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Integrated Solid Waste Management Framework for Korba Municipal Corporation, Korba, Chhattisgarh, India

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***Abstract*— In Chhattisgarh, an industrial and fast growing urban local body, the study of Korba Nagar Nigam was undertaken to assess the effectiveness of municipal solid waste management system and to identify the major gaps in the waste value chain. This study employed a descriptive-analytical research method with minimal field observation used for validation based on the official secondary data of the State Urban Development Agency and the Urban Administration and Development Department. Data on population, waste collection and composition, processing infrastructure, vehicle deployment, and workforce distribution were compiled and analysed using a set of ratio-based performance indicators (collection efficiency, waste composition share, processing efficiency, capacity utilisation, fleet adequacy, and workforce-to-population ratios). Results revealed that Korba produces 115.00 TPD (tonnes per day) of municipal solid garbage with high collection efficiency of 99.13%, which means excellent door to door collection with expected population of 5,47,000 in November 2026. As per data, 218 numbers of bio-compost units with a capacity of 327.00 TPD are reported but actual compost output is 6.98 TPD resulting in a compost conversion rate of 11.99% and capacity utilisation of only 2.13%. The waste stream is almost balanced with 55.80 TPD Dry waste and 58.20 TPD Wet waste. But downstream processing is still lacking. The study also revealed that the city does not have an Integrated Solid Waste Management plant and has only one 0.5 TPD Organic Waste Converter. The fleet is largely collection-oriented (308 tricycles and e-rickshaws) and there are 620 core personnel and 622 SHG/agency workers with a wide supervisory span of control. Overall, the results indicate that Korba Nagar Nigam is good in collection, but there are serious limitations in processing capacity, infrastructure utilisation and workforce structure. This suggests the need for more robust decentralised processing systems, better oversight and improved integration of waste recovery operations.**

***Keywords*— Korba Nagar Nigam, Municipal Solid Waste, Sanitation Workforce, Solid Waste Management, Swachh Bharat Mission, Urban Local Body, Waste Composition**

I. INTRODUCTION

India is at a defining point in its urban development journey and the rapid pace of urbanization and industrialization poses a unique challenge in the management of the streams of municipal solid waste and liquid waste. The country produces 62 million tons of waste annually, of which only 43 million tons are collected, 12 million tons are processed and 31 million tons are dumped in landfills. The problem is compounded by the fact that urban municipal solid waste generation is projected to reach 165 million tons by 2030, fueled by changing consumption patterns and rapid economic growth (International Trade Administration, 2023). The population characteristics of Korba make the planning of waste management complicated. The urban population of the district is 36.99 percent of the total population. The district has a sex ratio of 971 females per 1000 males and a literacy rate of 73.22%. The city is highly socio-economically diverse, with more than 51.80 % of the urban population living in slum areas (Population Census, 2026). India's waste management system is under serious pressure as the pace of urbanization, population growth and changing consumption patterns is picking up rapidly, resulting in a spurt in municipal solid waste generation that is outstripping the capacity for its collection and treatment. In many places uncontrolled dumping is still a common practice. It poses a serious health and environmental risk due to uncontrolled burning, rotting and greenhouse gasses (Pujara et al. 2019). The system is still dependent on landfill and source segregation; recycling and scientific treatment is uneven across cities (Gupta et al. 2015. Research in Elsevier and ScienceDirect journals shows that integrated solid waste management including composting, anaerobic digestion, material recovery facilities, sanitary landfilling and selective waste-to-energy can reduce the demand for landfilling and its environmental impacts, when infrastructure and governance are improved (Sudhir et al., 1996). The waste management system in India is made more complex by large unofficial recycling networks, uneven municipal capability and stark disparities between urban, semi-urban and rural areas (Pujara et al. 2019). The country is also facing challenges from biomedical, plastic and e-waste streams that require specialized infrastructure for collection, segregation and treatment, which is not yet widely available (Dhole et al. 2024). Recent research has also highlighted the significance of decentralized treatment at source, public awareness campaigns, and regulatory enforcement to enhance recovery rates and reduce landfill load (Raj et al. 2024).

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Overall the waste management environment in India is moving toward more integrated and sustainable models but for success investment in infrastructure, stronger enforcement of regulations and greater involvement of households, municipalities and industry is required (Sudhir et al. 1996). The model's key elements are door-to-door collection with strict segregation of wet and dry waste at the household level, which reduces contamination and improves recovery efficiency. This simple, yet disciplined, system has helped Ambikapur reduce its dependence on open dumping and large landfill sites, a common problem in many Indian cities. The Ambikapur model is considered as one of the benchmarks of sustainable waste management in India, demonstrating how a city can move toward near-zero-waste status through decentralized planning, source segregation and citizen participation. Another key feature of the model is the network of women-led self-help groups which has led to positive social and environmental outcomes. The organization's engagement in collection, sorting, processing and management activities adds value to service provision and makes waste management a revenue-generating activity for local women. A city can look at garbage as a resource stream rather than a disposal problem by composting the wet waste, sending the dry recyclable waste to recyclers and recovering or selling the residual waste. This approach reduces the amount of waste going to disposal sites and supports the principles of a circular economy. The Ambikapur Model stands out also for its unique combination of community ownership and institutional support. It was successful because it was decentralized in waste processing, collected fees from users, ran awareness programs and was led by the municipality. The recognition as zero waste or dustbin free city is a testimony to the fact that efficient waste management is not about expensive technology but about effective governance, social engagement and continuous implementation. This has made Ambikapur a regular model for other Indian villages and cities looking for inclusive and sustainable solutions to garbage management (Dutta, Joystu 2021).

India's solid waste management system is primarily governed by the Solid Waste Management Rules, 2016 under the Environment (Protection) Act, 1986 and further strengthened by the Solid Waste Management Rules, 2026, effective from April 1, 2026. The rules focus on scientific processing and eco-friendly disposal and specify source segregation and the responsibilities of households, bulk waste generators and municipal organizations (Deepa 2023; The Solid Waste Management Rules 2016).

The Central Pollution Control Board (CPCB) and the State Pollution Control Boards monitor, authorize and enforce compliance, but policy at the national level is set by the Ministry of Environment, Forests and Climate Change (MoEFCC). The new framework has now brought in online tracking, reporting and environmental compensation to improve accountability and enforcement (New Solid Waste Management Rules, 2026). The institutional structure functions at different tiers of government: district administrations coordinate local action, the federal government formulates policy, state governments adapt and implement it and Urban Local Bodies (ULBs) are the main body responsible for implementing municipal waste management. Apart from awareness and infrastructure development, ULBs have to take care of collection, segregation, transportation, processing and disposal of municipal solid waste. In reality, it means that the towns have to ensure that not only garbage is collected but also handled correctly scientifically with the help of safe disposal procedures, processing facilities, and material recovery technologies (New Solid Waste Management Rules, 2026).

II. METHODOLOGY

2.1 Study Area- The study area is selected as Korba Nagar Nigam (the main urban local body of Korba district of Chhattisgarh). Korba is a large industrial and coal-mining town, and makes a good case study to analyze the solid waste management issues of a mid-sized industrially active Indian city. This is because of its rapid urban expansion and associated garbage generating patterns.

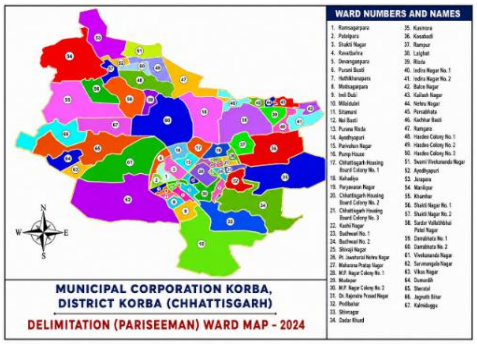


Figure 2.1: Map of Municipal Corporation Korba, Chhattisgarh
(Source: http://www.korbamunicipal.in/)

As per 2011 Census Korba Nagar Nigam has total population of 3,63,390 people. The population is expected to reach 5,47,000 by November 2026. This indicates a high intercensal growth which directly affects the waste generation rates, adequacy of infrastructure and manpower requirements. These are discussed in this thesis.

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2.2 Research Design— This study uses a quantitative descriptive-analytical research design. Quantitative secondary data from official ULB and State Urban Development Agency records were compiled, cross checked and analyzed to develop performance indicators to describe the effectiveness and sufficiency of the existing MSWM system. The process of research design has four main steps:

1. Data Gathering: Collection of data on garbage generation, collection, composition, transportation fleet, processing infrastructure and deployment of labor at the ULB level.

2. Data Validation: Reported data (e.g. per capita generation and mass balance of wet waste processing) are cross-checked against derivable values to identify discrepancies or reporting gaps.

3. Indicator calculation: Standardized performance indicators (collection efficiency, processing capacity utilization, worker-to-population ratios, vehicle-load ratios) are calculated for objective benchmarking.

4. Gap analysis and development of framework: The systemic gaps are identified by comparing the calculated indicators with the standards of Swachh Bharat Mission and the benchmarks of Solid Waste Management Rules 2016, so as to suggest the management framework as presented in the last chapters of this thesis.

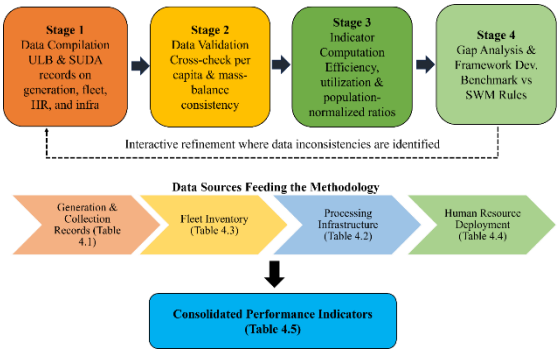


Figure 2.2: Flow Diagram of the 4-Stage Research Methodology Adopted in this Study

2.3 Data Source

2.3.1 Primary Data – Limited primary verification was carried out by visiting the field level door to door collection activities, secondary transit locations and bio-compost processing sheds of Korba Nagar Nigam. This was used to contextualize and sense check the secondary data rather than being a standalone quantitative data set.

2.3.2 Secondary Data- The main source of data for this study is the official ULB-wise Solid Waste Management dataset for Korba Nagar Nigam which is updated by the Urban Administration and Development Department/State Urban Development Agency, Chhattisgarh.

The empirical basis for this chapter and the following findings chapter is based on four structured data tables:

- ULB-specific information on the production, collection and transportation of municipal solid waste to MRFs, the composition of the trash (dry and wet) and the results of processing of wet waste (compost and inerts).
- Inventory of the ULB's waste transportation vehicles by vehicle type
- Details of deployment of Organic Waste Converter (OWC) machines, Integrated Solid Waste Management (ISWM) plant capacity and bio-compost infrastructure.
- Allocation of human resources among administrative, supervisory and field sanitation cadres including Self-Help Group (SHG) and agency staff involved in segregation, composting and door to door collection.

These records provide the baseline for the current study, the latest official reporting available for the ULB.

2.4 Method of Analysis— This analytical approach combines descriptive statistics and ratio-based performance indicators common in the literature on municipal solid waste management and Swachh Bharat Mission monitoring frameworks. Specifically:

- Collection efficiency was calculated as the ratio of garbage collected and transferred to MRFs to total waste generated, expressed as a percentage. This is a typical MSWM performance indicator to identify gaps in service delivery.
- Developed the waste composition ratios (dry-to-wet) to evaluate the feasibility of current processing equipment as dry and wet waste streams require essentially different downstream treatment (recycling/recovery versus composting).
- Performance in terms of processing was measured by the compost conversion rate (compost produced vs. wet waste collected) and the capacity utilization ratio (real compost production vs. installed bio-compost processing capacity).
- Adequacy was assessed using population-normalized ratios such as Population served per primary collection vehicle, Population served per sanitation worker, and Waste handled per worker and per secondary transport vehicle. This enabled a comparison with general standards of service.
- Workforce Structure Analysis: The analysis of workforce composition by job category (regular vs placement/contractual) and the tenure of supervisors in place, both of which have implications for accountability and service continuity.

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- Population Growth Analysis calculated the absolute growth rate and compound annual growth rate (CAGR) using Census 2011 and November 2025 projected population data to provide context for estimated future trash generation.

The dataset is a full census at the ULB level and is not a sample, so there was no need for statistical sampling or inferential testing. All ratios were computed directly from the four official tables of data provided by ULB. Mass-balance cross checks (e.g. wet waste intake vs compost and inerts output) were conducted to detect any discrepancies in reporting.

III. Results & Discussion

The results of the ULB-wise solid waste management dataset for Korba Nagar Nigam are presented in this chapter. The results are arranged by the stages of the waste management value chain i.e., transportation fleet, processing infrastructure, generation and demographic context, collection and composition and human resource deployment. The data reported are presented in each part and the computed performance indicators and their implications for the suggested management framework are discussed. Figure 3.1 shows the complete process flow which is currently being handled by Korba Nagar Nigam. It links the quantitative results of this chapter with all stages of the value chain from generation to the final processing outputs.

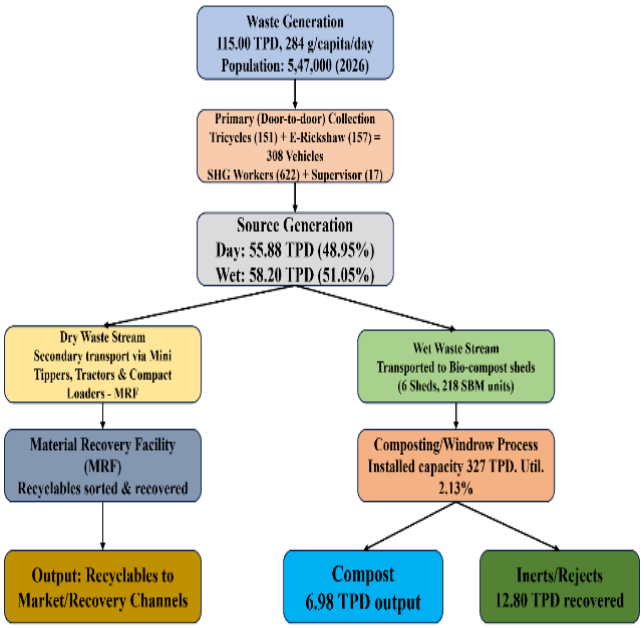


Figure 3.1: Municipal Solid Waste Management Process Flow – Korba Nagar Nigam

3.1 Demographic Context and Waste Generation– Projected Population for the year 2026 is 5,47,000 which is 50.53% increase over Census 2011 population of 3,63,390. The compound annual growth rate for the fourteen-year period is about 1.42%. This continuing growth pattern has direct implications for future waste generation but also fits with Korba's ongoing development as an urban center for the industrial and mining economy. Even at a constant per capita generation rate, the increase in waste generation resulting from population growth would be proportional to population size and would place additional strain on an infrastructure that is already nearing saturation.

3.2 Collection Efficiency and Waste Composition- The waste collection efficiency is 99.13% calculated by the ratio of garbage collected and transferred to MRFs (114.00 TPD) to total waste created (115.00 TPD) and uncollected residual is around 1.00 TPD per day. Thus, the door-to-door collection network of Korba Nagar Nigam, which has a large fleet of tricycles and e-rickshaws for primary collection (Section 4.4), is operating at or near full coverage. Compared to other ULBs of similar size in India this is a very high level of collection efficiency. The remaining 1 TPD gap is small but needs to be addressed as uncollected garbage of this nature tends to accumulate at drains, vacant plots or informal dumping sites and can disproportionately negatively impact public health relative to its small share in the total volume.

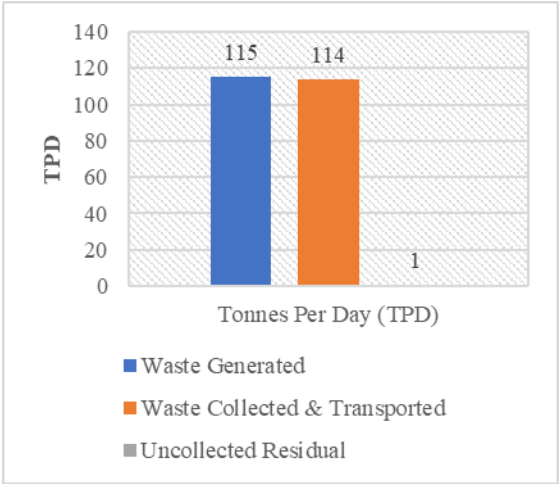


Figure 3.2: Waste Generation vs Collection and Uncollected Residual, Korba Nagar Nigam

3.3 Wet Waste Processing and Infrastructure Adequacy
Table 4.2 shows the reported details of wet-waste processing infrastructure operated by Korba Nagar Nigam. The Korba Nagar Nigam has six bio-compost sheds with 218 Swachh Bharat Mission (SBM) style compost units with an installed capacity of 327.00 TPD, which is approximately 54.50 TPD per shed.

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The installed capacity figure appears, prima facie, to be more than adequate for the stated 58.20 TPD of wet waste collected. It comfortably outstrips wet waste arisings.

However, the actual compost yield reported is only 6.98 TPD. This shows that only 11.99% of the compost is being converted, against the wet waste being handled at the rate of 58.20 TPD and the capacity utilization rate being a mere 2.13% against the installed capacity of 327.00 TPD. The key finding from the analysis of the processing infrastructure is the large difference between installed treatment capacity and actual throughput. Figure 3.3 shows the size of this gap.

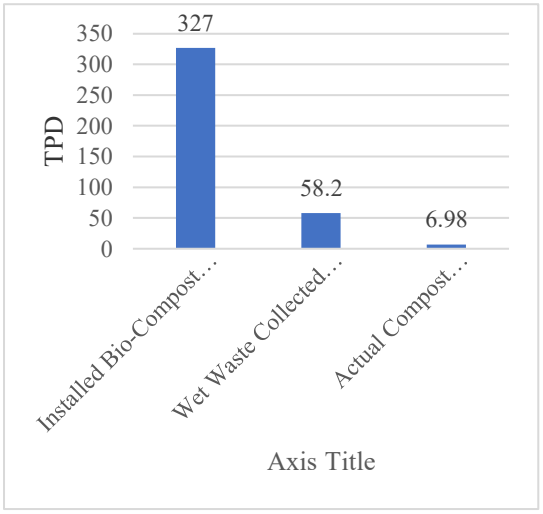


Figure 3.3: Installed Bio-Compost Capacity vs Wet Waste Collected and Actual Compost Output, Korba Nagar Nigam

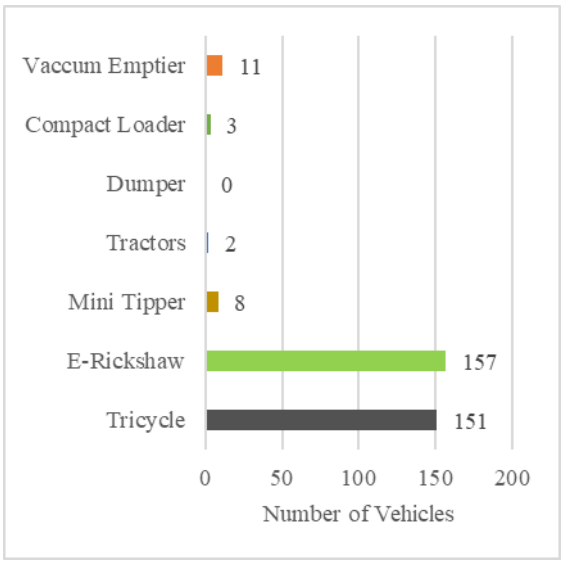


Figure 3.4: Waste Transportation Fleet Composition by Vehicle Type, Korba Nagar Nigam

The ULB's focus on manual/light-vehicle door-to-door collection in accordance with Swachh Bharat Mission guidelines is reflected in the heavy weighting of the fleet toward primary, door-to-door collection: tricycles (151) and e-rickshaws (157) together account for 308 of the 332 total vehicles (92.8% of the fleet). This yields an average of 1 primary collection vehicle per 1,315 persons, normalized to the predicted population.

The secondary transport fleet comprises just 13 vehicles: tiny tippers (8), tractors (2), dumpers (0), and compact loaders (3) for transporting the entire 114.00 TPD of collected garbage to MRFs. If any of these vehicles are taken out of service for maintenance, the secondary transport fleet may be a bottleneck or single point of strain in the collection-to-disposal chain, as indicated by the relatively high load factor of 8.77 TPD handled per secondary transport vehicle per day. Interestingly there are no specialist dumpers recorded (0) and this might suggest tippers and tractors are being used for jobs for which a dumper would normally be more appropriate in terms of payload capacity.

The fleet also has 11 hoover emptiers, used for septage and drain-cleaning work rather than the actual hauling of solid garbage. This means that the ULB sanitation department is dealing with liquid/septage, in addition to solid waste operations.

3.5 Human Resource Deplyoment–Table 3.4 Deployment of workforce by Korba Nagar Nigam in administrative, supervisory and field sanitation roles

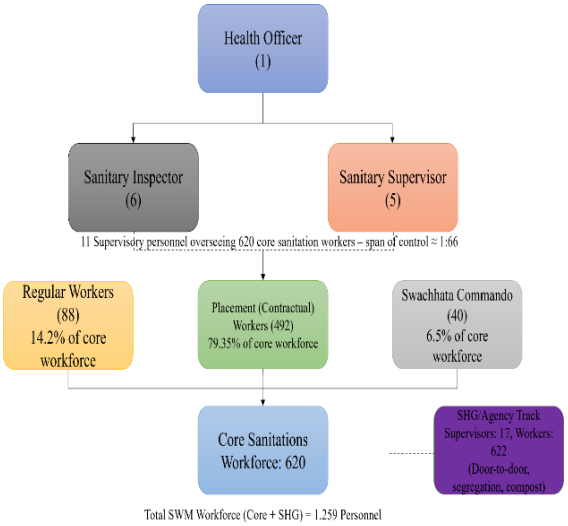


Figure 3.5 Sanitation Workforce Organizational Hierarchy and Span of Control, Korba Nagar Nigam

The total sanitation workforce is 620, consisting of 88 permanent employees, 492 placement/contractual employees and 40 Swachhata Commandos.

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Door to door collection, segregation and composting (SHG/agency workers) involves 622 workers and 17 supervisors, bringing the total number of workers employed in solid waste management to 1,259.

This translates to approximately one core sanitation worker for every 653 residents, or one total workforce (including SHG staff) for every 322 residents when adjusted to the population projections. That is, the core sanitation workforce manages an average of 183.87 kg of collected waste per worker per day. In absolute terms, this number may appear reasonable, but the reality of working conditions is largely influenced by route design, shift structure, and availability of personal protective equipment, none of which are covered by this dataset.

The composition of the labor force has two aspects which require special attention. First, there are 620 core sanitation workers, of which 492 are placement (contractual) workers, with a contractualization rate of 79.35%. This heavy reliance on contractual rather than regular employment is a well-documented trend in Indian ULBs and has implications for long-term accountability, continuity of training and stability of the work-force- all of which are relevant considerations for the human-resource component of the proposed management framework. Secondly, the span of control for supervisors is around 56 employees per supervisor as only 6 sanitary inspectors and 5 sanitary supervisors (11 supervisors in total) supervise 620 core sanitation workers. This may limit ULB's ability to closely monitor collection routes, compliance with segregation and worker welfare at the field level. Current public sector sanitation management standards generally recommend spans of 15 to 25 workers per first-line supervisor. A supervisory span of control of 620 core sanitation workers under just 6 sanitary inspectors and 5 sanitary supervisors (11 supervisors in total) means there are around 56 employees per supervisor. This could reduce the ULB's capacity to keep a close tab on collection routes, segregation compliance and welfare of workers at field level. Typical benchmarks for traditional public sector sanitation management suggest a ratio of 15 to 25 workers to a first-line supervisor.

3.5 Benchmarking against the Swachh Bharat Mission Urban – The performance indicators developed in the previous sections are contextualized through benchmarking four of Korba Nagar Nigam's main metrics against Swachh Bharat Mission-Urban (SBM-U) 2.0 targets and newly published national averages in Figure 3.6. The national waste processing levels increased from about 16 per cent in 2014 to about 81 per cent in 2026, the Ministry of Housing and Urban Affairs said. SBM-U 2.0 seeks 100% door-to-door waste collection, 100% source segregation & operational Material Recovery Facilities in each city.

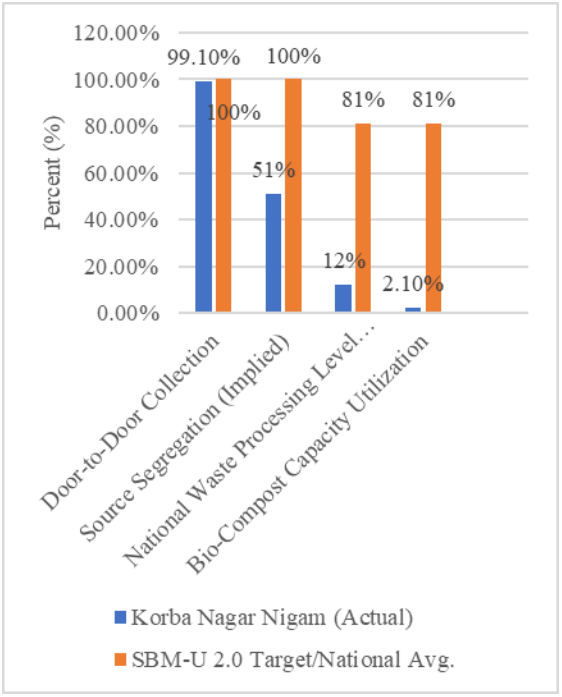


Figure 3.6: Korba Nagar Nigam Performance against SBM-U 2.0 Targets and Reported National Averages

The door-to-door collection performance of Korba Nagar Nigam (99.13%) successfully matches the national SBM-U 2.0 objective of 100%, indicating the real operational strength of the ULB. But the further down the value chain the more the other three indicators diverge. The close to even split between dry and wet waste (51.05% wet share, against a target of 100% segregation), which is a proxy for source segregation, indicates that segregation-at-source techniques may not be fully systematized across all wards. The wet-waste processing efficiency of Korba is 11.99%, which is far below the national level of 81% waste processing. Even more shocking is the bio-compost capacity utilization rate of a mere 2.13%.

IV. Conclusions

The results together indicate that the solid waste management system of Korba Nagar Nigam shows good performance in the front end of the value chain i.e. collection, but poor performance in the rear end, processing. This pattern is typical of Indian ULBs which have made large investments in door-to-door collection infrastructure driven by the Swachh Bharat Mission (seen here in the extensive SHG-based workforce and large fleet of tricycles and e-rickshaws) without making corresponding investments in mechanized, high-throughput processing capacity.

Four findings are identified as priorities for the management framework developed in this project:

1. The most serious gap found is in processing capacity utilization (2.13%) which directly limits the ability of the ULB to transform the collected wet waste to compost or other resource outputs, increasing the need for organic waste to be dumped or disposed improperly.
2. Complete lack of ISWM plant capacity, and a tiny 0.5 TPD OWC machine, is the highest priority infrastructure investment identified in this study, and indicates that mechanized processing infrastructure has not kept pace with the volume or dry/wet composition of waste generated.
3. Specific fleet additions, such as specialist dumpers, would reduce operational risk in the collection-to-MRF leg of the chain as the secondary transport fleet (13 vehicles carrying 114 TPD) operates at a high load factor and has little redundancy.
4. The wide span of control for sanitation staff (1:56) and the high share of staff placed through contracts (79.35%) indicate that the human-resource structure could be streamlined to enhance consistency and accountability of service by reviewing the mix of regular and contract staff and strengthening first-line supervision.
5. Korba Nagar Nigam compares well to national collection benchmarks as against SBM-U 2.0 targets but is far behind on the processing side indicators, which means that processing infrastructure and throughput should take priority over further expansion of collection capacity.

The solid waste management framework presented in the next chapter is based on the findings, which are directly derived from the data reported by Korba Nagar Nigam, and includes workforce restructuring, infrastructure augmentation and monitoring mechanisms calibrated to the specific gaps listed above.

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