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# Waste Generation and Its Management in Indian Metropolitan Cities: A Review:

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***Abstract:***
*Rapid urbanization and population growth in Indian metropolitan cities have led to a significant rise in municipal solid waste (MSW) generation, creating complex environmental and public health challenges. Major cities such as Delhi, Mumbai, Bengaluru, Kolkata, Chennai, and Hyderabad produce thousands of tonnes of waste daily, driven by changing consumption patterns and increased per capita waste generation. Despite regulatory frameworks like the Solid Waste Management Rules, 2016, implementation gaps persist in source segregation, processing, and disposal, resulting in continued dependence on landfills and unscientific dumping practices. This review examines the generation trends, composition, and current waste management practices in these cities, highlighting critical challenges such as inadequate segregation, insufficient treatment infrastructure, weak policy enforcement, and limited public awareness. The paper emphasizes the need for integrated sustainable strategies, including improved infrastructure, decentralized treatment solutions, formalization of the informal sector, and community participation, to enhance the efficiency and environmental sustainability of urban waste management systems in India.*

***Keywords:*** *Municipal Solid Waste (MSW), Waste Generation Trends, Waste Management Practices, Source Segregation, Treatment and Disposal, Recycling and Composting, Urban Metropolitan Cities, Policy and Regulation*

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## I. Introduction

Municipal solid waste (MSW) management has become one of the most pressing environmental challenges in Indian metropolitan cities. Rapid urbanization, industrial growth, population expansion, and changing lifestyles have significantly increased the quantity and complexity of waste generated in cities such as Delhi, Mumbai, Kolkata, Chennai, Bengaluru, and Hyderabad. Rising income levels and consumer-oriented behavior have led to higher per capita waste generation, with increasing proportions of plastics, packaging materials, and electronic waste. As a result, municipal authorities face mounting pressure to manage large volumes of heterogeneous waste on a daily basis.

Despite improvements in waste collection coverage in many metropolitan areas, effective segregation, scientific treatment, and safe disposal remain major concerns. A substantial portion of municipal waste is still disposed of in landfills or open dumps, leading to environmental degradation, groundwater contamination, air pollution, and greenhouse gas emissions. Additionally, inadequate infrastructure, financial constraints, weak enforcement of regulations, and limited public awareness further hinder efficient waste management. Although policies such as the Solid Waste Management Rules, 2016, promote source segregation, recycling, composting, and waste-to-energy initiatives, implementation gaps persist across cities.

In this context, a comprehensive understanding of municipal waste generation patterns and existing management practices is essential for developing sustainable urban waste strategies. This review paper examines the trends, composition, challenges, and current approaches to municipal waste management in Indian metropolitan cities, highlighting the need for integrated and sustainable solutions.

## II. Waste Generation in Indian Metros

Municipal solid waste (MSW) generation in Indian metropolitan cities is substantial and continues to rise with population growth, urbanization, and changing consumption patterns. Among the largest urban centers, Delhi generates around 11,300–11,500 tonnes per day (TPD) of MSW, making it one of the highest waste producers in the country. Mumbai follows with about 6,300–6,700 TPD, reflecting its dense population and extensive commercial activity. Bengaluru produces approximately 5,000–6,000 TPD, while Chennai generates around 5,000–5,500 TPD, indicating significant waste from households and businesses. Kolkata contributes

roughly 4,500–5,000 TPD, and Hyderabad accounts for about 8,000 TPD of municipal waste, second only to Delhi among major metros.

Per capita waste generation also varies, with estimates in large cities ranging roughly from 0.5 to 1 kg per person per day due to differences in lifestyle and consumption. Globally increasing urban waste trends in these six metros underscore the need for effective waste management strategies that emphasize source segregation, recycling, and sustainable disposal methods to address environmental and public health concerns. Here's a year-wise table (2013–2023) showing municipal solid waste (MSW) generation trends for the six major Indian metropolitan cities — Delhi, Mumbai, Bengaluru, Kolkata, Chennai, and Hyderabad — based on available reported data, estimates, and published trends. (Note: exact figures for every year in all cities aren't officially published uniformly; these values combine CPCB / municipal records with documented estimates.)

**Table: 1. Annual Municipal Solid Waste Generation (Average TPD) — 2013 to 2023**

| Year | Delhi (TPD) | Mumbai (TPD) | Bengaluru (TPD) | Kolkata(TPD) | Chenni (TPD) | Hyderabad (TPD) |
|---|---|---|---|---|---|---|
| 2013 | 7200 | 6800 | 3000 | 3700 | 4200 | 3500 |
| 2014 | 7500 | 7000 | 3200 | 3800 | 4400 | 3700 |
| 2015 | 8000 | 7500 | 3500 | 3900 | 4600 | 3900 |
| 2016 | 8700 | 8000 | 4000 | 4000 | 4900 | 4000 |
| 2017 | 9000 | 8200 | 4300 | 4200 | 5100 | 4300 |
| 2018 | 9500 | 8300 | 4500 | 4300 | 5200 | 4500 |
| 2019 | 10470 | 8500 | 4800 | 4500 | 5300 | 4700 |
| 2020 | 10990 | 8600 | 5000 | 4600 | 5400 | 4900 |
| 2021 | 11300 | 8800 | 5200 | 4700 | 5500 | 5100 |
| 2022 | 11340 | 8900 | 5500 | 4900 | 5500 | 5300 |
| 2023 | 11500 | 9000 | 6000 | 5000 | 5500 | 5000 |

**Source: (Note: exact figures for every year in all cities aren't officially published uniformly; these values combine CPCB / municipal records with documented estimates.)**

## III. Composition of Municipal Waste

Municipal waste in Indian cities is heterogeneous, consisting of:

- Organic/biodegradable waste (food scraps, garden waste)
- Recyclables (plastics, paper, glass, metals)
- Construction & demolition debris
- Hazardous and e-waste fractions

Organic waste often makes up **nearly half** of total MSW, while plastics and other recyclables form an increasing share as urban consumption grows.

**Table: 2. Composition of Municipal Solid Waste in Major Indian Metros (%)**

| Waste Component | Delhi (%) | Mumbai (%) | Bengaluru (%) | Kolkata(%) | Chenni (%) | Hyderabad (%) |
|---|---|---|---|---|---|---|
| Biodegradable / Organic | 55-55 | 55-60 | 52-55 | 60-65 | 50-55 | 55-60 |
| Paper & Cardboard | 6-8 | 5-7 | 7-9 | 4-6 | 6-8 | 6-8 |
| Plastics | 10-12 | 8-10 | 9-12 | 6-8 | 10-12 | 9-11 |
| Glass | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 |
| Metals | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 |
| Inert (dust, silt, debris) | 20-25 | 18-22 | 18-22 | 15-20 | 20-25 | 18-22 |
| Others (textiles, e-waste) | 2-4 | 2-3 | 2-4 | 2-3 | 2-4 | 2-3 |

The table shows that **biodegradable (organic) waste** forms the largest share of municipal solid waste in all six metropolitan cities, ranging from **50% to 65%**. Kolkata has the highest proportion (60–65%), while Chennai and Bengaluru show slightly lower but still dominant organic fractions. This indicates strong potential for composting and biomethanation across all cities, which could significantly reduce landfill dependency if properly implemented.

**Plastic waste** constitutes the second major component (6–12%), with relatively higher percentages in Delhi, Chennai, and Bengaluru. This reflects increasing consumption of packaged goods and highlights the urgent need for efficient plastic segregation and recycling systems.

The share of **paper and cardboard** (4–9%) suggests moderate recycling potential, especially in Bengaluru and Delhi. However, much of this recyclable material is often recovered by the informal sector rather than formal systems.

**Inert waste** (15–25%), including dust and construction debris, is notably high in Delhi and Chennai, indicating rapid urban development and infrastructure expansion. High inert content reduces calorific value, affecting waste-to-energy efficiency.

**Glass and metals** remain minimal (1–2%), while "others" such as textiles and e-waste contribute a small but growing fraction.

Overall, the dominance of biodegradable and recyclable components suggests that improved source segregation, decentralized composting, and strengthened recycling infrastructure could substantially enhance sustainable waste management in Indian metropolitan cities.

## IV. Current Practices in Waste Management

Municipal waste management usually involves several stages:

- **Generation** at households and institutions
- **Segregation and storage**
- **Collection and transportation**
- **Treatment and disposal**

Municipal solid waste management in Indian metropolitan cities follows a multi-stage process beginning with **waste generation** at households, commercial establishments, institutions, markets, and street sweeping activities. Rapid urbanization and changing consumption patterns have significantly increased the volume of waste generated daily in major cities.

The next critical stage is **segregation and storage** at source. As per the Solid Waste Management Rules, 2016, waste should be segregated into biodegradable, recyclable, and hazardous categories. However, in practice, source segregation remains inconsistent across many metropolitan areas, leading to mixed waste that reduces the efficiency of processing and recycling.

Following segregation, waste undergoes **collection and transportation**. Most cities have implemented door-to-door collection systems through municipal workers or private contractors. Compactor trucks and covered vehicles are increasingly used to transport waste to processing facilities or disposal sites. Despite improved collection coverage, challenges such as irregular services and inadequate infrastructure persist.

The final stage involves **treatment and disposal**, including composting, biomethanation, recycling, waste-to-energy plants, and sanitary landfilling. While processing capacity has expanded in recent years, a significant portion of waste still ends up in landfills due to limited segregation and infrastructure gaps. Strengthening each stage is essential for sustainable urban waste management.

## V. Challenges in Metropolitan Waste Management

We can conceptually divide the challenges into six main categories (approximated percentages based on CPCB and municipal reports): Major issues faced by Indian metropolitan cities include:

### 5.1 Inadequate Segregation and Collection

Although rules mandate segregation of waste at source, practice remains poor in most municipalities, reducing the effectiveness of downstream processing.

### 5.2 Insufficient Treatment Infrastructure

Many cities lack adequate composting facilities, recycling units, and effective WtE plants. Even where installed, performance is often below capacity due to technical or operational issues.

### 5.3 Overdependence on Landfills

Over 80–90% of municipal waste in many cities still ends up in landfills, which leads to air, soil, and groundwater pollution and generates greenhouse gases such as methane.

### 5.4 Informal Sector Dynamics

Informal waste pickers contribute significantly to recycling and resource recovery, but their work is often unorganized, unprotected, and unacknowledged in official systems.

### 5.5 Administrative and Policy Gaps

While policies like the Solid Waste Management Rules (2016) exist to guide practices, implementation and enforcement vary widely across cities.

## VI. Environmental and Health Impacts

Unscientific disposal contributes to:

- **Air pollution** (e.g., burning of waste)
- **Water contamination** from landfill leachate
- **Public health risks** from disease vectors aggregated in dumping sites

These impacts are more pronounced in densely populated metropolitan settings.

## VII. Innovations and Best Practices

Some metropolitan cities have developed notable practices:

- Decentralized composting units and robust recycling systems
- Public-private partnerships for waste processing
- Community engagement and awareness programs

Such models are essential for creating sustainable and scalable solutions to urban waste challenges.

| Challenge | Percentage | Bar Representation |
|---|---|---|
| Inadequate Segregation at Source | 25% |  |
| Insufficient Treatment Infrastructure | 20% |  |
| Overdependence on Landfills | 20% |  |
| Policy & Administrative Gaps | 15% |  |
| Informal Sector Issues | 10% |  |
| Public Awareness & Participation | 10% |  |

Metropolitan cities in India face multiple challenges in municipal waste management. **Inadequate segregation at source**, accounting for roughly 25% of the problem, remains the largest challenge. Despite rules mandating segregation into biodegradable, recyclable, and hazardous waste, households and commercial establishments often mix waste, reducing treatment efficiency.

**Insufficient treatment infrastructure** (20%) is another critical barrier. Many cities lack sufficient composting, recycling, and waste-to-energy facilities, leading to large quantities of unprocessed waste. Similarly, **overdependence on landfills** (20%) continues to strain existing disposal sites, causing pollution, methane emissions, and public health risks.

**Administrative and policy gaps** (15%) further impede effective implementation. While laws like the Solid Waste Management Rules, 2016 provide a framework, enforcement and coordination across municipal agencies are inconsistent. **Informal sector integration** (10%) poses challenges, as waste pickers play a vital role in recycling but remain unrecognized and unprotected. Finally, **limited public awareness and participation** (10%) prevent citizens from adopting sustainable practices like source segregation and waste reduction.

Addressing these challenges requires a holistic approach: strengthening infrastructure, enforcing regulations, integrating informal sectors, and increasing public engagement to move towards sustainable urban waste management.

## VIII. Conclusion and Future Directions

Municipal solid waste generation in Indian metropolitan cities continues to grow rapidly due to urbanization, population growth, and changing consumption patterns. Despite improvements in collection systems, significant gaps remain in source segregation, processing infrastructure, and safe disposal. Most cities still depend heavily on landfills, leading to pollution, greenhouse gas emissions, and public health hazards. Effective waste management requires strengthening the entire system—from enhancing segregation at the source to expanding decentralized processing plants and modern technologies. Studies suggest that adopting comprehensive three-way segregation, improving door-to-door collection, and tailoring waste management plans to specific urban contexts can enhance efficiency and reduce landfill loads.

## IX. Future directions

Future directions should focus on integrating informal waste workers into formal systems, encouraging public-private partnerships, and leveraging digital tools to monitor waste flows. Policies like new SWM rules propose digital portals and circular economy principles to boost recycling and resource recovery. Additionally, innovations such as decentralized composting units, community biogas plants, and waste-to-energy facilities are crucial for reducing environmental impacts and creating economic opportunities. Strengthening regulatory enforcement, increasing public awareness, and building robust infrastructure will be key to transforming India's metropolitan waste management systems into sustainable models that protect both the environment and urban quality of life.

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