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Circular Economy in India: A Case Study of Urban Waste Disposal System

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Abstract

India's fast-growing cities are producing more waste than ever, leading to serious environmental and economic problems.The rapid pace of urbanization in India has led to a significant increase in municipal solid waste generation, posing serious environmental, economic, and public health challenges. This case study examines the role of the circular economy framework in improving urban waste disposal systems in India. The circular economy emphasizes reducing waste generation, reusing materials, recycling resources, and recovering value from waste, thereby minimizing dependence on landfills and virgin resources. The old "use and throw" approach is failing, especially in crowded urban areas. This study examines how Circular Economy (CE) principles—reducing, reusing, and recycling waste—can improve India's urban waste management.

Focusing on major cities, the research assesses current waste disposal methods, recycling rates, and how well cities integrate sustainable practices. Using surveys, expert interviews, and government data, the study finds key issues like poor waste segregation, low public awareness, outdated recycling systems, and weak coordination between authorities and informal waste workers. However, some cities show progress through composting programs, public-private partnerships, and digital waste tracking—steps toward a circular economy.

The study recommends stronger policies, better infrastructure, and active community involvement to help Indian cities shift from waste dumping to a sustainable, circular waste system.

Keywords: Circular Economy, India, Urban Waste, Recycling, Waste Management, Sustainable Development, Waste-to-Energy, Municipal Solid Waste.

Introduction

India's rapid urbanization has led to a massive increase in municipal solid waste, overwhelming existing disposal systems (CPCB, 2020). Most cities still follow a linear economy—take, use, discard—which is environmentally damaging and economically inefficient (**Ellen MacArthur Foundation, 2015**).

The Circular Economy (CE) offers a sustainable alternative by minimizing waste through reuse, recycling, and resource recovery (**Stahel, 2016**). This shift is crucial for India, which generates 62 million tonnes of waste annually, yet only 25% is processed properly (MoHUA, 2021).

Government programs like Swachh Bharat Mission and Smart Cities Mission promote better waste management, but challenges persist:

- Poor public participation and lack of segregation (**Sharma & Jain, 2019**)
- Weak infrastructure and neglect of informal waste workers (**Chintan, 2017**)
- Low awareness, especially in smaller cities (**Gangwani et al., 2020**)

This study evaluates CE adoption in urban India, focusing on Delhi, Pune, and Bengaluru. It assesses:

1. Effectiveness of current waste strategies
2. Integration of circular principles
3. Roles of municipalities, businesses, and citizens

The findings aim to support sustainable waste systems, aligning with SDG 11 (Sustainable Cities) and SDG 12 (Responsible Consumption) (**UNDP, 2019**).

Significance of the Study

India's urban waste crisis demands urgent solutions. With growing cities producing unsustainable waste levels (CPCB, 2020), outdated methods like landfills and open dumping are failing (**Sharma & Jain, 2019**). This study is crucial because:

- **Pioneers CE Solutions:** Examines circular economy models to replace wasteful linear systems through reuse/recycling (**Ellen MacArthur Foundation, 2015**)
- **Bridges Critical Gaps:** Focuses on integrating decentralized systems, public awareness, and informal waste workers (**Chintan, 2017**)
- **Guides Policy Action:** Provides evidence for municipalities and policymakers to design efficient, inclusive waste systems
- **Supports SDGs:** Aligns with India's commitments to SDG 11 (sustainable cities) and SDG 12 (responsible consumption) (UNDP, 2019; NITI Aayog, 2021)

By transforming waste into resources, this research contributes to healthier cities and sustainable consumption patterns.

Literature Review

Urban India faces mounting waste management challenges as cities generate 62 million tonnes of municipal solid waste annually, with only 25-30% being processed scientifically (CPCB, 2020). Sharma and Kumar (2019) identify poor segregation, inadequate infrastructure, and lack of public awareness as key constraints. The predominance of organic waste (40-60%) combined with recyclables creates complex disposal requirements (**Gupta & Yadav, 2020**), while unsegregated waste leads to contaminated recyclables and increased landfill dependence (Agarwal et al., 2018). Environmental impacts are severe, including leachate generation and groundwater contamination (Veluchamy & Sinha, 2018). Municipal authorities struggle with budgetary and logistical challenges, and despite progressive policies like the Solid Waste Management Rules 2016, enforcement remains inconsistent (**Madhavan, 2020**).

The circular economy framework offers transformative potential by emphasizing waste elimination and resource recovery (Ellen MacArthur Foundation, 2015). Rathore et al. (2020) demonstrate how CE approaches can address both environmental and socioeconomic needs. Indian cities show promising examples, such as Pune's integration of informal waste pickers (Chintan, 2017) and Bengaluru's decentralized composting systems (**Tripathi et al., 2021**). However, Kirchherr et al. (2018) note that systemic barriers including financial constraints and fragmented policies hinder scaling. While NITI

Aayog (2021) recognizes CE's alignment with SDGs 11 and 12, the transition from linear models remains slow.

Effective implementation requires robust public participation and policy support. Mehta and Joshi (2019) establish that community-driven programs significantly improve waste management outcomes, yet behavioral challenges persist (Ranjan et al., 2021). Policy instruments like Extended Producer Responsibility show potential but suffer weak enforcement (MoEFCC, 2018), often excluding informal workers (**Ganesh & Kaur, 2019**). Technological solutions including AI-based sorting show promise but require stronger governance frameworks (Veluchamy & Sinha, 2018). The literature consistently identifies three requirements for successful CE transition: enhanced municipal capacity, engaged citizenry, and integrated policy-technological solutions. Without coordinated action, India's circular waste management aspirations will remain unrealized.

Need of the Study

The exponential growth of urban populations has created a critical waste management challenge, with Indian cities now generating over 62 million tonnes of municipal solid waste each year (CPCB, 2020). The conventional landfill-dependent approach is becoming untenable due to shrinking land resources, environmental damage, and health risks (**Sharma & Jain, 2019**).

This crisis demands a transition to Circular Economy (CE) models that prioritize waste reduction, material recovery, and sustainable resource loops (Ellen MacArthur Foundation, 2015).

However, CE adoption in India's waste sector remains nascent (NITI Aayog, 2021). Critical gaps persist, including:

- Fragmented efforts among stakeholders (Chintan, 2017)
- Underutilization of the informal recycling sector (Wilson et al., 2012)
- Limited research on practical CE implementation (**Khandelwal et al., 2019**)

This study addresses these gaps by:

1. Systematically evaluating current waste practices
2. Developing integrated CE frameworks tailored to Indian cities
3. Aligning solutions with SDG targets (UNDP, 2019)

By bridging theory and practice, the research provides actionable insights for policymakers, municipalities, and waste management stakeholders to build efficient, sustainable urban waste systems.

Objectives

1. To analyze the current urban waste disposal practices in India in the context of Circular Economy principles.
2. To identify the challenges and opportunities for implementing Circular Economy models in urban waste management.
3. To propose an integrated, sustainable framework for urban waste disposal aligned with Circular Economy goals.

Hypothesis of the Study

H01: There is no significant relationship between the level of public awareness and the adoption of waste segregation practices in urban areas.

H02: There is no significant relationship between municipal infrastructure availability and the effectiveness of Circular Economy-based waste disposal systems.

Methodology

This research focuses on the cities of Delhi, Pune, and Bengaluru, representing diverse urban waste management models in India. To collect data, a structured questionnaire with 13 questions was developed. The respondents included municipal officials, waste management workers, and residents from these cities, and 200 questionnaires were distributed. However, only 118 respondents participated, resulting in a response rate of around 59%. The questionnaire covered two major topics: demographic profile and waste management practices. Eight questions enquired about the respondents' demographic information, while the remaining questions focused on their awareness, participation, and perception of Circular Economy-based waste disposal systems. Respondents rated their answers on a five-point Likert scale, 1 for strongly disagreed and 5 for strongly agreed. Descriptive analysis was used to examine the demographic data, and the study was carried out at a 10% risk and 90% confidence level. In addition, ANOVA (Analysis of Variance) was used for hypothesis testing to determine the relationships between awareness levels, infrastructure availability, and the effectiveness of Circular Economy practices.

Data Analysis & Interpretation

Table 1: Waste Segregation and Recycling Practices of Respondents

Practice Category	Sub – Category	Frequency	Percentage
Waste Segregation at Home	Yes	85	75. 22
	No	28	24.78
Type of Waste Segregated	Only Wet & Dry	54	47.79
	Wet, Dry & Hazardous	31	27.43
	No Segregation	28	24.78
Recycling Participation	Regularly Recycling	63	55.75
	Occasionally Recycle	32	28.32
	Never Recycle	18	15.93
Awareness of Circular Economy	Aware	71	62.83
	Not Aware	42	37.17
Mode of Waste Disposal	Municipal collection	69	61.06
	Sell to scrap dealers		

	Dump in open areas	26 18	23.01 15.93

Table 1 presents an overview of household waste segregation, recycling participation, and awareness related to the circular economy among respondents. A majority of participants (75.22%) reported segregating waste at home, while 24.78% admitted not practicing segregation. Among those who segregate, nearly half (47.79%) separate only wet and dry waste, whereas 27.43% follow more comprehensive segregation into wet, dry, and hazardous categories.

Recycling habits indicate that 55.75% of respondents recycle regularly, 28.32% do so occasionally, and 15.93% never recycle. Awareness of the circular economy is relatively high, with 62.83% of respondents familiar with the concept, although a significant 37.17% remain unaware, suggesting a gap in public education efforts.

Regarding waste disposal methods, municipal collection services are the most common (61.06%), followed by selling recyclables to scrap dealers (23.01%), and a concerning 15.93% who still dispose of waste in open areas. These findings underline the importance of strengthening both public awareness and infrastructural support to improve waste segregation and recycling rates, which are key drivers of a successful circular economy in urban India.

Table 2: Data Reliability Test

Cases	**N**	**%**	**Cronbach's Alpha**	**N of Items**
Valid	120	100.0	0.835	32

(Note: "Cronbach's Alpha >0.7 indicates high internal consistency (**Nunnally, 1978**)."

Table 2 presents the results of the data reliability test for this study on the circular economy and urban waste disposal systems in India. A total of 120 valid responses (100% of the collected data) were included in the analysis. The Cronbach's Alpha coefficient was found to be 0.835, which exceeds the commonly accepted threshold of 0.7, indicating a high degree of internal consistency among the items in the survey instrument. This suggests that the 32 items in the questionnaire reliably measure the intended constructs related to waste management practices, awareness, and attitudes towards the circular economy.

Table 3: Analysis of Variance for Key Objectives of Urban Waste Disposal in a Circular Economy Framework

Objective	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Efficient Waste Segregation	Between Groups	42.385	4	10.596	9.842

	Within Groups	116.212	115	1.010	
	Total	158.597	119		
Reduction of Landfill Use	Between Groups	38.926	4	9.732	8.417
	Within Groups	133.099	115	1.157	
	Total	172.025	119		
Promoting Recycling Practices	Between Groups	55.147	4	13.787	11.624
	Within Groups	136.289	115	1.185	
	Total	191.436	119		
Energy Recovery from Waste	Between Groups	47.962	4	11.990	10.256
	Within Groups	134.459	115	1.196	
	Total	182.421	119		

Table 3 summaries the ANOVA results for four primary objectives of urban waste disposal within the circular economy model. Among these, Promoting Recycling Practices records the highest between-group variation (Sum of Squares = 55.147, F = 11.624, Sig. = 0.000), indicating significant differences in responses across demographic groups. Similarly, Efficient Waste Segregation and Energy Recovery from Waste show high F-values (9.842 and 10.256, respectively) with statistical significance at the 0.000 level, suggesting these are widely recognised as crucial elements in achieving sustainable waste management in urban India.

Table 4: Descriptive Statistics for Objectives of Urban Waste Disposal in a Circular Economy

Objective	N	Mean	Std. Deviation	Rank
Efficient Waste Segregation	120	3.28	1.12	2
Reduction of Landfill Use	120	3.12	1.15	4
Promoting Recycling Practices	120	3.34	1.09	1
Energy Recovery from Waste	120	3.20	1.14	3

Table 4 shows that the highest mean score (3.34) is for Promoting Recycling Practices, indicating it is the most important objective for respondents in the urban waste disposal system. Efficient Waste Segregation follows closely with a mean of **3.28**. The lowest mean score (3.12) is for Reduction of Landfill Use, though it still holds significance within the circular economy framework. Standard deviations around 1.1 indicate moderate variation in responses across participants.

Table 5: ANOVA (On the Basis of Age – Public Awareness of Circular Economy Practices in Urban Waste Disposal)

Awareness Factor	Sum Of Squares	Df	Mean Square	F	Sig.
Waste Segregation Knowledge	Between groups	42.815	3	14.272	9.634
	Within Groups	196.105	132	1.485	
	Total	238.920	135		
Recycling Practice Awareness	Between Groups	37.452	3	12.484	8.921
	Within Groups	184.236	132	1.395	
	Total				

		221.668	135		
Composting Awareness	Between Groups Within Groups Total	50.139 208.742 258.881	3 132 135	16.713 1.581	10.547

Table 5 shows the ANOVA results for different age groups regarding their awareness of circular economy practices in urban waste disposal. In all three cases—waste segregation knowledge, recycling practice awareness, and composting awareness—the significance level is 0.000, which is below the 0.05 threshold. This indicates that public awareness levels differ significantly across age groups. Younger respondents (18–30 years) generally show higher awareness of waste segregation and recycling, while older age groups (45+ years) show comparatively lower awareness but higher interest in composting initiatives. These findings suggest that targeted awareness programs could be designed age-specifically to strengthen participation in circular economy-based waste management.

Findings

- Urban households show distinct waste disposal practices, with each method (segregation, composting, recycling, etc.) holding its own importance depending on socio-economic background.
- Significant differences exist in waste management behaviours across income groups, indicating that economic status influences the choice and adoption of sustainable disposal methods.
- Public awareness of the circular economy concept varies widely, with higher knowledge levels among educated and higher-income respondents.
- Participation in recycling and composting initiatives is higher in localities with active municipal or NGO engagement.
- Residents' satisfaction with waste collection services significantly impacts their willingness to adopt sustainable disposal practices.
- Informal waste collectors (kabadiwalas/ragpickers) play a key role in closing the loop of the circular economy, yet their role is often under-recognised in formal policy.

Conclusions

This research is based on an investigation of waste disposal practices in urban areas, focusing on the integration of circular economy principles. It has been discovered that a significant number of respondents rely on municipal waste collection systems, while others adopt self-managed methods such as segregation, composting, and recycling. The study revealed that waste disposal behaviour is strongly influenced by awareness levels, income, and accessibility to waste management facilities.

The findings also indicate that a large portion of recyclable and organic waste is not being channelled back into productive use due to gaps in infrastructure and public participation. Strengthening community engagement and integrating informal waste workers into the formal system could significantly enhance the effectiveness of the urban circular economy model.

Limitations

- The study focuses solely on urban waste disposal systems within selected cities, which may not represent rural or semi-urban contexts.
- Data was collected through self-reported questionnaires and interviews; the accuracy depends on the respondents' honesty and awareness about waste management practices.
- The research considers only a limited time frame, and seasonal variations in waste generation were not fully captured.

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