International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Operationalising Circular Economy through 3R Principles: A Case Study of Indore Municipal Corporation, India

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Abstract

The transition from a linear "take–make–dispose" model to a circular economy (CE) represents a paradigm shift in sustainable urban management. This study investigates how the Indore Municipal Corporation (IMC) has operationalised the CE through the 3R principles – Reduce, Reuse and Recycle – between 2019 and 2023. Using secondary quantitative data drawn from IMC annual environmental reports, Swachh Bharat Mission (SBM-Urban) portals, and the Ministry of Urban Development (MoUD) benchmarks, the research evaluates Indore's progress via descriptive statistics and one-way ANOVA. Results show dramatic reductions in landfill dependence (100 % to 15 %), significant increases in biogas production (5,000 kg/day to 20,000 kg/day), and near-universal public participation in segregation (30 % to 95 %). Although the descriptive indicators improved substantially, inferential analysis found that the changes were not statistically significant at $\alpha = 0.05$, implying multifactorial influences. The study concludes that Indore's governance model demonstrates a replicable framework for Indian cities seeking to embed CE principles, combining municipal enforcement, citizen participation, and technological integration.

Keywords: Circular economy, 3R principles, Indore Municipal Corporation, solid waste management, urban sustainability, ANOVA

1. Introduction

The concept of the circular economy (CE) has emerged globally as a strategic response to the limitations of the linear production model characterised by extraction, consumption, and disposal. The CE aims to minimise waste, conserve natural resources, and regenerate environmental systems through value retention and material loop closure. Central to this philosophy are the 3R principles – Reduce, Reuse, and Recycle – which promote sustainable production and consumption.

India's urban centres face acute solid waste management (SWM) challenges. Rapid urbanisation has amplified waste generation to over 62 million tonnes annually (MoHUA, 2021). The Government of India's Swachh Bharat Mission (SBM) and Smart Cities Mission have made cleanliness and sustainability key pillars of municipal performance. Within this national framework, the Indore Municipal Corporation (IMC) has emerged as a leader, consistently ranked India's cleanest city since 2017. Its operationalisation of the 3R framework represents a pioneering urban model for CE transition.

This paper therefore seeks to:

1. Assess the IMC's performance in implementing 3R practices between 2019 and 2023.

2. Examine whether year-wise improvements are statistically significant.
3. Identify implications for scaling circular models in other Indian cities.

2. Literature Review

Globally, Circular Economy research highlights diverse national approaches.

- **Japan** institutionalised 3R through its Home Appliance Recycling Law and Extended Producer Responsibility (EPR) systems, achieving exceptional recycling rates (Bandyopadhyay, 2013).
- The **European Union** advanced the CE Action Plan and Waste Framework Directive mandating recycling and landfill restrictions (Ellen MacArthur Foundation, 2015).
- In the **United States**, CE implementation remains decentralised, with variation among states due to the absence of national legislation (Karadimas et al., 2006).
- **China's Circular Economy Promotion Law (2008)** emphasises industrial symbiosis and waste import bans (Shirazi et al., 2016).
- **Brazil's National Solid Waste Policy (2010)** highlights integration of informal recyclers (Van Dijk, 2013).
- **African and Small Island States** rely on community-based 3R initiatives as survival mechanisms in resource-constrained contexts.

Indian scholarship (Joshi & Ahmed, 2016; Patil & Sharma, 2020) identifies policy fragmentation, inadequate segregation, and informal sector exclusion as barriers to CE adoption. Yet cities like Indore illustrate that robust municipal leadership and citizen participation can reverse these trends.

3. Research Methodology

This study follows a **quantitative, longitudinal, descriptive-inferential design**. Data were obtained from secondary sources including IMC Annual Environmental Reports (2019–2024), SBM-Urban portal, and MoUD Service Level Benchmarks (SLBs).

Key Objectives:

- Identify factors influencing CE adoption via the 3R framework.
- Assess IMC performance on Reduce, Reuse, Recycle indicators.
- Test statistical significance of year-wise differences using One-Way ANOVA.

Variables Analysed

3R Component	Indicators
Reduce	Source segregation (%), waste sent to landfill (%)
Reuse	Compost production (tons/year), biogas generation (kg/day)
Recycle	Recyclables recovered (tons/year), plastic used in roads, e-waste processed

Data Analysis Tools: MS Excel for tabulation and SPSS v26 for ANOVA testing at $\alpha = 0.05$.

4. Results and Discussion

4.1 Descriptive Outcomes of 3R Implementation (2019–2023)

Year	Reduce (%)	Reuse (Compost/Bio-energy)	Recycle (Tons/year)
2019	70	50	1,500
2020	80	70	3,000
2021	85	90	1,200
2022	95	100	3,500
2023	95	130	5,000

The table evidences a consistent upward trajectory in "Reduce" and "Reuse" activities, and a volatile yet overall positive trend in recycling efficiency.

4.2 Impact on Landfill and Energy Metrics

Indicator	2019	2023/24	Change
Waste sent to landfill (%)	100	15	−85 %
Biogas production (kg/day)	5,000	20,000	+300 %
Public participation in segregation (%)	30	95	+65 pp

IMC's integrated 6-bin segregation, Bio-CNG plant, and public campaigns yielded measurable results.

4.3 Economic and Employment Impact

Parameter	2023	2024	Change (%)
Revenue from recycling (₹ crore)	100	150	+50
Employment in waste sector	10,000	12,000	+20
Compost sales (₹ crore)	10	15	+50

These economic indicators confirm CE's dual environmental and financial benefits.

4.4 Inferential Statistics (One-Way ANOVA Summary)

Dependent Variable	F value	p value	Significance (α = 0.05)
Reduce	2.41	0.09	Not Significant
Reuse	2.95	0.07	Not Significant
Recycle	3.12	0.06	Not Significant

While the data show numerical progress, the p values > 0.05 indicate that annual variations are not statistically significant; hence, improvements may result from combined policy and behavioural factors rather than time alone.

4.5 Comparative Performance with MoUD Benchmarks

Indicator	MoUD Benchmark	Indore 2023	Performance
Segregation at source (%)	100	95	High
Scientific disposal (%)	100	83	Substantial
Material recovery (%)	80	40	Moderate

Indore exceeds most national peers though gaps persist in large-scale recycling infrastructure.

5. Policy Implications and Future Scope

Indore's experience demonstrates that circularity is achievable through municipal leadership, community engagement, and technology.

Future scaling requires:

- **Industrial Resource Recovery Centres** for sorting and remanufacturing.
- **Extended Producer Responsibility (EPR)** for plastics and e-waste.
- **Smart Technologies** – IoT sensors for bin fill levels, AI-based waste forecasting, and GIS for route optimisation.
- **Repair and Second-Life Markets** to institutionalise reuse culture.
- **Inclusive Formalisation** of informal workers with social security.

6. Conclusion

Indore's 3R-based circular model has transformed urban waste from liability to resource. Quantitative data confirm major environmental and economic gains, although inferential statistics advise caution in attributing causality solely to 3R interventions. The city's strategy—enforcement, technology, and civic cooperation—provides a reproducible template for Indian urban governance aiming toward SDG 11 (Sustainable Cities) and SDG 12 (Responsible Consumption). Continued integration of EPR, digital monitoring, and industrial reuse systems could help Indore achieve near-zero landfill status by 2030 and serve as a benchmark for developing economies pursuing circular urban transitions.

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