions to guarantee sustainable practices within the district, this study sheds light on the situation of BMW management as it exists today.

Keywords: Biomedical waste; Waste management; Healthcare establishments; Chamarajanagar; CBMWTF; Environmental impact; Public health

1 Introduction

Whenever accomplished effectively, biomedical waste management is an essential component of healthcare that can reduce a number of threats to the public's health and the environment. The term "biomedical waste" (BMW) refers to materials produced by biological and medical sources, including labs, hospitals, clinics, and research facilities. Improper handling of BMW can result in environmental contamination and diseases (Haq & Jahan, 2020)[(1)]. Strict protocols must be followed for the segregation, storage, processing, transportation, and disposal of waste in order to manage biomedical waste effectively. Interprofessional collaboration between the legal, administrative, and medical fields is necessary (Bagali et al., 2021)[(2)].

In the context of public health situations like the COVID-19 pandemic[(3)], when there was a substantial rise in the output of medical waste, the handling of BMW has become even more important. The epidemic in India put additional strain on an insufficient healthcare waste management system (Bagwan, 2023)[(4)]. Because biomedical waste is dangerous, proper disposal methods must be used to

safeguard patients, healthcare staff, and the general public (Bansod & Deshmukh, 2023)[5]. The Bio-Medical Waste (Management and Handling) Rules were first implemented by the Indian Ministry of Environment and Forests in 1998. Since then, the rules have been strengthened to guarantee the safe disposal of BMW (Phupate et al., 2022)[6]. The most recent guidelines, which were published in 2016, stress that appropriate waste management is the responsibility of every healthcare facility in order to prevent negative impacts on the health of people and the environment (Chandra, 2023)[7].

Nonetheless, there are still a number of major obstacles facing the industry, such as low infrastructure, low public awareness, and healthcare staff that are not properly trained in waste management techniques (Winfield & Brooks, 2015)[8]. To enhance waste management procedures, BMW must be separated at the source and stringent restrictions must be put in place along with ongoing oversight (Udofia et al., 2015)[9].

1.1 Objective

- To evaluate the quantity and classification of biological waste produced in Chamarajanagar District by healthcare facilities.
- To evaluate the efficiency of the current biomedical waste management practices.
- To identify areas where the management process needs to be improved and offer practical suggestions.

1.2 Study Area

1.2.1 ***Geographical Description***

Approximately situated at 11.9236° N latitude and 76.9400° E longitude, the district of Chamarajanagar is situated in the southern region of Karnataka, India. With a land area of around 5,101 sq. km, the district shares borders with the districts of Mysuru and Mandya to the north, Kerala to the west, and Tamil Nadu to the south. The district is mostly covered by Bandipur National Park and other forest reserves, with a generally hilly and forested environment. The topography of the district affects biological waste transportation logistics as well as healthcare access, especially in rural and isolated locations. The climate of Chamarajanagar is tropical savanna with distinct wet and dry seasons and modest rainfall. The majority of the year's rainfall occurs during the monsoon season, which runs from June to September. The remainder of the year is largely dry. Strong waste handling systems are crucial for healthcare facilities since these climate elements affect waste management, storage, and decomposition.

1.2.2 ***Demographic statistics***

According to the 2011 Census, Chamarajanagar has a population of about 1.02 million people, or about 201 people per sq. km. With only 22% of the people living in urban areas, the district is predominately rural, with 78% of the population living in rural areas. Due to the possibility that rural healthcare facilities lack the sophisticated infrastructure present in urban regions, this rural predominance has an impact on the distribution of resources for biomedical waste management and healthcare accessibility. One of Karnataka's less developed districts in terms of socioeconomic status, Chamarajanagar is home to a sizable population that makes their living from farming and forestry. The state of the economy has an impact on the medical infrastructure and, in turn, on the standard of biological waste management procedures, particularly in rural healthcare facilities.

1.2.3 ***Healthcare Facilities***

The government hospitals, primary health centers (PHCs), and private clinics that make up the district of Chamarajanagar's basic healthcare facilities. The principal government-run medical facilities consist of:

a) Primary Health Centers (PHCs): Providing fundamental medical services, these are the mainstay of rural healthcare systems. In rural areas, PHCs are the main source of biomedical waste creation.

b) Government Hospitals: In addition to taluk-level hospitals in Kollegala, Yalandur, and Gundlupete, the district is home to a sizable district government hospital in Chamarajanagar city. Compared to smaller facilities, these hospitals produce more biomedical waste and are better equipped.

c) Private Clinics: Although they are smaller in scope, private healthcare providers play a major role in the amount of biological waste generated, particularly in urban areas.

According to the data presented for 2019, the district government hospital located in Chamarajanagar has the highest patient load and, as a result, the biggest volume of biomedical waste, especially in the categories of incinerable and autoclavable waste.

1.2.4 ***Waste Management Infrastructure***

The Common Biomedical Waste Treatment Facility (CBMWTF), run by Shree Consultants, is principally responsible for managing biomedical waste in Chamarajanagar. Situated in the heart of the district, the facility caters to various types of healthcare establishments, including private clinics, PHCs, and government hospitals. The Central Pollution Control Board (CPCB) has established criteria that the CBMWTF adheres to for handling and discarding biomedical waste. Authorized vehicles pick up waste from healthcare establishments and bring it to the CBMWTF for various waste treatment procedures like autoclaving and burning. Transporting garbage from remote places, especially from rural PHCs, might be tough due to the district's challenging geography, which could cause delays in the waste treatment process[10].

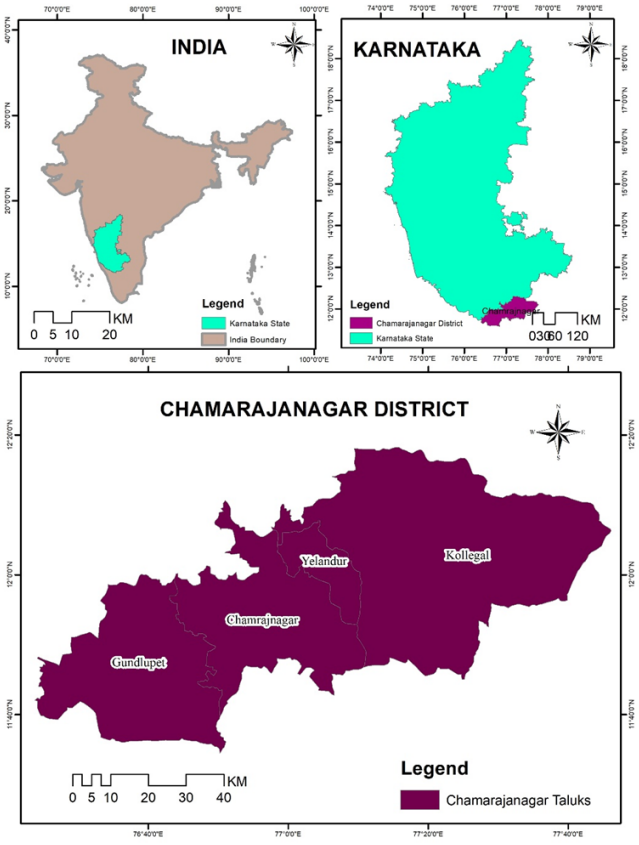

Fig. 1.

1.2.5 ***Waste Segregation Practices***

Healthcare establishments in the district must separate biomedical waste at the source into categories such as autoclavable, incinerable, and others in accordance with the Biomedical Waste Management Rules, 2016. Larger hospitals often follow better waste segregation methods than smaller PHCs and private clinics, though compliance varies throughout facilities. The scarcity of resources in rural regions frequently leads to inadequate separation and preservation, hence elevating the hazards linked to inappropriate management of trash.

1.2.6 ***Institutional and Regulatory Framework***

The Biomedical Waste Management Rules, 2016 regulate the management of biomedical waste in Chamarajanagar, and the Karnataka State Pollution Control Board (KSPCB) is responsible for enforcing these rules. The CBMWTF operator, Shree Consultants, is essential in making sure healthcare facilities follow the rules for the treatment, storage, transportation, and segregation of waste. The KSPCB conducts routine audits and inspections to ensure compliance and reduce any risks associated with inappropriate garbage disposal[11].

1.2.7 ***Environmental Concerns***

Improper biomedical waste disposal might have detrimental effects on the ecosystem because the district is close to environmentally sensitive regions like Bandipur National Park. Local ecosystems and public health are seriously threatened by contaminated soil and water sources, especially in rural areas with poor waste management procedures. In addition, the district's mountainous topography and regular rainfall raise the possibility of biomedical waste leakage into bodies of water, which could lead to water contamination.

1.2.8 ***Cultural and Social Factors***

In Chamarajanagar, particularly in rural regions, there is a dearth of knowledge among the general public regarding biological waste management. Urban areas have begun to emphasize the segregation and treatment of biological waste, but lack of resources and expertise in rural healthcare facilities frequently makes it difficult for them to adopt appropriate waste management procedures. There is very little involvement from the local community in trash management initiatives, such as awareness campaigns or segregation initiatives.It is necessary to implement training programs and educational campaigns to enhance waste management procedures, especially in rural healthcare facilities. An attempt to close the gap between the infrastructure of rural and urban healthcare could be made by including local populations in waste management projects.

2 Methodology

The research technique utilized in this study comprised a methodical strategy to gather and examine data regarding the production of biomedical waste (BMW) in different healthcare facilities located in the Chamarajanagar district of Karnataka. To guarantee thorough and precise data gathering, the study drew from primary as well as secondary sources. main health centers, government hospitals, and private clinics were among the healthcare facilities with which the main data was directly gathered. Each facility was requested to report the average monthly production of biomedical waste that could be burned or autoclaved throughout the period of January 2019 to December 2019 using a survey method[12].

Furthermore, Shree Consultants' Centralized Biomedical Waste Treatment Facility (CBMWTF) provided secondary data[13]. This information gave a combined picture of the typical monthly waste production for every healthcare facility, broken down by kind (incinerable and autoclavable). In order to ensure accuracy and dependability, the data from Shree Consultants was essential in verifying the information gathered from specific healthcare facilities. After that, the information was arranged into tables for every kind of healthcare facility, and statistical analysis was done to find patterns, variances, and any outliers in the amount of trash

produced.

Descriptive statistical techniques were used to analyze the data, with an emphasis on comparing waste generation throughout various facility types and taluks as well as on determining averages. Bar graphs were used to visually display the results, making it easier to understand the data. The results were then analyzed to determine how they will affect biological waste management procedures within the district's healthcare service delivery framework.

3 Results

3.1 Waste Generation Across Healthcare Facilities (2019)

The data analysis shows how much biomedical waste (autoclavable, incinerable, and total) healthcare facilities in the four taluks created on average each month in 2019. The results are summarized in the table below.

Table 1. Monthly average biomedical waste generation across healthcare facilities in Kollegala, Yalandur, Chamarajanagar, and Gundlupete taluks (2019)

Taluk	Healthcare Facility	Monthly Average Incinerable Waste (kg)	Monthly Average Autoclavable Waste (kg)	Monthly Average Total Waste (kg)
Kollegala	Government Hospital	140.14	129.13	269.27
	Private Clinics	1.0	1.0	2.0
	Primary Health Centers	5.53	3.47	9.0
Yalandur	Government Hospital	19.74	38.73	58.47
	Private Clinics	1.0	1.0	2.0
	Primary Health Centers	1.0	1.0	2.0
Chamarajanagar	Government Hospital	392.35	184.22	576.57
	Private Clinics	7.47	3.47	10.94
	Primary Health Centers	4.07	4.0	8.07
Gundlupete	Government Hospital	58.47	38.73	97.2
	Private Clinics	2.0	2.0	4.0
	Primary Health Centers	4.27	1.73	6.0

The following information is provided by the government hospitals in Chamarajanagar District Figure 2. The largest average monthly waste creation (576.57 kg) is found in Chamarajanagar, which is indicative of a high amount of healthcare operations. Kollegala (269.27 kg), which likewise exhibits notable trash creation, comes next. Gundlupete and Yalandur produce far less garbage, with respective totals of 97.2 kg and 58.47 kg. The percentage of incinerable garbage (392.35 kg) is higher in Chamarajanagar than in other taluks, where the ratios of autoclavable and incinerable waste are more evenly distributed. Based on this data, it appears that the government hospitals in Chamarajanagar and Kollegala need strong waste management systems in order to manage the increasing amounts of trash that can be autoclaved and incinerated.

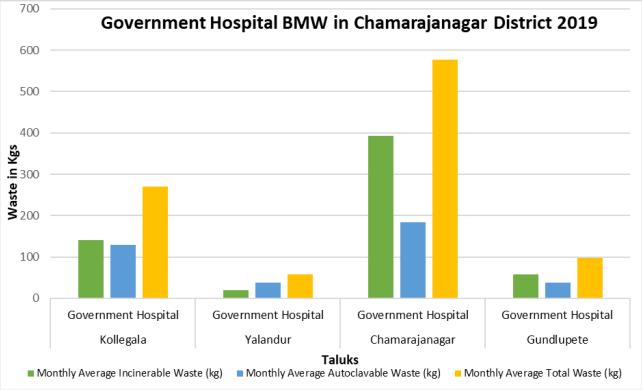

Fig. 2. Government Hospital BMW in Chamarajanagar District, 2019

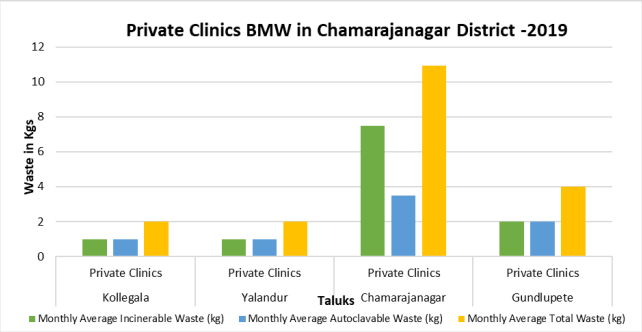

Fig. 3. Private Clinics BMW in Chamarajanagar District, 2019

The following patterns are displayed in the Chamarajanagar District private clinic Figure 3. With a notable amount of both incinerable (7.47 kg) and autoclavable (3.47 kg) garbage, Chamarajanagar produces the largest monthly average total waste (10.94 kg). This suggests that there are comparatively more patients or medical activity in this region. Next is Gundlupete, where 4 kg of trash are generated overall, with equal amounts of waste going to autoclave and incinerator. Kollegala and Yalandur produce the least amount of garbage—roughly 2 kg per month, split equally between the categories of autoclavable and incinerable waste. The data indicates that

the biomedical waste generated by private clinics in Chamarajanagar is considerably more than that of other taluks. This difference may be attributed to the fact that fewer medical procedures or lower patient numbers are done in the latter taluk.

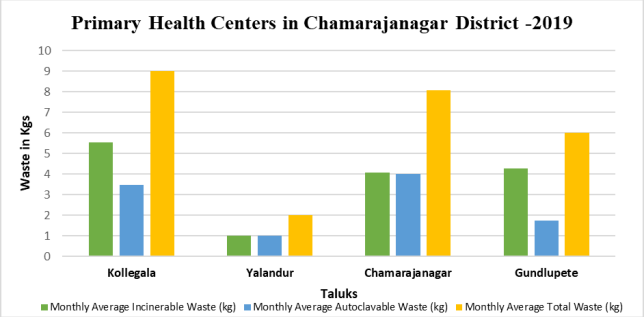

Fig. 4. Primary Health Centers in Chamarajanagar District, 2019

The biomedical waste generated by Primary Health Centers (PHCs) in four taluks of Chamarajanagar District is displayed monthly averagely in the Figure 4. Kollegala produces the most garbage overall (9 kg), of which 5.53 kg is suitable for incineration. When waste from autoclavable and incinerable categories is split evenly, Yalandur generates the least amount of waste (2 kg). Both Chamarajanagar (8.07 kg) and Gundlupete (6 kg) produce considerable amounts of garbage; the former has significantly more incinerable waste than autoclavable. Overall, Yalandur's low waste suggests lesser procedures, while Kollegala's large waste creation shows more intensive healthcare activities. The information indicates that different taluks may require different waste management plans.

4 Recommendation

The results of this study allow for the formulation of various important recommendations for enhancing the district of Chamarajanagar's biomedical waste management. To improve treatment and disposal efficiency, it is crucial to first establish a uniform policy that all healthcare facilities must follow. This protocol should specifically concentrate on separating waste at the source. Healthcare staff need to be trained in specific waste management techniques, such as segregation, collection, and storage, as evidenced by the differences in waste creation between taluks and facility types.

In order to ensure that the Shree Consultants-run Centralized Biomedical Waste Treatment Facility (CBMWTF) can handle a range of waste loads without sacrificing environmental and safety standards, there should also be a focus on expanding the facility's capacity and efficiency. Additionally, it is advised that regular evaluations and audits be carried out to keep an eye on these facilities' waste management procedures and make sure that the Central Pollution Control Board's (CPCB) rules are being followed.

One way to lessen the environmental impact of disposing of biomedical waste is to invest in more sophisticated and eco-friendly waste treatment technology, like non-burn solutions for specific waste kinds. Finally, local government organizations ought to work with healthcare institutions to educate the public and employees about the significance of biological waste management, which might lower the risk of contamination and guarantee a safer atmosphere for everybody[14].

5 Conclusion

This study emphasizes how urgently healthcare establishments in the Chamarajanagar district need to enhance their biomedical waste management procedures. The information gathered from different healthcare facilities, private clinics, government hospitals, and basic health centers shows notable differences in the production and handling of biomedical waste. The results highlight the significance of strong management practices in these establishments by showing that larger facilities, especially government hospitals contribute the most waste. Improved segregation procedures, expanding the Centralized Biomedical Waste Treatment Facility's (CBMWTF) capacity, and utilizing cutting-edge waste treatment technology are all highlighted in the research. The district can lessen the threats to the environment and public health that come with inappropriate disposal of biomedical waste by addressing three crucial areas. The suggestions made are meant to assist healthcare providers and local government bodies in developing more sustainable and successful waste management plans. In the end, the district of Chamarajanagar will have better public health outcomes and a safer, cleaner environment if these steps are successfully implemented.

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