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Evaluating Source Segregation and Waste Stream Efficiency in Ahmedabad: A Case of Vasna Refuse Transfer Station

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Abstract: ***Effective solid waste management (SWM) is a critical component of sustainable urban development, particularly in rapidly urbanizing Indian cities. Despite policy frameworks promoting circular economy (CE) and source segregation, practical inefficiencies in waste collection, transfer, and treatment persist. This paper presents a systemic evaluation of source segregation and waste stream efficiency in Ahmedabad, with a detailed case study of the Vasna Refuse Transfer Station (RTS). Using a mixed-methods approach that combines field observations, stakeholder interviews, route-wise waste data analysis, and review of municipal records, the study identifies operational, mechanical, behavioral, and regulatory challenges influencing waste management outcomes. The results reveal that while primary source segregation is practiced in select wards, inconsistencies in waste stream handling at transfer points and gaps in RTS infrastructure reduce overall efficiency. Quantitative analysis highlights the proportion of segregated versus mixed waste, collection route efficiency, and downstream processing performance. Policy and design implications are discussed, emphasizing mechanical upgrades, integrated enforcement mechanisms, and targeted information-education-communication (IEC) interventions to enhance CE transitions. This study contributes to the urban SWM literature by providing evidence-based insights into the practical challenges and opportunities of implementing source segregation and efficient waste streams in mid-sized Indian cities.***

Keywords: Solid Waste Management, Source Segregation, Waste Stream Efficiency, Refuse Transfer Station, Circular Economy, Ahmedabad, Urban Governance

1. Introduction

Urbanization in India has increased the complexity of solid waste generation, collection, and processing. Ahmedabad, with a population of over 8 million, generates approximately 3, 600 metric tons of municipal solid waste (MSW) per day, of which only a fraction is effectively segregated and processed. The city's SWM system follows a mixed model of door-to-door collection, secondary transfer via Refuse Transfer Stations (RTS), and treatment through composting and waste-to-energy (WTE) facilities.

Source segregation, wherein households separate organic and inorganic waste at the point of generation, is a key pillar of the circular economy and waste minimization strategies. However, despite municipal regulations and citizen awareness campaigns, operational gaps persist at multiple levels—collection, transfer, and processing. RTS play a pivotal role in maintaining waste stream integrity between collection and final disposal, but performance evaluation at this intermediate stage is limited in the Indian context.

This paper aims to evaluate the efficiency of source segregation and waste stream handling at the Vasna RTS in Ahmedabad, assessing operational, infrastructural, and behavioral factors that influence system performance. By adopting a systemic perspective, the study links local practices to broader CE objectives and provides evidence-based recommendations for policy and design interventions.

2. Literature Review

2.1 Urban SWM and Circular Economy

Global best practices emphasize the integration of CE principles into urban waste management. Source segregation, recycling, composting, and energy recovery form the backbone of CE-based waste systems (Liu et al., 2020). Indian municipal frameworks, including the Solid Waste Management Rules 2016, mandate segregation at source, scientific processing, and citizen participation. Previous studies indicate that while Indian cities demonstrate awareness of these rules, implementation gaps—particularly in transfer and processing stages—reduce system efficiency (Gupta & Yadav, 2019).

2.2 RTS as Critical Nodes in Waste Systems

RTS act as intermediate aggregation points where collected waste is temporarily stored, compacted, and transferred to treatment facilities. International literature underscores the importance of RTS design, route optimization, and mechanical handling in minimizing contamination and improving downstream processing (Kumar et al., 2021). In India, few empirical studies assess RTS efficiency in maintaining segregated waste streams, highlighting a research gap addressed in this study.

2.3 Operational Challenges in Indian Cities

Several recurring inefficiencies affect SWM: inconsistent segregation, limited citizen awareness, inadequate mechanical infrastructure, and regulatory enforcement gaps (Sharma & Jain, 2018). Quantitative monitoring, route-wise efficiency analysis, and behavioral assessments are

recommended to systematically identify bottlenecks and optimize waste streams.

3. Methodology

A **mixed-methods approach** was employed to capture both quantitative performance metrics and qualitative operational insights at the Vasna RTS.

3.1 Case Selection

Vasna RTS, one of the largest in Ahmedabad, was selected due to its centrality in the city's collection network and its proximity to both composting and WTE facilities. It serves multiple municipal wards, making it a representative node for evaluating source segregation performance and waste stream efficiency.

3.2 Data Collection

- **Primary Data:** Field observations of waste arrival, segregation quality, mechanical handling, and storage practices.
- **Stakeholder Interviews:** Sanitation workers, RTS supervisors, municipal officials, and waste-pickers were interviewed to understand operational and behavioral challenges.
- **Route-wise Waste Data:** Daily collection and transfer data were obtained from Ahmedabad Municipal Corporation (AMC) records.
- **Secondary Data:** Review of municipal SWM reports, policy documents, and previous studies provided contextual and regulatory insights.

3.3 Analytical Framework

The study analyzed waste streams across three dimensions:

1) **Segregation Efficiency:** Proportion of segregated organic and inorganic waste relative to total waste received.
2) **Operational Efficiency:** Time, manpower, and mechanical processes required to handle and transfer waste.
3) **Systemic Bottlenecks:** Identifying points where segregation fails, contamination occurs, or mechanical processes are suboptimal.

Tables and figures from the thesis were summarized as follows:

- **Table 1 (Text Summary):** Daily waste received at Vasna RTS, segregated vs. mixed, by ward.
- **Figure 1 (Text Summary):** Flow diagram of waste movement from households to RTS to WTE/composting units.
- **Graph 1 (Text Summary):** Route-wise collection efficiency (%) and average contamination rate.

4. Results and Discussion

4.1 Source Segregation Performance

Field observations and data analysis indicated that approximately **62% of organic waste and 48% of inorganic waste** were segregated at source across wards served by Vasna RTS. Contamination was particularly high for recyclables, often due to mixed collection practices or insufficient citizen awareness.

Table 1: Ward-wise Waste Segregation Performance (Text Summary)

Ward	Total Waste (t/day)	Organic Segregation (%)	Inorganic Segregation (%)	Contamination Rate (%)
Ward A	33	70	50	15
Ward B	16	60	45	20
Ward C	20	55	50	18

Note: Values derived from AMC records and field observations

4.2 RTS Operational Efficiency

Vasna RTS employs basic mechanical handling: tipper trucks, conveyor belts for compacting, and manual sorting at peak hours. Observations revealed:

- Average transfer time from arrival to dispatch: **4–5 hours**
- Labor allocation: **40–50 workers per shift**
- Mechanical bottlenecks: frequent conveyor breakdowns and insufficient storage for segregated streams

Households → Primary collection → Ward-level collection trucks → Vasna RTS → Segregation → Transfer to WTE/Composting → Disposal of residuals

Figure 1: Waste Flow at Vasna RTS (Text Summary)

Graphical analysis showed **route inefficiencies** where certain collection zones contributed disproportionately to mixed waste contamination.

Graph 1: Route-wise Collection Efficiency (Text Summary)

- Route 1: 75% segregation efficiency, 12% contamination
- Route 2: 60% segregation efficiency, 18% contamination
- Route 3: 50% segregation efficiency, 22% contamination

4.3 Behavioral and Institutional Challenges

Interviews revealed recurring issues:

- **Behavioral:** Lack of consistent segregation by residents, low motivation among informal waste-pickers to separate recyclable streams.
- **Institutional:** Limited enforcement of SWM Rules, inadequate IEC campaigns, and gaps in monitoring tools.

4.4 RTS–WTE Linkages

Analysis indicated that only **55–60% of segregated organic waste** reached composting facilities effectively, with the rest contaminated or misrouted. Inorganic recyclables suffered higher losses, impacting the efficiency of recycling loops and CE outcomes.

5. Policy and Design Implications

The study identifies several intervention areas:

1) **Mechanical Optimization:** Upgrading conveyor belts, adding storage bays for segregated streams, and installing sensors to monitor contamination.
2) **Route Optimization:** Use of GIS-based collection scheduling to reduce contamination and improve collection efficiency.
3) **IEC Campaigns:** Targeted awareness programs in high-contamination wards to improve household-level segregation.
4) **Enforcement Mechanisms:** Integration of penalty and incentive systems, supported by real-time monitoring.
5) **Systemic Integration:** Better coordination between RTS and WTE/composting facilities to ensure complete recovery of segregated streams.

Table 2: Recommended Interventions (Text Summary)

Intervention	Target Area	Expected Outcome
Mechanical Upgrades	RTS infrastructure	Reduced handling time, less contamination
GIS-based Route Planning	Collection	Improved segregation rates, reduced collection costs
IEC Campaigns	Households	Higher source segregation compliance
Real-time Monitoring	RTS & Transport	Early identification of contamination points
Policy Incentives	Residents & Operators	Sustained behavioral change

6. Conclusion and Way Forward

Ahmedabad's Vasna RTS provides critical insights into the practical challenges of implementing source segregation and efficient waste stream management in Indian cities. While progress has been made in raising awareness and partial adoption of CE principles, operational inefficiencies, behavioral lapses, and mechanical constraints limit the overall effectiveness.

The study demonstrates that systemic evaluation—integrating route-wise data, RTS performance, and stakeholder perspectives—can guide evidence-based interventions. Recommendations emphasize mechanical upgrades, improved coordination between collection and treatment nodes, and stronger citizen engagement through IEC initiatives.

Future research could expand the RTS-level evaluation to multiple stations across Indian cities, compare efficiency metrics, and explore technological interventions such as IoT-based monitoring, automated segregation, and advanced WTE solutions.

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