Educational Administration: Theory and Practice
2024,30(2), 1829-1839
ISSN:2148-2403
https://kuey.net/

Research Article

Urban Solid Waste Management in Rohtak Municipal Corporation: An Analytical Study

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Citation: Dr. Seema, et al (2024) Urban Solid Waste Management In Rohtak Municipal Corporation: An Analytical Study, *Educational Administration: Theory and Practice*, 30(2), 1829-1839
Doi: 10.53555/kuey.v30i2.9337

ARTICLE INFO

ABSTRACT

This study examines the critical challenges and current practices of urban solid waste management in Rohtak Municipal Corporation, Haryana, against the backdrop of rapid urbanization and population growth. The study analyzes the current waste management system, including waste generation, collection, transportation, and disposal practices. It also examines the infrastructural gaps and the impact of rapid urbanisation and population growth on waste management. Key findings reveal that inadequate infrastructure, poor waste segregation practices, and insufficient public awareness severely hinder effective SWM in Rohtak. The absence of a systematic approach to waste separation at the source complicates recycling efforts and contributes to environmental pollution, including air and water contamination. Through primary surveys conducted with 250 households, the study highlights a strong correlation between waste management issues and public health concerns, with over 90% of respondents acknowledging the detrimental impact of solid waste on their health. The study emphasizes the necessity for strategic interventions, including enhancing community engagement, promoting waste reduction and recycling, and improving the operational efficiency of waste collection and disposal systems. This research provides a comprehensive overview of the challenges faced by the Rohtak Municipal Corporation and serves as a foundational analysis for developing effective, sustainable solid waste management practices that can adapt to the needs of rapidly urbanizing Indian cities.

Key Words: Municipal Solid Waste Management, Public Health, Rohtak Municipal Corporation, Urbanisation, Waste Collection Systems

Introduction

The rapid growth of population has placed immense strain on urban infrastructure making Municipal Solid Waste Management a critical and obligatory responsibility for municipal corporations and urban local bodies. Efficiently managing solid waste is essential yet Indian cities particularly rapidly growing ones face significant challenges in this area (Srivastava et al., 2015). These challenges stem from both the high volume of municipal solid waste generated and the complex nature of its composition. While infrastructural development is vital it must be accompanied by a well-planned solid waste management system (Kumar and Agrawal, 2020). Currently, the solid waste management system in many Indian cities is under strain and often inefficient and unscientific (Ghosh and Kumar, 2021). Typically, it encompasses waste generation, collection, transportation, and disposal. However, the system frequently falters due to inadequate infrastructure, poor maintenance, and a lack of necessary upgrades to effectively handle the increasing waste loads. Poor collection and insufficient transportation lead to the unsightly and unhygienic accumulation of Municipal Solid Waste (MSW) in public spaces. This situation is exacerbated by the unavailability of suitable facilities for treating and disposing of the large quantities of MSW generated daily in metropolitan areas (Das et al., 2019). The consequences of ineffective MSWM are severe where unscientific disposal practices such as dumping waste in low-lying areas without proper precautions have detrimental impacts on all aspects of the environment and pose significant risks to human health (Joshi and Ahmed, 2016). This situation is further compounded by the often-precarious financial status of municipal corporations, hindering their ability to provide the desired level of public service in urban centers (Kumar et al., 2009). Furthermore, effective MSWM planning, design, and operation must be grounded in an understanding of the composition and

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quantity of generated MSW. Notably, the characteristics of MSW in India, in terms of composition and hazardous nature differ considerably from that in Western countries (Sharma and Jain, 2019). The combination of rapid urbanization and industrialization in India has overstretched essential urban services with SWM being a particularly impacted sector (Soni et al., 2023). Civic bodies struggle to provide adequate services across the board, including water, electricity, roads, education, and public sanitation, inclusive of SWM. The SWM system is currently in a critical phase due to the lack of sufficient treatment and disposal facilities to handle the escalating volumes of waste produced in metropolitan cities. This problem is projected to worsen as India progresses towards industrialized nation status (Mohanty et al., 2022). The majority of India's Solid Waste Management challenges originate in urban areas, and the resulting unscientific disposal practices have documented adverse effects on both the environment and human well-being. While efficient solid waste management is crucial for sustainable urban development, many Indian cities, particularly those experiencing rapid growth, grapple with significant challenges in this sector. These challenges are compounded by the sheer volume and complex composition of municipal solid waste, often overwhelming existing systems limited by inadequate infrastructure and resources. This situation is pertinent in rapidly urbanizing states like Haryana where cities are struggling to cope with escalating waste generation (Singh and Satija, 2018). This study seeks to address this pressing issue at the local level with a focus on Rohtak Municipal Corporation, Haryana. The study aims to investigate and assess the current state of urban solid waste management within Rohtak and identifying specific challenges and potential areas for improvement.

Study Region

Rohtak is one of the oldest districts in Haryana and is the administrative center of the district and tehsil and is situated in the southeastern part of the state. Geographically, Rohtak lies between 76°31'47.764" to 76°42'43.071" East longitude and 28°49'53.354" to 28°56'33.819" North latitude, at an elevation of 220 meters above mean sea level. Strategically located approximately 70 kilometers northwest of New Delhi along National Highway No. 10 and 250 kilometers south of Chandigarh, the state capital, Rohtak benefits from excellent connectivity via rail and road networks. It is recognized as one of the eight regional centers within the National Capital Region and ranks as the fourth-largest city in Haryana. The neighboring districts include Jind and Sonipat to the north, Jhajjar and Sonipat to the east, and Hissar, Sirsa, and Bhiwani to the west. Rohtak experiences a subtropical monsoon climate, characterized by sub-humid conditions, hot summers, and mild, dry winters. The average annual rainfall is 592 mm. Temperature variation throughout the year is significant, with mean maximum temperatures reaching 40.5°C in May and June, while mean minimum temperatures drop to 7°C in January. The city has witnessed substantial population growth over the decades. In 1951, Rohtak's population was recorded at 71,902. Five decades later, the population had drastically increased to 2.9 lakh by 2001, followed by a further 27% increase to 3.74 lakh in 2011. The city currently maintains a population growth rate of 3 to 4% per annum. This rapid population growth, coupled with increasing urbanization, has led to a considerable expansion of Rohtak's municipal limits. In 2007, the municipal area was 30.96 km², which expanded to 104.10 km² by 2010. Further expansion in 2012, with the inclusion of nine surrounding villages, resulted in a municipal area of 139.4 km² and an estimated population of 4.8 lakh by 2013.

Objectives of the Study

- To analyze the existing solid waste management practices in Rohtak city.
- To assess the public perception of solid waste management in Rohtak city.

Database and Methodology

This study systematically investigated urban solid waste management in Rohtak by integrating both spatial and non-spatial data. Spatial data, which was foundational to the study's geographic analysis, facilitated the mapping and analysis of waste management infrastructure and patterns across Rohtak. The sources of spatial data were diverse and comprehensive: Survey of India Toposheets at a 1:50,000 scale provided a base layer depicting the terrain; the Municipal Council map of Rohtak city delineated administrative boundaries and urban features; the Town and Country Planning Map of Rohtak city offered insights into planned urban layouts and land-use patterns; high-resolution Google Earth Imagery furnished a current visual context of the city; and GPS survey data collected in the field pinpointed the locations of existing waste management infrastructure, thereby supplementing the spatial information. Complementing this spatial data, non-spatial data provided essential attribute information and a contextual understanding of the waste management scenario. These non-spatial sources included the District Gazetteer, which offered valuable socio-economic background information about Rohtak; road network data from the Municipal Council, detailing road names and widths crucial for transportation analysis; traffic volume details, important for assessing transportation efficiency within the city; comprehensive details regarding the existing Solid Waste Management (SWM) system, encompassing waste generation rates, the locations of waste bins, the types of vehicles used for waste transportation, and the designated disposal sites; and primary survey data collected directly from Rohtak residents, which provided insights into household waste generation habits and residents' perceptions of the current waste management system.

Following data acquisition, the study proceeded with On-Screen Digitization and Layer Creation. Utilizing the study area map obtained from the Rohtak Municipal Council as a base, the map was scanned and digitally processed. The resulting raster image was then imported into a Geographic Information System (GIS) and georeferenced using appropriate projection tools. Subsequent to georeferencing, on-screen digitization was conducted using point, line, and polygon tools within the GIS to create vector layers representing relevant geographical features. Upon completion of the digitization and necessary editing to ensure accuracy, these layers were saved as shapefiles within the GIS database. To ensure the accuracy of the spatial data, Ground Truth and Data Correction were critical steps in the methodology. Field verification was undertaken, employing GPS surveys and direct observation to compare the digitized features with real-world conditions on the ground. Any discrepancies identified during this ground truthing process led to the Correction of Layers within the GIS, thereby enhancing the overall accuracy and reliability of the spatial database. With these verified spatial layers established, the study progressed to Superimposition of Layers and Thematic Map Generation. Different spatial layers were overlaid and analyzed within the GIS software to generate thematic maps. These maps specifically focused on key aspects of solid waste management, such as waste generation areas, the locations of existing infrastructure, and transportation networks. This thematic mapping stage facilitated a comprehensive Analysis of the existing SWM system. Utilizing these thematic maps in conjunction with the associated non-spatial data, a range of factors was systematically analyzed to evaluate the performance of the current system. These factors included waste generation rates, household distribution patterns, road network characteristics, the existing SWM infrastructure, land use patterns across the city, and environmental sensitivities relevant to waste management. Furthermore, to optimize waste transportation, parameters such as road networks, road widths, shortest distances, waste bin locations, and traffic volumes were carefully considered to trace the most efficient, minimum distance and cost collection paths for waste transportation. Furthermore, a sample survey was conducted to gather primary information from the residents of Rohtak city regarding household waste generation, the types of waste generated in households, and their perspectives on the effectiveness of the prevailing waste management system in the city. This study employed a Google survey to gather data from 250 households in Rohtak city. A key characteristic of this research is its targeted approach, specifically focusing on households categorized as upper-income within the city. The majority of the respondents were below 30 years of age accounting for 60.7% of the respondents followed by those aged 40-49, accounting for 19.1% of the respondents. Substantially smaller proportions were seen in the other age brackets: 13.5% were aged 30-39, while the remaining categories of 50-59, 60-64, and 65 and above collectively made up a minor segment of the survey participants. Majority of these respondents have been living in the city for more than 20 years and accounted for 38.9% of the respondents. Besides, 20% of respondents reported living in Rohtak for 10-19 years. A smaller proportion, 15.6%, indicated a residence duration of 3-4 years, while 10% have lived in the city for 5-9 years. The primary survey enabled to have a comprehensive understanding of the ground level status of waste management in the city.

Results and Discussions

Waste management is a multifaceted process encompassing a series of crucial steps. It begins with the systematic collection of waste, followed by segregation based on waste type. Careful transportation and labeling are essential before the waste undergoes various treatments designed to reduce its hazardous properties. Finally, waste is disposed of through methods such as burning, burying in controlled landfills, and recycling. The primary objective of waste management is to safeguard the environment from detrimental pollution, thereby creating a healthy habitat for all living organisms and protecting public health from the harmful effects of waste. To achieve these goals, a variety of modern waste management techniques are employed worldwide. These techniques include biological reprocessing, recycling for material recovery, sanitary landfill dumping, composting, waste-to-energy conversion, bioremediation, incineration, pyrolysis, plasma gasification, and even disposal in the ocean or sea in specific cases. Implementing effective waste management techniques is not only essential for creating a better living environment today but also for ensuring a peaceful and healthy environment for future generations. Therefore, identifying and adopting the most suitable waste management techniques is a critical and urgent need for the well-being of people globally, paving the way for a more effective and ultimately successful waste management process.

Challenges to Effective Solid Waste Management

The challenge of effective solid waste management in India is fraught with multifaceted challenges, primarily stemming from the nation's rapid urbanization and rural to urban migration with expanding population, which generate ever-increasing volumes of waste. A critical bottleneck lies in the severely inadequate infrastructure for waste collection, transportation, treatment, and disposal, often overwhelmed by the sheer scale of the problem (Balasubramanian, 2018). Financial constraints faced by municipal corporations further exacerbate these infrastructure deficits, limiting their capacity to invest in and maintain modern SWM systems. Beyond infrastructure, a significant impediment is the lack of widespread public awareness and active participation, particularly in waste segregation at the source, which is crucial for efficient processing and recycling (Kumar et al., 2017). Institutional weaknesses, including enforcement of existing regulations

and policies, coupled with technological gaps in advanced waste treatment and processing technologies, also contribute to the inefficiencies (Jaiswal and Bharat, 2013). The scarcity of land for sanitary landfills, especially in densely populated urban centers, presents a major logistical challenge (Nanda and Berruti, 2021). Integrating the vast informal waste sector, which plays a significant role in waste collection and recycling but often operates outside regulatory frameworks is another complex issue (Gidwani, 2015). Finally, the heterogeneous and often hazardous composition of Indian municipal solid waste (Sharma and Jain, 2019), varying significantly across regions and seasons, necessitates tailored management approaches and further complicates treatment and disposal processes.

Municipal Solid Waste Management Rules in India

The Government of India has launched several significant initiatives to address the growing challenge of solid waste management across the country. A cornerstone initiative is the Swachh Bharat Mission, launched in 2014, which includes a major focus on cleanliness and sanitation, encompassing solid waste management in both urban and rural areas. Under Swachh Bharat Mission, the government has promoted source segregation, door-to-door collection, and scientific processing of waste, moving away from traditional open dumping. The Municipal Solid Waste Management Rules provide the regulatory framework, emphasizing waste segregation at source, promoting waste processing and resource recovery, and mandating responsibilities for urban local bodies. The Municipal Solid Waste Management Rules in India, specifically the Municipal Solid Waste Management Rules, 2016, are a comprehensive framework designed to address the growing challenge of urban waste in the country. These rules are a significant update from the previous 2000 version and reflect a more decentralized and environmentally conscious approach to waste management. At their core, the rules emphasize segregation of waste at source, making it the responsibility of waste generators to separate their waste into categories like biodegradable, non-biodegradable, and hazardous waste. This segregation is intended to facilitate efficient processing and resource recovery. A key aspect of the 2016 rules is the focus on reducing landfill burden and promoting waste processing. They mandate that municipal authorities prioritize waste processing methods like composting, biomethanation, and waste-to-energy over simply dumping waste in landfills. The rules also encourage the utilization of waste as a resource, promoting recycling and recovery of valuable materials. Furthermore, the rules strengthen the accountability of municipal corporations and urban local bodies in ensuring effective waste management within their jurisdictions. The guidelines specify timelines for implementing various aspects of the rules, including infrastructure development and waste processing capacity. The rules also address the integration of the informal waste sector, recognizing their crucial role in waste collection and recycling. They encourage municipalities to formalize and integrate waste pickers and waste recyclers into the formal waste management system, ensuring their livelihoods and improving the overall efficiency of waste collection. Moreover, the 2016 rules place a greater emphasis on public awareness and citizen participation. They encourage municipalities to conduct Information, Education and Communication (IEC) campaigns to educate citizens about waste segregation, responsible waste disposal practices, and the importance of their role in effective waste management.

Solid Waste Management Challenge in Haryana

Haryana, like many Indian states faces significant challenges in managing its solid waste, particularly within its rapidly urbanizing areas. Studies indicate that urban centers in Haryana are experiencing a surge in municipal solid waste (MSW) generation, driven by population growth, changing consumption patterns, and economic development. However, the infrastructure for effectively managing this escalating waste load is often lagging. One of the major concerns in the state is the inadequacy of existing waste collection, transportation, and treatment systems in Haryana's urban areas (Priti and Mandal, 2019). Studies highlight issues such as insufficient door-to-door collection coverage, reliance on open and inefficient transportation methods, and a limited capacity for scientific waste processing (Misra et al., 2018; Indraj et al., 2019 and Kumar and Sharma, 2019). Many urban local bodies in Haryana struggle with outdated infrastructure and a lack of modern waste treatment technologies, resulting in a heavy reliance on uncontrolled and environmentally damaging open dumping. Financial constraints faced by these urban bodies are often cited as a major impediment to infrastructure upgrades and the adoption of improved SWM practices. Further studies highlight the challenges related to waste segregation and public participation. Low levels of source segregation in households and commercial establishments are reported, hindering efficient recycling and composting efforts. Public awareness and engagement in responsible waste management practices remain limited, impacting the overall effectiveness of SWM initiatives. Moreover, studies suggest that institutional capacities and regulatory enforcement related to SWM in Haryana's urban areas need strengthening to ensure compliance and promote sustainable practices.

Solid Waste Management in Municipal Corporation Rohtak

The Rohtak Municipal Corporation (MC) bears the responsibility for solid waste management within the city, encompassing collection, transportation, and disposal. The estimated total solid waste generation in Rohtak is approximately 150 metric tons per day. This translates to a per capita waste generation rate of roughly 0.35 kg, exceeding the guidelines set by the CPHEEO (Central Public Health and Environmental Engineering

Organisation). Waste is collected from various points across the city and transported to a 25-acre landfill site situated about 15 kilometers away on Bhiwani road, utilizing trucks, tractors, and other four-wheeled vehicles. Safai Karamcharis are employed by the Municipal Corporation to manage the solid waste system.

Table 1: Waste Generation Trends in Rohtak City (2001-2021)

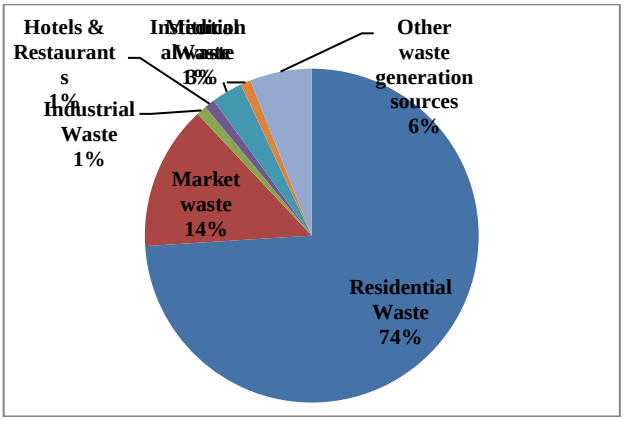
Sr. No.	Particular		2001	2011	2021
1	Population		294577	374292	541522
2	Per capita waste generated(kg)	As per standard(.45kg)	132559.65	168431.4	344071. 35
		Existing as per MC (.22kg)	64806.94	8230344. 24	168212. 66
3	Existing Quantity of MSW Generation in Ton +30% extra(Kg)		84249.02	107047.5	218676.5

Source: Municipal Corporation Rohtak

As can be noted from Table 1, there is significant increase in municipal solid waste (MSW) generation in Rohtak City evident over the two decades from 2001 to 2021. This increase is strongly correlated with the city's substantial population growth, which increased from 294,577 in 2001 to 541,522 in 2021. When determining the waste generation using a standard per capita rate of 0.45 kg, the MSW generation more than doubled, increasing from approximately 132,560 kg in 2001 to 344,071 kg in 2021. Even when considering a lower per capita rate of 0.22 kg, as per Municipal Corporation estimations, the estimated waste is increasing from roughly 64,807 kg to 168,213 kg over the same period. Furthermore, the Existing Quantity of MSW Generation data, although potentially incorporating a 30% addition, also demonstrates a significant rise, from 84,249 kg in 2001 to 218,677 kg in 2021. The data clearly indicates a growing challenge of solid waste management in Rohtak City directly linked to its expanding population.

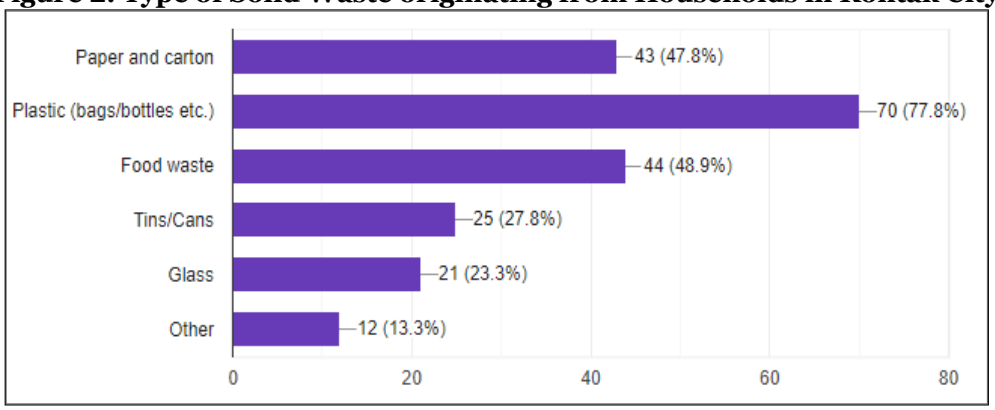
Solid waste itself can be categorized based on its origin, commonly including household, industrial, medical, and other distinct types. In Rohtak, various sources contribute to the city's overall waste generation profile. Residential areas constitute a major source of solid waste in Rohtak, alongside commercial zones. It is estimated that approximately 74% of the city's municipal solid waste originates from households (Figure 1). This residential waste stream typically comprises kitchen refuse, newspapers, liquid waste, and e-waste. Commercial areas, notably marketplaces, also contribute significantly. Market waste, accounting for around 14% of the total, is generated from major commercial hubs such as Qilla Road, D-Park, the Bus Stand, the Railway Station, local markets, and street vendors. Rohtak is also characterized by numerous daily markets, adding to this waste stream.

Figure 1: Source of Waste Generation in Rohtak City



Industrial activity within the Municipal Corporation boundaries also generates waste, though to a lesser extent, estimated at around 1% of the total MSW. The hospitality sector, encompassing approximately 125 to 150 hotels and restaurants in Rohtak city, contributes about 1% to the waste stream as well. Notably, in hotels and restaurants, the separation of dry and wet waste was not observed. Medical waste, given Rohtak's status as a medical hub in Haryana and housing around 200 hospitals and nursing homes including PGIMR, constitutes approximately 3% of the city's waste. However, a lack of biomedical waste segregation is a concern in this sector. Institutional waste generation from Rohtak's educational institutions, including PGIMR, MDU, and around 150-180 schools and colleges, is relatively low, contributing about 1% (0.5 - 1 MT) of the total. Other sources collectively contribute approximately 6% of the city's solid waste. These diverse sources include dairies operating within the city limits, which can create hazardous conditions, construction waste from both public and private projects, as well as waste from cinema houses, function halls, religious places, and parks and gardens across the city.

Figure 2: Type of Solid Waste originating from Households in Rohtak City



Source: Primary Survey

Furthermore, based on primary survey findings, among the residential wastes, Plastic (bags/bottles etc.) constitutes the most prevalent type of waste, with a significant 77.8% of households reporting it (Figure 2). Following closely behind are Food waste and Paper and carton, representing 48.9% and 47.8% of household waste respectively. Comparatively smaller proportions are observed for other waste categories: Tins/Cans account for 27.8%, Glass for 23.3%, and Other waste types make up 13.3%. The findings indicates that plastic, food waste, and paper/cardboard are the primary components of solid waste generated by households in Rohtak City, while tins, glass, and other miscellaneous waste contribute to a lesser extent.

Waste Collection in Rohtak Municipal Corporation

In Rohtak city, the primary collection of municipal solid waste is managed through a Door-to-Door Collection (D2D) system, overseen by the Municipal Corporation Rohtak (MCR) in partnership with a private company. This system relies on laborers who utilize push carts, tricycles, and auto tippers to collect waste directly from households across all 20 wards of the city. Collection activities are scheduled throughout the day, operating between 7:00 am and 5:00 pm. The waste collected through this primary D2D system is then transported and deposited at designated secondary collection points within the city for further management.

Table 2: Gap Analysis of infrastructure – Door to Door Garbage Collection

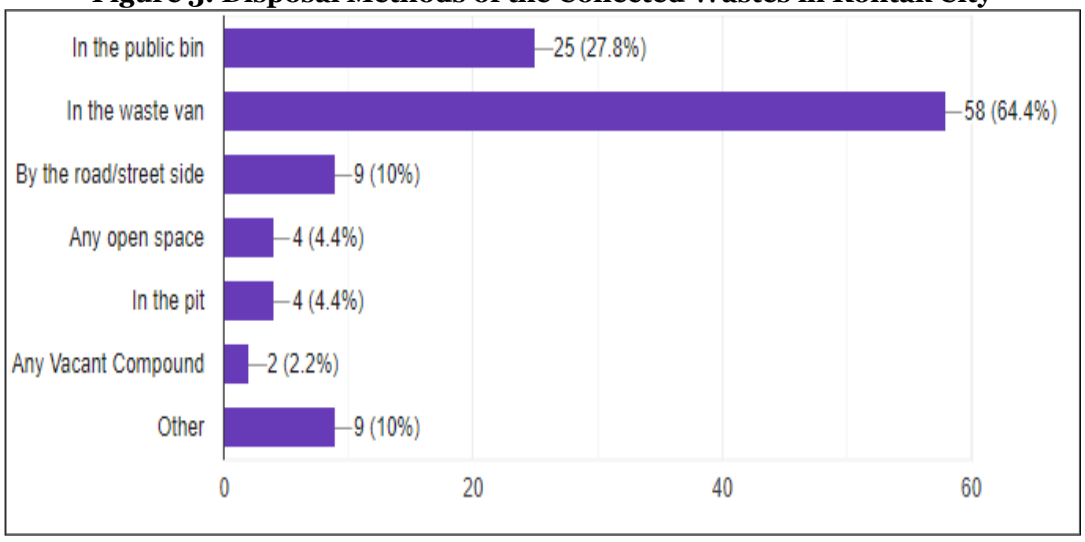
Sr. No	Functional Equipment's /Vehicles	Capacity	Requirement as per Norms	Usable Existing equipment 's/vehicles	Gap
1	Segregation Bins	10-12 liters (2 for each HH)	167936	0	167936
2	Push Cart	1 for 150- 200 HH (avg. 175)	480	0	480
3	Pedal Tri cycle	1 for 200- 300 HH	336	150	186
4	Auto Tipper	1 for 1000- 1500 HH	68	40	28

Source: Municipal Corporation of Rohtak

There are significant deficits across essential functional equipment and vehicles with regards to door to door collection in the city. Table 2 reveals a complete absence of segregation bins, with a requirement of 167,936 bins (two 10-12 liter bins per household) and similarly there are no existing usable bins. Similarly, for push carts, deemed necessary at a ratio of one per 150-200 households, the requirement stands at 480, but no usable push carts are currently available. While there are some existing Pedal Tricycles (150) and Auto Tippers (40), these numbers fall short of the required 336 and 68 respectively, leaving gaps of 186 Pedal Tricycles and 28 Auto Tippers. This infrastructure gap highlights a critical need for significant investment in procurement of segregation bins, push carts, pedal tricycles and auto tippers to effectively implement door-to-door garbage collection in Rohtak city as per established norms.

Furthermore, the survey findings indicate that the most prevalent method for waste disposal in Rohtak City is collection by waste vans, with a significant 64.4% of respondents reporting this method (Figure 3). A considerable proportion, 27.8%, also utilize public bins for waste disposal. In contrast, less formal disposal methods are less common where 10% report disposing of waste by the road/street side, and another 10% indicated other disposal methods. Even smaller percentages are observed for disposal in any open space and in the pit, both at 4.4%, while the least common method is disposal in any vacant compound, at 2.2%. Therefore, the findings show a reliance on organized waste collection systems like waste vans and public bins in Rohtak city while less sanctioned and potentially environmentally problematic disposal methods are comparatively less frequent within the surveyed households.

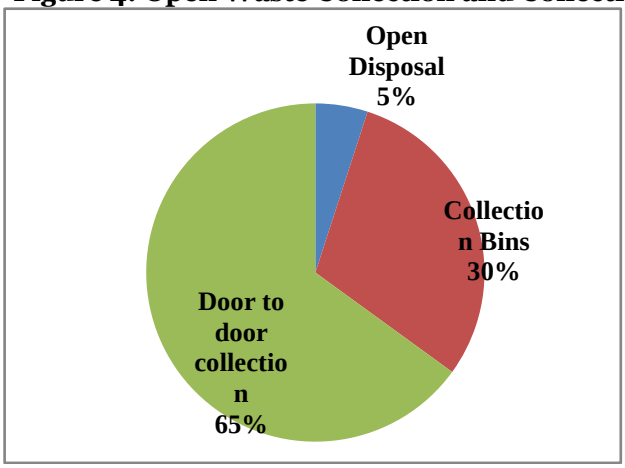
Figure 3: Disposal Methods of the Collected Wastes in Rohtak City



Source: Primary Survey

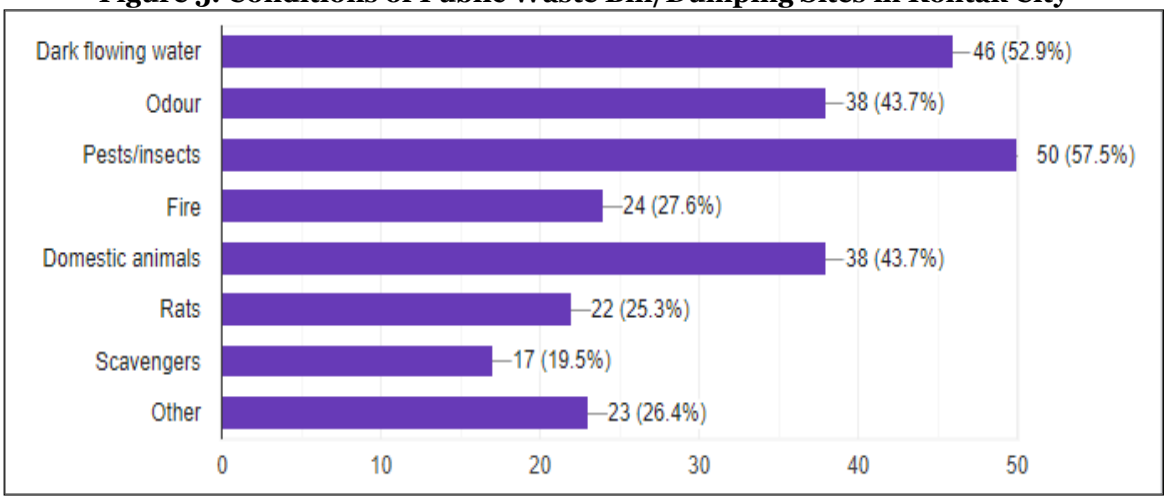
Secondary waste collection in Rohtak City is a continuous, daily operation practiced throughout the year. Waste accumulated in open spaces, likely from the primary door-to-door collection system or other sources, is gathered and transported further. Loading of this waste for secondary transportation is carried out both manually by laborers and with the assistance of mechanical loaders. This collected waste is then consolidated at approximately 30 designated collection points strategically located throughout the city, awaiting further transport to the final disposal site.

Figure 4: Open Waste Collection and Collection by Workers in Rohtak City



The Door to door collection accounts for 65% of the total waste collection where as Collection Bins represent 30% of waste collection (Figure 4). Open Disposal accounts for 5% of the waste collection in the city. Even though the city has been deemed to be bin free but the location where bins existed previously continue to be used as waste disposal sites by the residents and commercial establishment authorities and given this situation the wastes are left in the open creating nuisance for the residents and creates the need for continuous collection activities in the city in such locations.

Figure 5: Conditions of Public Waste Bin/Dumping Sites in Rohtak City



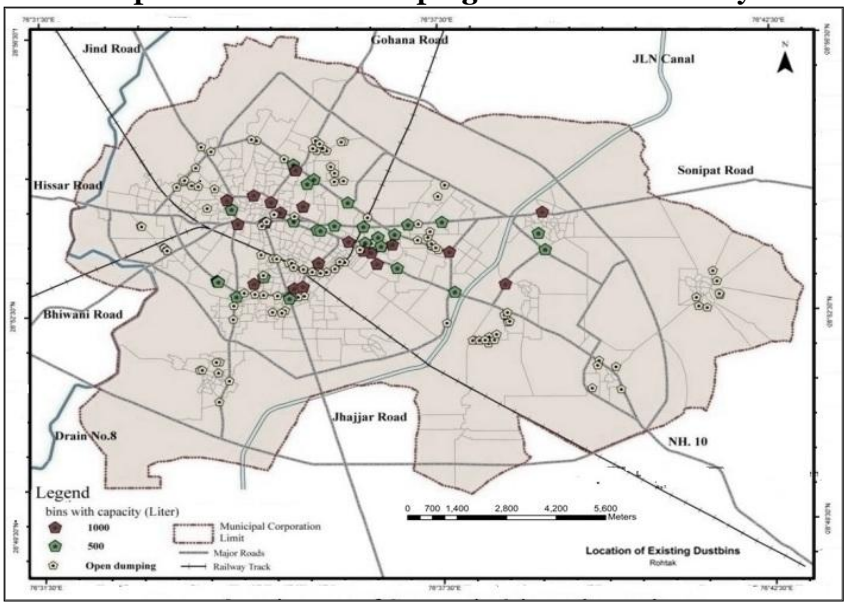
Source: Primary Survey

The survey results clearly illustrate a range of problematic conditions prevalent at public waste bin/dumping sites in Rohtak City (Figure 5). A significant majority of respondents, 57.5%, reported observing pests/insects, highlighting a potential health and hygiene concern associated with these sites. Dark flowing water was also a frequently noted condition, with 52.9% of respondents indicating its presence, suggesting possible leachate or unsanitary liquid accumulation. Furthermore, odour and the presence of domestic animals were each reported by 43.7% of respondents, further emphasizing sanitation issues and the potential for disease vectors. While less frequent, concerns about fire (27.6%), other unspecified conditions (26.4%), rats (25.3%), and scavengers (19.5%) were also recorded, contributing to an overall picture of unsanitary and potentially hazardous conditions at public waste disposal locations in Rohtak City.

Storage, Segregation and Transportation of Waste in Rohtak Municipal Corporation

In Rohtak Municipal Corporation, the initial stage of solid waste management, waste storage, is recognized as critical, ideally occurring at the point of waste generation until collection. However, improper waste storage practices are prevalent, contributing to drainage blockages across the city. While source segregation of waste is acknowledged as essential for efficient resource recovery and reducing landfill burden, it is currently absent at the city level. Although the Swachh Bharat Abhiyan has directed urban local bodies to implement segregated dustbins (blue and green) to promote citizen awareness and source separation, this practice is not yet realized in Rohtak. For waste transportation, the Municipal Corporation utilizes a fleet of dumpers, tractors, Tata Ace vehicles, and small tippers to move collected waste from storage points directly to the designated landfill site. Notably, a comprehensive waste treatment and segregation system is not yet in place, with waste being disposed of directly at the landfill, and the potential for waste reuse remaining largely untapped.

Map 1: Location of Dumping Sites in Rohtak City



Source: Municipal Corporation of Rohtak

Location of Dumping Sites in the Rohtak city

The location of dumping sites in the city have been shown in Map 1. There are designated communal dustbins with capacity of 1000 liter and 500 liter that were strategically distributed throughout the municipal area predominantly along major roads. Additionally, there are presence of numerous open dumping sites in the city. Even though the city has been bin free the pre-existing sites where bins were installed continued to be used as open dumping sites. Earlier, the location of both formal bin infrastructure and informal open dumping across Rohtak implies a mixed waste management scenario where designated bins existed but were either insufficient in number, inconveniently located, or underutilized that lead to the continued practice of open dumping. Both the designated bins and open dumping sites are mainly located along major roads like Jind Road, Gohana Road, Sonipat Road, Hissar Road, Bhiwani Road, and Jhajjar Road.

Municipal Solid Waste Management Plant

The Municipal Solid Waste Management (SWM) plant for the Rohtak cluster has been designed to serve a consortium of Urban Local Bodies (ULBs), including Bahadurgarh, Beri, Gohana, Jhajjar, Julana, Kalanaur, Kharkhoda, Meham, and Rohtak itself. Developed with a 20-year design horizon, the plant's conceptualization is firmly grounded in key design criteria aligned with sustainable and effective waste management principles. Foremost is the commitment to full compliance with the Municipal Solid Waste Management Rules of 2016, ensuring adherence to regulations governing waste collection, transportation, treatment, and disposal processes. The plant design emphasizes improved waste management practices at the source level, aiming to implement door-to-door collection with a two-bin system to facilitate segregation of green (wet) and dry waste right from households. Furthermore, the plan incorporates an efficient secondary waste collection and transportation system to optimize waste logistics within the cluster. A core principle guiding the plant's operation is the adoption of the 4Rs – Reduction, Reuse, Recycle, and Recover to minimize waste generation and maximize resource utilization. Ultimately, the plant aims to significantly reduce landfill burden by treating and processing the majority of the waste, with only residual rejects, targeted to be less than 25% of the generated waste, designated for final disposal in a scientifically designed sanitary landfill.

Solid Waste Management Challenges in Rohtak City

Rohtak City encounters significant hurdles in effectively managing its solid waste. A primary challenge lies in the absence of waste segregation at the source, meaning households and commercial establishments are not separating different types of waste like wet, dry, and hazardous materials. This lack of initial segregation complicates the subsequent waste processing and recycling stages. Furthermore, the open burning of waste remains a persistent issue, contributing to air pollution and posing health risks to the population. Exacerbating these operational challenges is a lack of robust public participation in waste management initiatives, hindering the effectiveness of any city-wide programs. The consequences of these combined challenges manifest in practical urban problems, as waste often chokes drains and the sewerage system. This blockage becomes particularly critical during the monsoon season, significantly increasing the risk of flooding and further compounding the city's environmental and public health vulnerabilities.

Additionally, the findings from the primary survey of 250 households in the city highlight additional concerns. Public waste burning is widely observed, with approximately four out of five residents reporting awareness of this practice. Similarly, a majority of the population, nearly 90%, perceives waste accumulation within water bodies throughout the city. This issue extends to public roads, where an even larger proportion, exceeding 90%, acknowledges the presence of waste. The broader issue of waste in public areas is also widely recognized, affecting the perception of about 80% of the surveyed residents. Critically, there is a strong consensus within the community, with over 90% in agreement, that solid waste is contributing to health problems in Rohtak City. Collectively, these findings paint a picture of a city grappling with visible and impactful waste management deficiencies across various public spaces and environmental domains, leading to a strong public perception of associated health risks.

Recommended approach to Effective Solid Waste Management in the city

Effective solid waste management necessitates a hierarchical approach, prioritizing waste reduction and resource optimization before resorting to final disposal. The most desirable first step is to aggressively pursue waste reduction at the source, encouraging practices that minimize waste generation initially. This includes promoting reuse of materials and products to extend their lifecycle and lessen the demand for new resources. For waste that is inevitably produced, recycling should be the next priority, diverting materials from landfills and reintroducing them into the production cycle. Organic waste fractions can be effectively managed through composting, transforming them into valuable soil amendments, thereby reducing landfill burden and creating a beneficial byproduct. Finally, waste disposal, ideally in engineered landfills, should be considered the last resort, reserved for materials that cannot be reduced, reused, recycled, or composted. This hierarchical strategy moving from reduction to responsible disposal forms the basis of an effective framework for sustainable solid waste management.

Conclusion

Rohtak City has been recording a substantial increase in waste generation over the past two decades primarily due to rapid population growth and urbanization. While the city has implemented a door-to-door waste collection system, significant infrastructural gaps persist, including a lack of segregation bins and inadequate numbers of push carts, tricycles, and auto tippers. This has led to the continuation of open dumping practices, posing environmental and public health risks. The absence of source segregation and the prevalence of open waste burning further exacerbate these challenges. Despite the planned Municipal Solid Waste Management plant designed to address the waste management needs of the Rohtak cluster, the city's current waste management practices fall short of the desired standards. The findings underscore the urgent need for a comprehensive and integrated approach to solid waste management in Rohtak City. This approach should prioritize waste reduction at the source, promote waste segregation, and improve collection and transportation infrastructure. The survey results also indicate an understanding of the issues among the residents of the city and their concerns have to take into consideration when formulating strategies to waste management in the city. The enhancement of public awareness and participation are also crucial for the success of any waste management initiative. A concerted effort from the municipal corporation, citizens, and other stakeholders is essential to transform the solid waste management system in the city and create a cleaner and healthier urban environment.

References

1. Balasubramanian, M. (2018). Municipal solid waste management in India: status, problems and challenges. International Journal of Environment and waste management, 21(4), 253-268.
2. Das, S., Lee, S. H., Kumar, P., Kim, K. H., Lee, S. S., & Bhattacharya, S. S. (2019). Solid waste management: Scope and the challenge of sustainability. Journal of cleaner production, 228, 658-678.
3. Ghosh, R., & Kumar, M. S. (2021). Challenges and Opportunities Towards Management of Solid Wastes in Indian Cities: Beyond the Rhetoric of Convenience. Resource Management, Sustainable Development and Governance: Indian and International Perspectives, 445-460.
4. Gidwani, V. (2015). The work of waste: inside India's infra-economy. Transactions of the Institute of British Geographers, 40(4), 575-595.
5. Indraj, K. A., Singh, G., & Gurjar, G. L. (2019). Smart city mission, urbanization and its challenges: a case study of Haryana. International Journal of Scientific Research in Science and Technology, 6.
6. Jaiswal, A., & Bharat, A. (2013). Assessing Institutional and Regulatory Framework for Solid Waste Management in India. International Journal of Regulation & Governance, 13(2).
7. Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review. Cogent environmental science, 2(1), 1139434.
8. Kumar, A., & Agrawal, A. (2020). Recent trends in solid waste management status, challenges, and potential for the future Indian cities–A review. Current Research in Environmental Sustainability, 2, 100011.
9. Kumar, S., & Sharma, H. R. (2019). Wealth from waste an initiative for solid waste management in rural areas of Haryana: issues, challenges and way forward. Indian Journal of Waste Management, 3(2), 61-67.
10. Kumar, S., Bhattacharyya, J. K., Vaidya, A. N., Chakrabarti, T., Devotta, S., & Akolkar, A. B. (2009). Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: An insight. Waste management, 29(2), 883-895.
11. Kumar, S., Smith, S. R., Fowler, G., Velis, C., Kumar, S. J., Arya, S., & Cheeseman, C. (2017). Challenges and opportunities associated with waste management in India. Royal Society open science, 4(3), 160764.
12. Misra, A. K., Masoodi, M., Poyil, R. P., & Tewari, N. K. (2018). Water demand and waste management with respect to projected urban growth of Gurugram city in Haryana. Beni-Suef University Journal of Basic and Applied Sciences, 7(3), 336-343.
13. Mohanty, S., Saha, S., Santra, G. H., & Kumari, A. (2022). Future perspective of solid waste management strategy in India. In Handbook of Solid Waste Management: Sustainability through Circular Economy (pp. 191-226). Singapore: Springer Nature Singapore.
14. Nanda, S., & Berruti, F. (2021). Municipal solid waste management and landfilling technologies: a review. Environmental chemistry letters, 19(2), 1433-1456.
15. Priti, & Mandal, K. (2019). Review on evolution of municipal solid waste management in India: practices, challenges and policy implications. Journal of Material Cycles and Waste Management, 21(6), 1263-1279.
16. Sharma, K. D., & Jain, S. (2019). Overview of municipal solid waste generation, composition, and management in India. Journal of Environmental Engineering, 145(3), 04018143.
17. Singh, D., & Satija, A. (2018). Prediction of municipal solid waste generation for optimum planning and management with artificial neural network—case study: Faridabad City in Haryana State (India). International Journal of System Assurance Engineering and Management, 9, 91-97.

18. Soni, A., Das, P. K., & Kumar, P. (2023). A review on the municipal solid waste management status, challenges and potential for the future Indian cities. Environment, Development and Sustainability, 25(12), 13755-13803.
19. Srivastava, V., Ismail, S. A., Singh, P., & Singh, R. P. (2015). Urban solid waste management in the developing world with emphasis on India: challenges and opportunities. Reviews in Environmental Science and Bio/Technology, 14, 317-337.