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A GROUND-LEVEL LOOK AT WASTE MANAGEMENT REALITIES IN DELHI, THE CAPITAL OF INDIA

Savita Bargujar[1], Yatharth Mehta[1] and Suruchi*[1]

[1]Department of Chemistry, Ramjas College, University of Delhi, Delhi, India

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Corresponding Author: Suruchi (suruchi@ramjas.du.ac.in)

ABSTRACT

Managing municipal solid waste (MSW) has become progressively challenging in India due to fast population growth. The challenge extends beyond ecological and aesthetic concerns to the large scale of waste generated daily. Poor waste management affects urban, semi-urban, and rural areas alike. Accumulation of trash along roadsides, in empty plots, low-lying areas, and drainage systems not only declines apparent appeal but also poses harsh health and environmental risks. This review analyses the key criteria of MSW management, with a comprehensive analysis of waste generation in Delhi and the options for classification, collection, and treatment. It also assesses the current condition of MSW in Delhi, featuring the challenges of public-private partnerships and the neglected contributions of rag pickers. The findings underline the urgent need for Delhi to establish both a conventional recycling sector and decentralized solid waste processing units in metropolitan cities.

KEYWORDS: Solid waste management, Challenges, Recycling, MSW, Population, Urbanization

1 INTRODUCTION

The residue or junk that is produced as a result of commercial and domestic activity within municipalities is referred to as municipal solid waste." Wastes produced by hospitals and industry, along with other types of electrical and electronic trash, are not included in this measure. Rapid urbanization, overpopulation, lifestyle changes, and the lack of scientific refuse management have all contributed to the problems that plague the health of a human being and the environment (Ranganathan, n.d.). The legislative clearances, such as environmental clearances, required for the growth of municipal solid waste treatment, processing, and disposal facilities are included in the control of municipal solid waste. These clearances are essential for municipal solid waste management. It is likely that pre-feasibility and feasibility studies will be required to determine the most appropriate treatment and processing methodologies for specific regions (CPHEEO, n.d.).

Solid wastes are the organic and inorganic refuse materials that are generated in a society and have no value for the original user(s). Solid waste covers a wide range of discarded materials generated from daily life, including household garbage, paper, bottles, clothing, and product packaging, as well as bulkier items like old furniture and broken appliances, and potentially hazardous leftovers such as paint cans, used batteries, and garden trimmings like grass clippings. There are two categories of solid refuse: organic waste and inorganic waste. Grass clippings and furniture are two additional categories of debris that are considered solid waste. As a result, solid wastes include not only the diverse collection of trash generated by the urban community but also the more uniform accumulation of wastes generated by agriculture, industry, and mineral extraction. Although trash may have little or no value in one setting or to the person who wishes to dispose of it, the waste that is discharged may acquire enormous value in another situation. The plan and execution of solid waste management functional elements (BBAU, n.d.) require knowledge of solid waste sources, kinds, content, generation, and disposal rates.

Controlling industrial hazardous waste is accomplished through the application of the Hazardous Waste (Management, Handling, and Transboundary Movement) Rules, 2008, which underwent further amendments in 2009. These rules operate under a distinct system from that of the MSWM. In general, the existence of properties such as ignitability, corrosivity, reactivity, and toxicity can be used to identify waste as hazardous. At the unitary level, it is the duty of the local governments to make sure that hazardous waste from industries does not become mixed in with the garbage that is collected from the municipality. This Manual refers to wastes that contain dangerous components and are frequently classified as municipal solid waste (MSW) as "special wastes." Batteries, compact fluorescent lamps (CFLs), tube lights, various household cleaning products, and other similar items are all examples of what are referred to as "special wastes" (CPHEEO, n.d.).

2. CONDITION OF MUNCIPAL WASTE MANAGEMENT- A WIDER PERSPECTIVE

India is a predominantly agricultural nation having a population of approximately 1020 million (Singhal and Pandey, 2001). There are twenty-eight states and seven union territories that make up the nation India. A significant rise in industrial output is causing significant urban population growth. In consequence, the 677 localities and municipalities that were classified as Class I in 1991 increased to nearly 700 by 2001 (Mandal, 2000). Due to advancements in the standard of living and social standing of urban populations, municipal waste production has increased significantly (Sharholy et al., 2007). With increase in population and urbanization, trash output has increased, making disposal more difficult (Idris et al., 2004). Over the past three decades, the National Environmental Engineering Research Institute (NEERI) has performed research in over fifty Indian towns. 30–45% of municipal solid trash is organic, 6–10% is recyclable, and the rest is inorganic. The quantity of organic matter in the solid waste of developing nations is significantly greater than the amount of organic matter in the solid waste of industrialized nations (Bhide and Sundersan, 1983). Organic matter has the potential to be converted into beneficial products, which can help alleviate the load on current landfills (Richard, 1992). Municipal solid waste (MSW) can be converted in to energy. Biomethanation is one possible method for recovering energy from municipal solid waste (Bhattacharyya et al., 2008). The MSW (Management and Handling) Rules, 2000, require source-specific garbage collection, transportation, processing, and disposal. To know the quantity and characteristics of municipal solid waste (MSW) helps to create a long-term MSWM plan. Local organizations rarely provide reliable statistics and information. Thus, the New Delhi-based Central Pollution Control Board decided to evaluate the municipal solid waste management (MSWM) systems in 59 Indian cities.

These cities included 35 metropolitan areas with populations exceeding 1 million, along with 24 state capitals and territories. In accordance with directives provided by the Supreme Court of India in New Delhi, the Central Pollution Control Board in New Delhi has commissioned NEERI to investigate the current condition of MSWM in the aforementioned areas. Extensive field investigations were conducted in the context of this study to quantify municipal solid waste (MSW), analyze the physical composition of MSW, and characterize MSW in each of the recognized cities. In addition, the status of the MSWM was evaluated (in accordance with the MSW Rules of 2000), and a plan for enhanced management was developed.

Municipal corporations employ employees and provide vehicles for the purpose of removing trash from communal bins. The company's employees use the trash cans located throughout the neighbourhood to transfer garbage onto the vehicles. Transporting the waste to the location where it will be disposed of is the final phase. The dumper placer transports the metallic containers directly to the site of disposal, where they are unloaded after being deposited. In some of the larger towns and cities, personal vehicles are also leased to supplement the municipal convoy that transports the majority of the scorn. The maintenance of vehicles takes place in a municipal facility alongside the maintenance of other municipal vehicles; however, garbage vehicles receive the lowest priority. The overwhelming majority of these shops are only able to perform simple maintenance and repairs. Even though preventive maintenance is required to keep the collection convoy in excellent operating state, it is frequently ignored. There are a few urban areas with transfer stations only (Joseph, 2002).

It is a very usual practice in the majority of metropolitan areas to dispose of waste in low-lying areas by depositing it, and the majority of cities engage in uncontrolled waste disposal at landfills. The disposal sites are chosen based on their proximity to the collection sites, and new disposal sites are frequently identified only when the ones in use reach capacity. Bulldozers are only occasionally used to compact the refuse at the discarding site (Joseph, 2002), with the exception of the four metropolitan cities and in these cities also, bulldozers are used to level the dumped garbage only. When the dumpsites are being filled, the vehicles carrying MSW are not weighed, and there is no set plan that is adhered to. There are no provisions for regulating leachate or gas, and soil cover is almost never applied, except when a site is being permanently decommissioned. The lack of fencing at the majority of landfills and the prevalence of trash picking pose challenges for the controlled administration of the landfills. The landfills are not lined, no efforts are made to compact the refuse, and no dirt is applied on the waste. In response of this, the conditions at the landfills are insanitary, and they contribute to the degradation of the environment. Rainwater permeates the trash and soil strata during the wetter months, contaminating the groundwater as it travels deeper. Fly and mosquito breeding grounds are created at the disposal locations. In addition, the practice of illegally burning trash by rag pickers creates a smoky nuisance; open combustion of municipal solid refuse at disposal sites is common because it facilitates rag picking and reduces waste volume (Diaz et al., 1997). In India, there are different sets of regulations for biological waste and hazardous waste. The administration of different types of waste necessitates the use of distinct collection, storage, transportation, treatment, and disposal procedures. On the other hand, it has been displayed that municipal solid waste is sometimes mixed with hazardous refuse and biological waste due to a lack of oversight and comprehension.

The majority of cities have implemented a system for garbage collection from communal receptacles. In some towns and cities, residential areas, street sweepings, gardens, parks, office buildings, and retail establishments generate trash that is collected in distinct heaps. At the storage containers, municipal solid waste is combined with waste from slaughterhouses and hospitals. In a number of cities, there are open collection sites that create unsanitary conditions and corporeal wellness dangers to workers and the surrounding population (Gupta, 2001a).

The MSW (Management and Handling) Rules of 2000 stipulate that the availability of suitable containers should be proportional to the amount of waste generated by the local population. Waste collection utilizes a variety of brick masonry bins and RCC bins, in addition to M.S. and PVC containers. It was discovered that the size of the waste cans and the distance between them are not determined by the amount of garbage donated by local residents. Certain communities utilize front-end loaders to load solid refuse into storage containers. In 52 of 59 cities, the manual collection of trash from community receptacles is prevalent. Dry and wet refuse are collected together during the city-wide house-to-house collection that has been implemented in Nashik. The Ghanta Gadi vehicles are a form of tractor-trailer system used to transport municipal

solid waste directly to a waste processing facility.

In a lot of the towns in India especially in Delhi, municipal solid waste, also known as MSW, is often disposed of in an open landfill. This is done despite the fact that open dumps present a number of risks and produce ecological imbalances in the form of increased levels of land, water, and air pollution. Because open landfills present threats to the surrounding ecosystem and encourage improper garbage disposal, this type of trash disposal is unacceptable and should not be used. More than ninety percent of municipal solid waste (MSW) in India is being disposed of by dumping it straight on the ground (Das et al., 1998). This is an undesirable practice. In addition to dietary practices, cultural traditions, lifestyle choices, climate, and income, numerous other factors determine the composition of refuse. In each city, municipal authorities were consulted prior to the selection of sampling points, which were located in affluent, middle-class, and low-income neighbourhoods (Gupta et al., 1998). These regions included residential, commercial, and industrial areas, as well as a market. In the process of analysing refused samples for a variety of physicochemical parameters, standard protocols were adhered to.

2.1 Current Status of Solid Waste Management: The 2026 Regulatory Landscape

The state of solid waste management in India has observed a regulatory intervention with the notification of the Solid Waste Management (SWM) Rules, 2026, by the Ministry of Environment, Forest and Climate Change on January 28, 2026. These rules, which came into force on April 1, 2026, if we look upon the SWM Rules of 2016 and signal a primary going away from the "collect and dump" model that had long totally controlled municipal waste governance in the India (Press Information Bureau, 2026). The official announcement of this new framework was not done by any incident; it was a direct response to the persisting failure of the 2016 rules to deliver meaningful change on the ground. Despite a regulatory structure having been in place for nearly a decade, India continued to face extremely bad solid waste management crisis. As per the Central Pollution Control Board's data for 2023–24, only 1.14 lakh tonnes of waste was processed daily, while the remainder continued to be disposed of in unregulated landfills and open dumping sites across the country (Ministry of Environment, Forest and Climate Change, 2026). In cities like Delhi, the gap between waste generation and waste processing remained very broad, with thousands of tonnes of fresh municipal solid waste being deposited at already overburdened landfill sites such as Ghazipur and Bhalswa on the daily basis.

One of the most important shifts under the 2026 Rules is an expansion of applicability that goes well beyond what was contemplated in 2016. Whereas the earlier framework was mainly directed at urban local bodies and notified areas, the revised rules bring both urban and rural local bodies within their range, along with all the categories of waste generators including domestic households, commercial establishments, institutions, railways, airports, defence establishments, and special economic zones (Ministry of Environment, Forest and Climate Change, 2026). This broadening of scope shows a growing recognition that solid waste does not respect administrative boundaries and that a piecemeal, urban-centric approach is not enough sufficient for a country with India's demographic diversity.

If we talk about the waste segregation, the 2026 Rules introduce a four-stream classification that replaces the three-category system established under the 2016 framework. Under the earlier rules, waste generators were required to separate biodegradable, non-biodegradable and domestic hazardous waste. The new rules made it mandatory segregation into wet waste, dry waste, sanitary waste and special-care waste, a proper and needed categorization that acknowledges the health and environmental risks which are being associated with sanitary and household hazardous materials, which were rarely operationalised in practice under the previous regime (Ministry of Environment, Forest and Climate Change, 2026). This shift is widely referred to as the "four-bin revolution," and its success will depend in large measure on sustained public awareness campaigns and the capacity of local bodies to enforce compliance at the household and institutional level. The 2026 Rules also formally articulate a waste hierarchy that places prevention and minimization at the top, followed by reduction, reuse, recycling, and recovery, with disposal at a landfill treated as a last resort. This hierarchy was visibly not present from the 2016 framework (Ministry of Environment, Forest and Climate Change, 2026).

Perhaps the most appreciable feature of the 2026 Rules is the introduction of a centralised online portal, operated by the Central Pollution Control Board (CPCB), which is intended to function as a single national data repository for waste management across the country. All obligated entities which include bulk waste generators, urban and rural local bodies, waste transporters, processors and waste pickers are required to register on this

platform, file returns and track waste flows from the point of generation through collection, processing, and final disposal (Ministry of Environment, Forest and Climate Change, 2026). This measure directly addresses one of the most apprearing criticisms of the 2016 regime, namely its reliance on inconsistent manual reporting and the resulting issues in waste data. The digital layer, in principle, removes the scope for informal adjustments and creates a centralised accountability framework that raises the enforcement risk for non-compliant actors. Complementing this is a strengthened polluter-pays mechanism: Rule 21 of the 2026 framework introduces environmental compensation for violations such as operating without registration, submitting manipulated data, or failing to comply with waste management obligations. State Pollution Control Boards are empowered to impose compensation, conduct audits and enforce environmental standards, with collected funds held in escrow accounts and directed specially towards the activities for solid waste management (Ministry of Environment, Forest and Climate Change, 2026).

The treatment of waste and existing dumpsites under the new rules deserves particular attention. Rule 15 of the 2026 framework requires all existing dump sites to be geographically mapped and evaluated by October 2026, with local authorities made compulsory to undertake biomining and bioremediation in a time-bound manner. Fresh waste dumping at sites recently undergoing remediation is strictly not allowed, and all remediation activities are subject to quarterly progress reporting through the centralised portal and third-party environmental audits (Ministry of Environment, Forest and Climate Change, 2026). For a city like Delhi, where landfills at Okhla, Ghazipur, and Bhalswa have long exceeded their intended capacity and continue to pose serious environmental and public health hazards, this provision explains a significant departure from prior practice, where remediation timelines were rarely enforced. The rules also restrict the use of sanitary landfills to non-recyclable, non-biodegradable dry waste and processing residues; a prohibition that, if properly implemented, would appreciably reduce the volume of waste being landfilled (Ministry of Environment, Forest and Climate Change, 2026).

2.2 Recent Trends: A Decade of Change from 2016 to 2026

The ten years separating the Solid Waste Management Rules of 2016 from those of 2026 tell a story not simply of regulatory revision but of an evolving understanding of what solid waste governance must mean in a rapidly urbanising, middle-income country. When the 2016 Rules were notified, they were widely regarded as a progressive step; the first serious attempt to make laws for local bodies, prescribe segregation at source, mandate waste processing facilities, and set timelines for the remediation of existing dumpsites. Yet within a few years of implementation, the gap between regulatory ambition and ground-level reality became clearly noticeable. Segregation at the household level remained very inconsistent across most cities. User fees, though required under the rules, were politically sensitive and rarely collected with any regularity. Accountability for waste generators, beyond municipal bodies was largely ignored. And the monitoring of compliance believed on manual self-reporting by local bodies, a system that generated data which is not trustable.

The issues between the two regulatory frameworks, when examined closely then it reveals a clear directional shift in governance philosophy. The 2016 Rules were essentially a service-delivery framework; they placed all the primary burden on urban local bodies and conceived of waste management as a municipal responsibility to be discharged on behalf of residents. The 2026 Rules rectified accordingly, solid waste management as a shared legal responsibility in which all generators, households, bulk generators, institutions and commercial establishments bear enforceable obligations (Ministry of Environment, Forest and Climate Change, 2026). Under the 2016 framework, a residential society or a university campus could, in practice, hand over unsegregated waste to the municipal collection vehicle and bear no further consequences. Under the 2026 Rules, bulk waste generators must register on a national portal, process wet waste on-site, and obtain Extended Bulk Waste Generator Responsibility certificates; a shift that brings them within the same accountability regime as producers of plastic and electronic waste under Extended Producer Responsibility provisions (Ministry of Environment, Forest and Climate Change, 2026).

The pathway of waste generation over this decade explains why the regulatory upgrade was overdue. India's total waste generation, already substantial when the 2016 Rules were framed, has continued to grow in step with urbanisation and rising consumption. Projections suggest that total waste generation will reach 165 million tonnes annually by 2030 and may rise to 436 million tonnes by 2050 (Ministry of Environment, Forest and Climate Change, 2026). Against this backdrop, the persistence

of open dumping and the underperformance of processing infrastructure is not merely an administrative failure but an environmental crisis. Only 60 to 70 per cent of generated waste was being collected nationally, and merely 15 to 20 per cent was being processed through any form of scientific treatment, with the remainder going directly to open dumps and landfills. The situation in Delhi expresses the essential feature of this crisis in a strong manner: by 2024–25, the city was generating nearly 11,852 tonnes of municipal solid waste per day, of which just 64 per cent was being actively processed, with approximately 4,241 tonnes per day being deposited at Bhalswa and Ghazipur landfill sites (CPCB, 2025). Another major area of change deals with the role of technology in waste governance. The 2016 Rules made no provision for any centralised digital monitoring system which results in leaving compliance tracking entirely to the discretion of individual state governments and local bodies, with knowingly uneven results. The 2026 Rules, by contrast, place digital governance at the centre of the regulatory architecture. The centralised online portal operated by CPCB is not merely a data repository; it is the primary accountability mechanism through which waste flows will be registered, monitored, and audited going forward (Ministry of Environment, Forest and Climate Change, 2026). This shift from a paper-based, locally managed compliance framework to a nationally integrated digital system represents perhaps the single most transformative change between the two regulatory regimes. Whether this shift translates into genuine improvement in waste management outcomes will depend on factors that go beyond the text of the rules which includes the capacity of local bodies to use the portal effectively, the integrity of the data that is submitted, and the readiness of State Pollution Control Boards to exercise their elevated enforcement powers.

What the pathway from 2016 to 2026 ultimately reveals is that India's waste management challenge is as much about implementation as it is about regulation. The 2016 Rules were not poorly designed; they were poorly enforced. The 2026 Rules attempt to correct for this by expanding the range of accountable actors, introducing financial disincentives for non-compliance and creating a digital infrastructure for monitoring. The introduction of rural local bodies, the formalisation of the role of waste pickers through compulsory registration with urban local bodies, and the creation of state-level implementation committees are all steps that reflect lessons learned from a decade of uneven progress (Ministry of Environment, Forest and Climate Change, 2026). For cities like Delhi, which sit at the intersection of extreme population pressure, not good enough processing infrastructure, and historically poor compliance with waste management rules, the 2026 framework offers both a blueprint and a challenge. The blueprint is more consistent than what existed before; the challenge of translating it into practice remains, as it always has, the harder task.

3. URBANIZATION AND SOLID WASTE GENERATION IN DELHI

Population increase, rural decline, and the transfer from still, low-paying agriculture to higher-paying urban jobs drive urbanization. One in three people reside in an urban area, and it is anticipated that 50% of India's population will live in cities within 10 years (Khurshid and Sethuraman, 2011). This fact bears more examination. During the 64 years since Delhi gained its freedom, the city has maintained a high population while also making significant strides in a variety of socioeconomic areas (as seen in figure 1). This demonstrates how urbanization has been a significant contributor to Delhi's ever-increasing population growth. Nevertheless, the Management of Municipal Solid waste (MSW) pursues to be one of the most ignored sectors of urban development in Delhi. This is despite the fact that civic organizations have spent a significant amount of money on the subject. The urban lifestyle has made it so that it is now commonplace to see waste of every kind strewn about, including heaps of garbage. Most Delhi metropolitan local authorities face a major solid waste problem that demands wartime control. The lack of a comprehensive waste management mechanism shows that Delhi's municipal authorities are struggling to deliver one of their most basic and essential services, solid waste management.

In 2022, the metro area population of Delhi was recorded at approximately 32.07 million, rising from 31.18 million in 2021. This upward trend has continued in subsequent years: Delhi's population reached 32.94 million in 2023, further grew to 33.81 million in 2024, and is estimated at 34.67 million in 2025 — representing a consistent annual growth rate of approximately 2.5–2.7 per cent (Macrotrends, 2025). The population statistics are drawn from UN World Population Prospects data as compiled by Macrotrends and reported by the Ministry of Statistics and Programme Implementation. Figure 1 presents a comparative view of population growth alongside solid waste generation trends for Delhi from 2021 to 2025, illustrating how rapid

urbanization continues to drive increasing waste volumes. As Delhi's population surpassed 34 million by 2025, the pressure on municipal solid waste management infrastructure has intensified correspondingly, underscoring the urgent need for enhanced waste processing capacity in the national capital (Macrotrends, 2025).

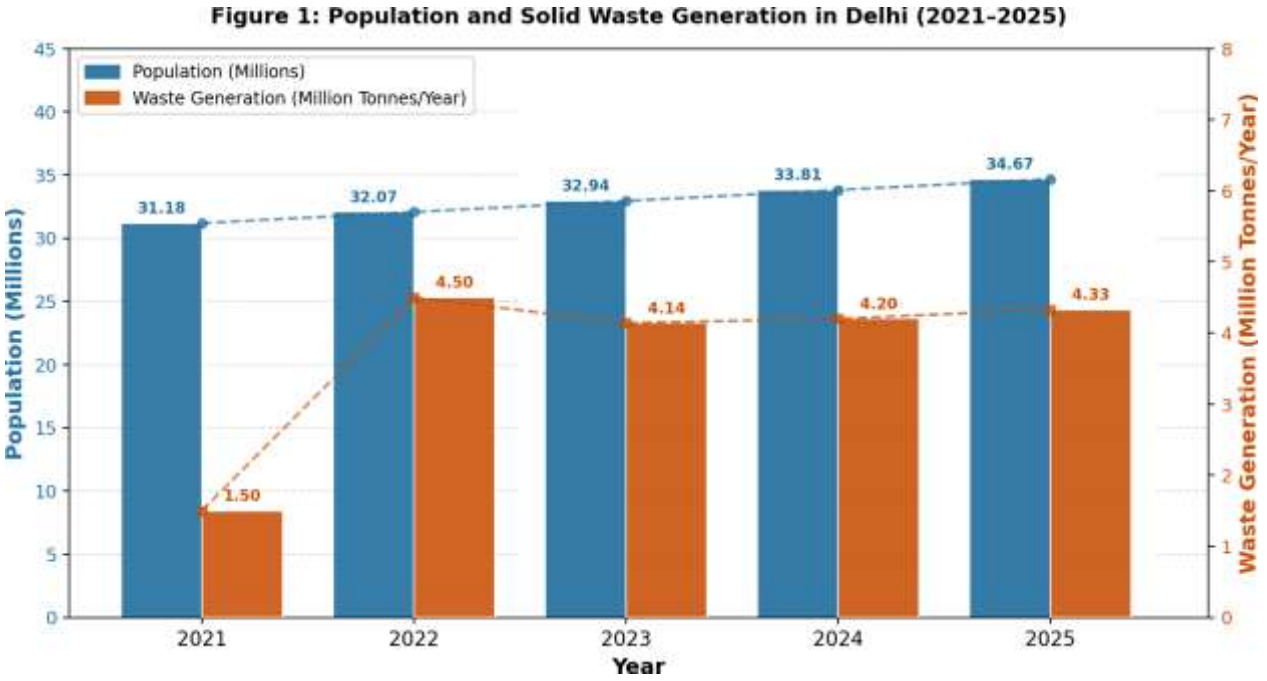


Figure 1: Population and Solid Waste Generation in Delhi (2021-2025)

In emerging nations, the effects of a swiftly growing population in urban areas are more readily apparent than in industrialized nations. India's urban population comprised 377 million individuals (Census, 2011a), or 31 percent of the country's overall population. The rate of urbanization accelerates when the country's urban population exceeds 25 percent of its overall population, as it has in the current situation (Kumar and Gaikwad, 2004). Global case histories have demonstrated that this is the case. Consequently, the percentage of the population living in urban areas elevated from 18.2% to 31.2% between 1961 and 2011 (Census, 2011b).

Rapid urbanization and unchecked population growth are the main reasons for worsening the municipal solid waste problem in Delhi. Table 1 displays, according to population size, the rate of garbage production per capita as well as its increase over a ten-year period.

Table 1: Population and Waste Generation in Delhi (2021–2025)

Population Size	Waste Generation
31,181,000 (2021)	~1.5 million tonnes/year
32,066,000 (2022)	~4.5 million tonnes/year
32,941,000 (2023)	~4.14 million tonnes/year
33,807,000 (2024)	~4.20 million tonnes/year
34,666,000 (2025)	~4.33 million tonnes/year

According to officials of the Municipal Corporation of Delhi (MCD) and reports from the media, around 1.5 million metric tons of waste had been processed and removed by the end of November 2022. Following this, an invitation to submit bids was extended to private contractors in order to treat the remaining approximately 4.5 million metric tons. However, in larger dumpsites such as Okhla, Bhalswa, and Ghazipur, the most significant problem with the utilization of trommels is the lack of available space. This is due to the fact that a large number of trommels are necessary to meet the daily waste sorting target. Additionally, as trommels are stationary devices, their utilization in larger dumpsites is restricted (Singh, n.d.).

The growth trajectory of Delhi's population has continued unabated beyond 2022. According to data compiled from the UN World Population Prospects (2024 Revision) by Macrotrends, Delhi's metro area population reached 32.94 million in 2023, further grew to 33.81 million in 2024, and is estimated at 34.67 million in 2025, representing a consistent annual growth rate of approximately 2.5–2.7 percent (Macrotrends, 2025). This sustained demographic expansion has intensified pressure on the city's already strained solid waste management

infrastructure. According to the Delhi Pollution Control Committee (DPCC) Annual Report for 2022–23, the combined daily municipal solid waste generation across the Municipal Corporation of Delhi (MCD), New Delhi Municipal Council (NDMC), and Delhi Cantonment Board stood at approximately 11,352 tonnes per day (TPD) in 2023, equivalent to roughly 4.14 million tonnes per year (DPCC, 2023). A central government affidavit filed before the Supreme Court of India in 2024 further confirmed that daily waste generation had risen to approximately 11,500 TPD, while only 8,073 TPD was being processed, leaving around 3,800 TPD as raw waste dumped at the Ghazipur and Bhalswa landfill sites (Ministry of Housing and Urban Affairs, 2024). By 2024–25, the CPCB, citing the DPCC Annual Report for 2024–25, informed the National Green Tribunal (NGT) that Delhi was generating 11,852 TPD of municipal solid waste, of which only 7,611 TPD (64.2%) was actively processed, and approximately 4,241 TPD (35.8%) was being disposed of at dumpsites (CPCB, 2025). To address this growing deficit, an augmentation of an additional 7,750 TPD of processing capacity has been planned for the period 2025–2028. These figures underscore the widening gap between waste generation and treatment capacity in Delhi, a direct consequence of its rapid urbanization and population growth.

According to a Planning Commission report (2014) (Planning Commission, 2014), 377 million people reside in cities and generate 62 million tons of MSW. These urban hubs may generate 436 million tons of garbage by 2050, up from 165 million tons in 2031. By the year 2031, there will be enough trash to fill 23.5 x 107 cubic meters of landfill space, or 1,175 hectares of land annually. Between 2031 and 2050, 43 thousand hectares of land will be necessary for landfills to reach a height of twenty meters. These projections are predicated on a per-person daily waste generation rate of 0.45 kg. There is a lack of main data on per capita waste generation in India; there are also insufficient statistics on the characteristics of garbage; and the influence of informal sectors contributes to the reality that estimates and projections for India from different sources vary. As a result, it is difficult to determine how much land will be required and to select appropriate treatment and disposal methods. According to the findings of a study performed by the National Environmental Engineering Research Institute (NEERI) in 59 cities (35 Metro cities and 24 State Capitals) in 2004–2005, these municipalities produced 39,031 TPD of municipal solid waste (MSW). In the same 2009–2010 study conducted by CIPET for CPCB, it was determined that the 59 cities in question generated a total of 50,592 TPD of refuse (CPCB, 2013). This discovery was realized during the course of the research endeavor. In 2011, approximately 1,27,486 TPD of municipal solid waste was produced nationwide. Only 89,334 TPD, or 70% of the total, were collected, and 15,881 TPD, or 12.45%, were processed or treated (CPCB, 2013). In the past decade, solid waste production has elevated by 2.44 times (CPCB, 2013).

4. CHALLENGES

The appropriate provision of solid waste management services to the general public necessitates that the government and other municipal entities give serious consideration to the pressing issue of solid waste management. Apathy on the favour of the general public and a low social status afforded to SWM activities by municipal bodies are significant obstacles to the successful resolution of this issue. In this regard, stringent legislation should be enacted so that trash can be properly disposed of and addressed. No new proposal for a residential or commercial area should be allowed unless there is a location suitable for the collection, transportation, and treatment of waste from that area. There is a compelling case for private sector involvement in this field in India, and the private sector could contribute its knowledge, technological capabilities, financial resources, and an enhanced and properly managed service. The public's involvement is of the utmost need and has the potential to yield significant results (Vij, 2012).

The Management and Conservation Division (MCD) has difficulty managing ordinary municipal solid waste (MSW) due to the lack of an action plan to implement source segregation in the city. In addition, there is a lack of infrastructure for waste treatment and recycling, with the exception of four waste-to-energy facilities, to manage the garbage. Despite the presence of a waste-to-energy plant adjacent to the site with a processing capacity of 2,000 TPD, a team from the Centre for Science and Environment in New Delhi discovered, during a site visit to the Okhla dumpsite that one side of the site continues to accept fresh garbage. This was the case despite the close proximity of a waste-to-energy facility. In addition, vehicles transporting fresh MSW created pools of leachate outside the site's perimeter wall. Continuous waste disposal contributes to an increase in the total volume, preventing MCD from completing the rehabilitation procedure (Singh, n.d.).

People must be known of environmental issues and

encouraged to participate in the sorting of waste at its source, door-to-door collection, and disposal in specially designated containers. It is impossible to overstate the significance of awareness in multi-stream waste management (MSWM) and how it can increase the efficacy of various waste management streams. It is the most crucial stage of multi-staged waste management system (MSWM), contributing to the effective management of solid refuse and ultimately leading to success. Because policymakers rely on limited information sources that are only accessible from a limited number of websites, they are not able to provide appreciable solutions for the numerous types of waste generated in a region (Joshi and Ahmed, 2016).

The regulations governing SWM must take into account existing conditions on the ground and provide sufficient time for the development of processes and mechanisms that are tailored to the particulars of the situation. Even though they are one of the most significant stakeholders in India's Solid Waste Management, the significance of rag-pickers in Solid Waste Management has not yet been sufficiently acknowledged. In order to foster their growth and boost their morale, it is essential to accommodate their roles within the appropriate system. This will achieve both of these objectives. Nonetheless, rag-pickers are employed by the unorganized sector; consequently, it is necessary to develop an appropriate organized sector for the reuse and recycling of refuse in order to increase employment and income while simultaneously reducing the pressure on transportation and landfills (Joshi and Ahmed, 2016).

The urbanization process is becoming a world-wide phenomenon, although its effects are most noticeable in developing nations. Rapid population growth, deteriorating prospects in rural areas, and the move from a still and low-paying agriculture sector to higher-paying urban employment are significant factors driving urbanization. The process by which pastoral areas become more urbanized is called urbanization. It has become increasingly difficult to provide sufficient infrastructure in urban areas, and as a result, the location of new landfills has become an important factor. Most landfills in urban areas have attained or even exceeded their maximum capacity. The lack of funding to address the issue is exacerbating the waste management crisis (Joshi and Ahmed, 2016).

In addition, the unanticipated migration has resulted in the proliferation of slums as well as the emergence of squatters and informal housing, which can be found in cities in the developing world that are rapidly expanding. Rapid population growth in a number of cities has rendered municipal governments incapable of providing even the most fundamental services to their residents. Unscientific waste management endangers health of public and contributes to the urban environment's deterioration. Urbanization is a direct contributor to refuse production, and this fact directly contributes to the problem. The administration of solid waste in India, which is already difficult because of the country's increasing urbanization, altered lifestyles, and rising levels of consumerism, is expected to become even more difficult in the coming years. Due to financial constraints, institutional failures, a poor choice of technology, and public indifference regarding municipal solid waste (MSW), this scenario has become much more difficult. Existing practices of dumping waste uncontrollably on the edges of cities and villages pose a significant threat to both the environment and the health of public (Vij, 2012).

By providing shelter to rodents and insects, both of which carry disease-causing organisms, a health risk is created. The prevalence of mosquitoes is a contributing factor to infectious fevers like dengue and malaria as well as other communicable diseases like typhoid and cholera. The illegal disposal of waste pollutes the air, soil, and water when it combines with these natural elements to produce leachate, causing environmental damage. The offensive odour emanating from street heaps is a source of annoyance. The problem at the LF site was caused by the simultaneous disposal of hazardous materials (Ranganathan, n.d.).

To address the practically exponential growth of municipal solid refuse, we require environmentally friendly processes. In order to accomplish this, PPP-facilitated technology solutions are required. However, urban and rural local governments (ULBs) encounter significant obstacles in developing municipal solid waste (MSW) infrastructure because of the lack of expertise and insufficient financial support. PPP must employ management and handling utilizing the most up-to-date technology and knowledge in collaboration with firms and organizations that are subject matter experts. For public-private partnerships (PPPs) to be successful, effective governance must be confirmed, which must be in compliance with a safe regulatory structure, have sufficient financial support, and adhere strictly to contracts. Real challenges include capacity building and the convenience of competent labor, experienced with new ideas and accessible appreciable practices for solid waste management, financial reasons for developing new technologically

possible solutions, and swift and appropriate decision-making at the level of ULBs to ensure seamless implementation (Joshi and Ahmed, 2016). In Delhi, municipal solid waste management (MSWM) processes are in some way improving. However, the full extent of structural inefficiencies also remains to be addressed. Now, more than 11,000 tonnes of waste is generated by the city each day, a staggering figure and continuing to rise on the side of population growth and urban expansion. But the real issue is in processing and disposal, although authorities have addressed the problem by developing better door-to-door waste collection systems (Raj et al., 2024).

Much of the collected waste remains in landfills because treatment facilities have not scaled up at the same rate as the generation of waste. This mismatch creates an unbroken gap between the generated waste and the scientific processing amount. Even where facilities exist, performance is often suboptimal as mixed waste is moved about, without segregation being in place. Another noteworthy observation is that MSWM systems in Delhi and adjacent Indian cities remain primarily linear. This means that waste gets picked up and disposed of, but never into reuse, recycling or conversion into electricity. Ideally modern waste systems should focus on resource recovery. However, a great portion of recyclable and energy-rich waste remains unutilized in practice. One of the main reasons for this is no segregation at source. Households frequently mix biodegradable with non-biodegradable waste, which hinders both recycling plants and waste-to-energy units. Despite awareness campaigns, behavior change is slow and inconsistent. In addition, the waste system remains predominantly dependent on landfills. At Delhi's largest landfill sites like: Ghazipur, Bhalswa and Okhla, the capacity has already been surpassed, yet fresh material continues to flow into them daily (Gupta et al., 2015).

These sites have turned into huge rubbish mountains, posing serious environmental risks. Although some measures have been taken to remediate and reduce landfill height, change is relatively slow. Waste-to-energy plants have been developed as a response, but their effectiveness remains up for debate because they do not have proper segregation of waste and emission controls. A different problem is the inconsistency of deployment of rules and technology. Some parts of Delhi have better waste recovery and disposal systems while others do not and are still using some old age practices. This results in disparate waste management efficiency throughout the city. Moreover, infrastructure and adoption of advanced technologies are often more limited by financial and administrative constraints. In general, from present days, we observed that both collection and policy frameworks have developed, but the very primary issues that needed addressing: segregation, processing, and sustainable disposal, remain to be considered (Mondal et al., 2025).

5. ENVIRONMENTAL AND HEALTH IMPACTS

There are serious environmental and health impacts from ineffective municipal solid-waste management in Delhi. Air pollution due to the open dumping or burning of waste is one of the very visible consequences. Methane gas, a very powerful greenhouse gas, is emitted from landfills, which plays an important role in climate change. Fires break out in landfill sites due to methane accumulation, releasing highly toxic fumes that endure in the atmosphere (Kafle, 2025). These emissions harm not only the earth's air quality but cause serious respiratory problems for people nearby to put up with them:

- Groundwater contamination has been reported around landfill sites impacting drinking water sources and agricultural productivity.
- The lasting environmental damage from such pollutions is virtually non-recoverable and generally goes unrecognized until it’s too late.
- The buildup of waste is a boon for the species that cause diseases, like mosquitoes, flies and rodents. It contributes to the rise in communicable diseases including dengue, malaria, cholera, and typhoid.
- The health risks are even greater in dense urban areas with no proper regular collection of the waste. Those who live close to dumping sites are especially vulnerable to direct and indirect health threats. And we do think the effects are not limited to physical health effects, but also psychological and social.

Living in regions with waste can have impact on the quality of life, as it can induce stress, discomfort, and decrease overall well-being. A filthy smell, visual pollution and unsanitary conditions make this a bad urban world. Moreover, environmental degradation due to improper waste disposal influences biodiversity. Animals ingest plastic waste and end up in pain, or dead. The accumulation of non-biodegradable substances likewise affects the soil quality. Untreated waste dumped into water bodies in and around Delhi has seriously polluted waterways, leading to even more pollution and

environmental degradation. There is no denying that the environmental and public health consequences of inadequate MSWM are interrelated and far ranging. Solving this problem demands better treatment methods of waste and more attention from the general public and harsher regulatory enforcement of environmental regulations (Wilson et al., 2006).

6. CIRCULAR ECONOMY IN MSWM

The circular economy model is a solution to the burgeoning "city waste crisis" like the one described in Delhi. Contrary to that linear approach – collect–use–dispose – in the "circular economy", waste generation is less and materials are reused, and resources are recycled. This method intends to reduce ecological footprint and maximize resource efficiency through minimum consumption. The application of a circular economy in MSWM is also regarding that waste should not be seen as an issue but as a valuable resource. Thus, waste materials based on chemistry can be processed to compost or energy for organic waste. Recyclable materials, such as plastics, metals, paper can be used and recycled which minimizes the requirement for raw material extraction. This also saves natural resources and reduces the pollution of environment. Delhi's pathway to a circular economy faces several challenges. However, the only major challenge is the absence of adequate segregation from source to target. Biodegradable and recyclable waste cannot be efficiently separated from each other to process waste or not (Delhi Pollution Control Committee, 2024). While public participation is important for this, awareness is still low. So many households are mixing waste together which makes it very difficult for recycling systems to work. The absence of infrastructure and investment in recycling and processing facilities is a further challenge. Not only do they not do enough with the enormous quantity of waste created in the city but many initiatives have been undertaken. Community composting and local recycling units are examples of decentralized waste management systems that can alleviate some of the concerns about this concern but require the support of infrastructure through proper implementation (Council on Energy, Environment and Water, 2025). There is also plenty of economic gain to be had from the circular economy. It generates jobs in recycling related sectors and lowers our waste management bill. Rag pickers in informal industries can be absorbed in formal systems as well to enhance productivity and living standards. But it needs policies and coordination of institutions. At the end of the day, we can see the circular economy as a sustainable, long-term solution to issues with waste management in the industry. Though Delhi is starting toward that end, it is much more than that to make full use of the potential. Policy reforms, new technology, and public participation must be in place for its successful implementation (Municipal Corporation of Delhi, 2025).

7. TECH-SAVVY INTERVENTIONS AND WASTE MANAGEMENT

New technologies are playing an increasingly crucial role in improving municipal solid waste management (MSWM) systems and the technology needs are increasing in all major cities in the world, including Delhi. There have been various technologies over the years that have been introduced with the motivation to reduce or eliminate landfill dependence and increase waste resource usage. Of all these, waste-to-energy (WTE) plants are frequently cited as the answer for disposal. And the plants turn waste into power or heat for city, reducing amount of waste that gets tossed into landfills (Ministry of Housing and Urban Affairs, 2024).

But in Delhi's case, their efficiency has often met criticism. One of the key reasons for this is the fact that these plants will frequently receive mixed amounts of waste. As waste is not well separated at the source, it has a significant portion of moisture and non-combustible materials, which make the resulting material with a low calorific value. Consequently, WTE plants do not function at full throttle and even experience operational issues. Composting and biomethanation are perceived as eco-friendly alternatives, in contrast to the above, and are primarily used to handle and manage organic waste, being a large part of municipal waste in India (Raj et al., 2024).

Composting can also convert biodegradable waste into nutrient-dense manure for crops that might be applied to agriculture or to garden cultivation. On the other hand, biomethanation generates biogas that can be used as a renewable energy source. This not only lessens landfills burden but also helps recover resources. However, again the success of these recycling programs are highly reliant to some extent on good segregation of organic waste, a problem that remains one of its major challenges. In the majority of cases, when plastics and other materials are mixed with organic waste, compost quality is degraded and its functionality is also reduced. As well as conventional methods, smart waste management systems are being considered as promising solutions. These can involve the incorporation of digital

technologies (sensors, GPS tracking for example) and data analytics for the better and cheaper management and detection of waste collection and control system (Mondal et al., 2025).

Smart bins with sensors, for example, can signal when it's full, offering more efficient collection routes. Waste transport can be monitored and fuel consumption can be minimized with GPS-enabled vehicles. This kind of innovation can drastically increase the operational efficiency of these MSWM operations. There are obstacles to the deployment of such technologies, however. High investments in initial costs, inadequate technical know-how, and limited institutional capacities do not make them available to as many as they could. There is a frequent financial or administrative challenges to municipal institutions' capacity to support and operate sophisticated systems. Proper personnel training is also required to utilise such techniques effectively. The implementation and adoption of technological interventions on better waste management are promising but they should not happen without a good integration with existing systems, public input and good policy support. Technology will not solve the waste management problem without tackling fundamental problems of segregation and governance (Gupta et al., 2015).

8. GOVERNANCE AND INSTITUTIONAL CONSTRAINTS

Governance and institutional problems are still the biggest obstacles in effective municipal solid waste management in Delhi. The system is multi-level; municipal corporations, pollution control authorities and central government bodies are involved too. This multisectoral working is meant to facilitate a thorough management, but in application fragmentation of duties has frequently resulted in disjointed departments being the most common consequences (Government of NCT of Delhi, 2025).

Different agencies sometimes share responsibility for a particular activity and, at times, can be unclear who is doing what in each of these departments. Such ambiguity can in turn cause decision fatigue and diminished effectiveness. The second key problem is the limited enforcement of existing regulations. Policies and rules on handling the refuse are created, but its implementation is often erratic. Not all mechanisms put in place are strong enough to supervise compliance, and violations often run rampant. Rules for waste segregation at source are not strictly complied with, meaning mixed waste is collected and transported. All this reduces the efficiency of downstream processing systems (Central Pollution Control Board, 2024).

Financial limitations also have an important impact on the performance of MSWM systems. Local government is subject to minimal budgets, which limits their ability to improve infrastructure, technology and staff. Old infrastructure maintenance is also a problem which, due to less funds provided on an on-time basis, complicates the task. Outdated assets are in some cases still being utilised as there are not enough resources to upgrade them. Public-private partnerships (PPPs) have been implemented in an attempt to overcome these limitations. Through participation of the private sector, efficiency, innovation and investment will likely increase. PPPs have contributed to improvements in waste collection and processing services in some contexts. Yet they are not to be counted as a success. Challenges include lack of transparency, payment delays, and weak compliance with the law. Without monitoring and accountability mechanisms in place for PPP projects, outcomes cannot be delivered as anticipated. Institution need for Capacity Building and another important factor. Strengthening governance requires staff training initiatives, improved management practices and improved communication between agencies (Delhi Pollution Control Committee, 2024).

Without such enhancements, even policy that would seem well-designed will not yield the desired effect. Finally, governance problems are intrinsically linked with other problems in MSWM.

There is a great need for urban/informal sector, which also has a much bigger and less recognised role to play in municipal solid waste management in Delhi. Rag pickers (receiving, organizing, selling and recycling) are key contributors to recycling and resource recovery in local cities such as Delhi, and they gather, sort and sell recyclable materials like plastics, paper and metal. They contribute to reducing the amount of waste that goes to landfills and assisting the recycling industry. As it turns out, the strain on the municipal waste management systems would be way more severe without them (Municipal Corporation of Delhi, 2025).

For all their contributions, there are no easy situations for informal workers to work either. Most of the time, they do not have good protection for the body, low incomes, or coverage of social protection. There is always an environment of health hazards in the work of them, such as injury and infections. Furthermore, they are not formally identified as a member of the national waste management system providing barriers to their development and support. By introducing informal economy into the system of

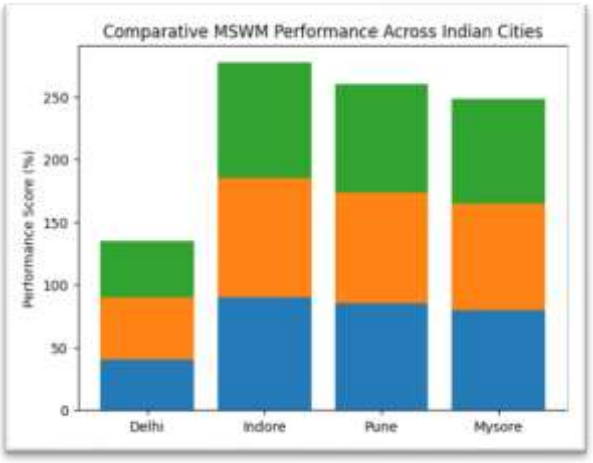
formal waste management, there are potential reasons. It's good for efficiency in recycling of this kind, employment potential, efficiency and effectiveness of the overall efficiency of MSWM (Ministry of Housing and Urban Affairs, 2024).

This formal recognition may mean further working conditions and social protection access benefits for these workers. Achieving that necessitates policy and bureaucratic intervention or assistance, coordination and co-operation of government agencies and non-governmental organisations, among others. The wider social aspects of waste governance are not limited to the casualisation of waste management. Public involvement plays a critical role on the success of MSWM. Household behaviors, including waste segregation, are key. If waste is not properly separated from the source, it is hard to both deal with and recycle it. But behavior change isn't simple. It will need ongoing awareness campaigns, education and incentives. Management also reflects cultural attitudes regarding waste. Waste too often becomes something we just discard, without responsibility, as opposed to a resource we reclaim, collect and recycle. This mindset must be changed in establishing a sustainable waste management system. Addressing social dimensions and the socialization of the informal sector together are imperative for enhancing MSWM in Delhi. Not accounting for these things, technical and institutional responses do not suffice.

9. COMPARATIVE INSIGHTS AND BEST PRACTICES

It is useful to compare it with other Indian cities in order to gain insight of how to develop municipal solid waste management of Delhi. Cities like Indore, Pune and Mysore have delivered stronger outcomes in terms of cleanliness, segregation of waste and processing efficiencies. Good governance and public involvement in public goods have helped these cities have maintained good ranks nationwide as cleanliness hubs. Their success can be attributed to the heavy emphasis on segregation of waste at its source. Households must separately separate biodegradable from non-biodegradable waste and there is a fine for non-compliance. That helps waste that comes before processing facilities get sorted, saving energy and reducing contamination (Kaza et al., 2018).

Delhi remains, on the other hand, lacking in effective application of segregation. Community involvement is another crucial aspect. Successful cities have spent on awareness campaigns and citizen participation programs. Responsible for their waste management, residents are encouraged to do so, and communities often take an active role in managing it. This level of interaction is yet to be discovered in Delhi, and the level of participation can range widely between groups. Integrated informal sector is also an important practice in cities such as Pune, where waste pickers are officially acknowledged and have been grouped into cooperatives. This improved recycling and labour (Kapoor and Chakma, 2024).



Source: Adapted from Central Pollution Control Board (2024), Municipal Corporation of Delhi (2025), Ministry of Housing and Urban Affairs (2024)

These are models that can be replicated in Delhi to realize similar dividends. Successful cities have also made strides in technological adoption. Performance as a whole has been boosted by efficient waste collection systems, improved infrastructure and the use of digital tools. Yet technology alone does not determine, it must be backed with good governance and active involvement of local communities. The lesson learnt from other cities is that sound practices, public involvement, and control systems are crucial to good waste management (Municipal Corporation of Delhi, 2025).

10. CONCLUSION

This review on municipal solid waste management (MSWM) in Delhi has provided an in-depth analysis comparing MSWM in Delhi with other instances in Indian context. It's evident in the commentary that municipal waste management is not the basic civic service it used to be, but also became a vast complex environmental, social and economic issue. With rapid urbanization, population increase and shifts in consumption behavior, the ever-growing waste burden makes it hard today. Existing systems are failing to catch up with the growth, making matters

even worse. At the end of all this review, one of the most important points that emerged was that waste should be viewed more as a resource than an unwanted by-product of society. When people started to see garbage as a resource, it had clear opportunities to recycle, reuse, and recover energy. In fact, a formal recycling sector or industry is especially recommended. Not only would such a system allow for the recovery of valuable materials from waste, it would alleviate the strain on landfills as well. Currently, a significant portion of recyclable waste is either lost or handled inefficiently due to the lack of proper infrastructure and organization.

Thereby improved material recovery rates through improved recycling facilities can be a big step towards a more circular economy. A second aspect emphasized in this review is the informal sector, especially rag-pickers, in particular. The informal sector is already an invaluable part of both waste collection and recycling but this aspect is often undervalued and unrecognized. Incorporating them into the formal waste management system brings various potential advantages. It can help to enhance their work-load by helping to make waste separation and recycling systems more efficient and can also create job security and better work environment of skilled labour. But such integration does not come easily and needs policy support from an institutional framework that can both coordinate the actions, institutional coordination, and social acceptance. Public awareness and involvement are also key to advancing MSWM. Citizens need clear, and accurate, information on how the waste is organized at the point of collection and when it's disposed.

There can be no proper waste processing technology, no matter how advanced the technology, without segregation at source. Behavioural change at the household level is therefore very beneficial but takes time and consistent effort. We cannot overlook the importance of educating people in this context, which makes it easier for individuals to use waste management practices with effective incentives and strong regulations. The government must push on educational institutions, for example, colleges and universities including technical institutions to include an important aspect of the waste management as part of their curricula.

This will equip students with a sound foundation on environmental issues and in addition, allow them to contribute to the development of sustainable approaches in the future. Educational institutions also can direct waste characterisation studies in their local environment with their involvement in them. Such a method can produce useful data that informs the development of region-specific waste management systems. As the composition of waste will vary greatly by region such localized studies are highly useful for designing proper treatments and disposal methods.

The management of landfills is another important issue addressed in this review. Currently, most of the landfill facilities in Delhi are in poor condition and leachate and gas are mismanaged. It's more complicated by the blending of biodegradable waste with other materials in transit. In contrast, industrial countries are implementing new techniques - leachate recirculation and controlled landfilling that optimize the waste stabilization and gas recovery. Similar practices used in India could result in much better landfill management and a significant reduction in environmental impacts. But it would take infrastructure investment, technical know-how and the aggressive enforcement of regulations.

According to the review, waste generation and quality of life are strongly correlated with one another as well. The amount and the content of waste also change as income levels and consumption patterns begin to change. Packaging and plastic waste are generally from higher to lower income groups while low-income groups produce the most biodegradable waste. This diversity means we need more flexible and adaptable approaches to waste management than a one size fits all approach. The future of MSWM in Delhi is based on having integrated, sustainable solutions. Of these all, there is no denying that the circular economy, where waste is minimised and resources are constantly reused, is one of the most compelling and hopeful strategies. Not only does this technique mitigate damage to the environment, but it also generates economic benefits. Waste-to-energy and composting technologies and recycling industries can result in the simultaneous generation of energy and new jobs.

But these remedies need to be underpinned by appropriate segregation, good governance and public involvement. The next large potential aspect is technological innovation. An intelligent waste management system, including sensor-based monitoring and data-driven decision-making and smart waste management systems, could improve its efficiency and even transparency. But the appropriate implementation of such technologies relies on financial investment and institutional capacity to success. However, without tackling governance issues, even the best technologies lose the capacity to produce the desired results. In terms of governance, there is a policy requirement for strong enforcement of existing regulations and inter-agency

coordination. Public-private partnerships can strengthen infrastructure and service delivery, but we need to be careful not to throw these partnerships for good before they have gotten out of hand.

At an institutional level, capacity building is equally as important as implementing policy to ensure effective policies are implemented. All in all, municipal solid waste management in Delhi is still a problem of monumental magnitude, yet it also opens a space of possibility for innovations and sustainable development. Treating waste as a resource, enhancing recycling, integrating informal workers, and publicizing the problem are all ways to make the whole system be a little bit better. Equally as technological and environmentally friendly processes can bring minimising to minimize environmental and sustainable practices contribute to reduce environmental harm and increase efficiencies. A comprehensive and multi-dimensional approach is required to tackle the problems of MSWM based on the results of this review. Technological and institutional is not just a part but also socio-behavioural solution. If planned out, well governed and with all parties engaged, there is a good way to establish the system we need for a smarter, green and fair waste management in Delhi in the future.

REFERENCES

BBAU (n.d.) Introducing Municipal Solid Waste Management. Lecture Notes, Course on Foundation of Environmental Science. Babasaheb Bhimrao Ambedkar University. Available at: https://www.bbau.ac.in/Docs/FoundationCourse/TM/lecture1.pdf

BHATTACHARYYA, J. K., KUMAR, S. AND DEVOTTA, S. (2008) Studies on acidification in two-phase biomethanation process of municipal solid waste. *Waste Management*, Vol. 28, No. 1, 164–169. https://doi.org/10.1016/j.wasman.2006.11.014

BHIDE, A. D. AND SUNDERSAN, B. B. (1983) *Solid Waste Management in Developing Countries*. Indian National Scientific Documentation Centre, New Delhi.

CEIC DATA (2022) Population: Delhi. CEICdata.com. Available at: https://www.ceicdata.com/en/india/population/population-delhi

CENSUS OF INDIA (2011a) *Provisional Population Totals*. Office of the Registrar General and Census Commissioner, India.

CENSUS OF INDIA (2011b) *Report of the Registrar General of India*. Office of the Registrar General and Census Commissioner, India.

CENTRAL POLLUTION CONTROL BOARD (CPCB) (2024) *Annual Report on Solid Waste Management in India*. Available at: https://cpcb.nic.in

COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW) (2025) *Sustainable Solid Waste Management Practices in Indian Cities*. Available at: https://www.ceew.in

CPCB (2013) *Status Report on Municipal Solid Waste Management*. Central Pollution Control Board, New Delhi. Available at: http://www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdf

CPCB (2025) *Status of Solid Waste Management in Delhi: Report to the National Green Tribunal*. Central Pollution Control Board. Based on DPCC Annual Report 2024–25. Reported in: ProKerala News, Delhi processes only 64 pc of daily waste, rest dumped at Bhalswa, Ghazipur landfills: CPCB tells NGT (January 1, 2026). Available at: https://www.prokerala.com/news/articles/a1713672.html

CPHEEO (n.d.a) *Manual on Municipal Solid Waste Management, Part 1*. Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India. Available at: https://cpheeo.gov.in/upload/uploadfiles/files/Part1(1).pdf

CPHEEO (n.d.b) *Manual on Municipal Solid Waste Management, Part 2*. Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India. Available at: https://mohua.gov.in/upload/uploadfiles/files/Part2.pdf

DAS, D., SRINIVASU, M. AND BANDYOPADHYAY, M. (1998) Solid state acidification of vegetable waste. *Indian Journal of Environmental Health*, Vol. 40, 333–342.

DELHI POLLUTION CONTROL COMMITTEE (DPCC) (2024) *Action Plan for Municipal Solid Waste Management in Delhi*. Available at: https://dpcc.delhigovt.nic.in

DIAZ, L. F., GEORGE, M. AND EGGERTH, L. L. (1997) Managing solid wastes in developing countries. *Waste Management*, 43–45.

DPCC (2023) *Annual Report on Solid Waste Management 2022–23*. Delhi Pollution Control Committee, Government of NCT of Delhi.

GOVERNMENT OF NCT OF DELHI (2025) *Delhi Economic Survey 2024–25*. Directorate of Economics and Statistics, New Delhi. Available at: https://des.delhi.gov.in

GUPTA, N., YADAV, K. K. AND KUMAR, V. (2015) A review on current status of municipal solid waste management in India. *Journal of Environmental Sciences*, Vol. 37, 206–217.

GUPTA, S., MOHAN, K., PRASAD, R., GUPTA, S. AND KANSAL, A. (1998) Solid waste management in India: options and opportunities. *Resources, Conservation and Recycling*, Vol. 24, No. 2, 137–154. https://doi.org/10.1016/s0921-3449(98)00033-0

GUPTA, S. K. (2001a) *Rethinking Waste Management in India*. Humanscape, New Delhi.

IDRIS, A., INANC, B. AND HASSAN, M. N. (2004) Overview of waste disposal and landfills/dumps in Asian countries. *Journal of Material Cycles and Waste Management*, Vol. 6, No. 2. https://doi.org/10.1007/s10163-004-0117-y

JOSHI, R. AND AHMED, S. (2016) Status and challenges of municipal solid waste management in India: A review. *Cogent Environmental Science*, Vol. 2, No. 1, 1139434. https://doi.org/10.1080/23311843.2016.1139434

JOSEPH, K. (2002) Perspectives of solid waste management in India. *Proceedings of the International Symposium on the Technology and Management of the Treatment and Reuse of Municipal Solid Waste*, Chennai, India.

KAFLE, S. (2025) A review of global municipal solid waste management trends and practices. *Recycling*, Vol. 10, No. 3. Available at: https://www.mdpi.com/2313-4321/10/3/113

KAPOOR, A. AND CHAKMA, N. (2024) *Challenges of Solid Waste Management in Urban India*. Economic Advisory Council to the Prime Minister, New Delhi. Available at: https://eacpm.gov.in

KAZA, S., YAO, L., BHADA-TATA, P. AND VAN WOERDEN, F. (2018) *What a Waste 2.0: A Global Snapshot of Solid Waste Management*. World Bank, Washington, DC. Available at: https://openknowledge.worldbank.org

KHURSHID, S. AND SETHURAMAN, S. (2011) *New India: All Roads Lead to City*. Hindustan Times, New Delhi.

KUMAR, S. AND GAIKWAD, S. A. (2004) Municipal solid waste management in Indian urban centres: An approach for betterment. In: GUPTA, K. R. (ed.) *Urban Development Debates in the New Millennium*. Atlantic Publishers & Distributors, New Delhi.

MACROTRENDS (2025) Delhi, India Metro Area Population 1950–2025. Based on UN World Population Prospects (2024 Revision). Available at: https://www.macrotrends.net/global-metrics/cities/21228/delhi/population

MANDAL, A. (2000) *Report on Management of Municipal Solid Wastes*. Central Pollution Control Board (CPCB), New Delhi, India.

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE (MoEFCC), GOVERNMENT OF INDIA (2026) *Solid Waste Management Rules, 2026*. Gazette of India (Extraordinary), Notification No. S.O. 388(E), notified on January 27, 2026; effective from April 1, 2026. Available at: https://static.pib.gov.in/WriteReadData/specificdocs/documents/2026/jan/doc2026129773501.pdf

MINISTRY OF HOUSING AND URBAN AFFAIRS (2024a) *Affidavit Submitted before the Supreme Court of India on Municipal Solid Waste Management in Delhi-NCR*. Government of India, New Delhi.

MINISTRY OF HOUSING AND URBAN AFFAIRS (2024b) *Swachh Bharat Mission (Urban): Guidelines and Progress Reports*. Government of India, New Delhi. Available at: https://mohua.gov.in

MONDAL, A., DUBEY, B. K. AND YADAV, V. (2025) Life cycle assessment of municipal solid waste management strategies. *Journal of Environmental Management*. Available at: https://www.sciencedirect.com

MUNICIPAL CORPORATION OF DELHI (MCD) (2025) *Swachhta Survekshan 2024–25 Report*. Available at: https://mcdonline.nic.in

PLANNING COMMISSION OF INDIA (2014) *Reports of the Task Force on Waste to Energy (Vol. I): In the Context of Integrated MSW Management*. Government of India, New Delhi. Available at: http://planningcommission.nic.in/reports/genrep/rep_wte1205.pdf

PRESS INFORMATION BUREAU (PIB), GOVERNMENT OF INDIA (2026) New Solid Waste Management Rules Notified; To Come into Force from April 1, 2026. Press Release No. PRID: 2219676. Ministry of Environment, Forest and Climate Change. Available at: https://pib.gov.in/PressReleasePage.aspx?PRID=2219676

RAJ, R. S., JAIN, S. AND SHARMA, A. K. (2024) Transforming municipal solid waste management through material and substance flow analysis: Conversion pathways for sustainable energy production. *Energy Conversion and Management*. https://doi.org/10.1016/j.enconman.2024.119164

RANGANATHAN, K. (n.d.) *Government Perspective on Municipal Solid Wastes Management*. Central Pollution Control

Board (CPCB), Bengaluru. Available at: https://cpcb.nic.in/zobengaluru/MSW_Perspectives%20.pdf

RICHARD, T. L. (1992) Municipal solid waste composting: Physical and biological processing. *Biomass & Bioenergy*, Vol. 3, No. 3–4, 163–180. https://doi.org/10.1016/0961-9534(92)90024-k

SHARHOLY, M., AHMAD, K., VAISHYA, R. C. AND GUPTA, R. D. (2007) Municipal solid waste characteristics and management in Allahabad, India. *Waste Management*, Vol. 27, No. 4, 490–496. https://doi.org/10.1016/j.wasman.2006.03.001

SINGH, R. (n.d.) Delhi plans to remediate Okhla landfill by end of 2023. How will it do this? *Down to Earth*. Available at: https://www.downtoearth.org.in/blog/waste/delhi-plans-to-remediate-okhla-landfill-by-end-of-2023-how-will-it-do-this--89164

SINGHAL, S. AND PANDEY, S. (2001) Solid waste management in India: Status and future directions. *TERI Information Monitor on Environmental Science*, Vol. 6, 1–4.

TALYAN, V., DAHIYA, R. P. AND SREEKRISHNAN, T. R. (2008) State of municipal solid waste management in Delhi, the capital of India. *Waste Management*, Vol. 28, No. 7, 1276–1287.

VIJ, D. (2012) Urbanization and solid waste management in India: Present practices and future challenges. *Procedia – Social and Behavioral Sciences*, Vol. 37, 437–447. https://doi.org/10.1016/j.sbspro.2012.03.309

WILSON, D. C., VELIS, C. AND CHEESEMAN, C. (2006) Role of informal sector recycling in waste management in developing countries. *Habitat International*, Vol. 30, No. 4, 797–808.