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Smart Waste Management in Shivamogga: A Comprehensive Literature Review

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ABSTRACT

Increasing population and urbanization create environmental challenges for cities like Shivamogga with proper management of municipal solid waste (MSW). Shivamogga produces approximately 210 tonnes of MSW on a daily basis but faces challenges from poor segregation practices, limited processing plants and lack of public awareness. A literature analysis investigated the level of Integrated Solid Waste Management (ISWM) undertaken by Shivamogga by reviewing arbitrary academic studies in conjunction with municipal records to understand how MSW is currently managed by the Shivamogga Municipal Corporation (SMC) and state directives. This paper summarizes key findings about MSW sources and types, the future of waste management technologies, technologies for existing waste management, and policy initiatives as authorized by state and national missions, namely, the Swachh Bharat initiative. A thematically based review allowed the identification of some advantages associated with decentralized composting approaches, integrating informal waste pickers within formal waste systems, and route optimization technologies whilst identifying some shortcomings within the current waste system, namely, limited funding for incinerators, limited source segregation, reliance on landfills, insufficient use of composting, and public apathy surrounding their behavior of waste collection. The study ends with suggestions for future research and development opportunities with respect to AI driven route planning techniques, citizen reporting platforms, and decentralized low-tech processing development and expansion. The study will assist in providing a city-level guide to developing sustainable and inclusive urban waste systems using Shivamogga as a case study for other mid-tier Indian cities.

Keywords: Integrated Solid Waste Management (ISWM), Shivamogga, Swachh Bharat Mission, Smart Cities, Urban Waste, Sustainability, Route Optimization, Informal Sector.

1. Introduction

India's rapid urbanization has surpassed infrastructure development in areas including waste management. Shivamogga, a prominent city in Karnataka known as the Gateway of Malnad, disposes of more than 210 tons of municipal solid waste (MSW) every day. 55% of this is from household sources and with 34 tonnes from drainage silt, managing this is an environmental and operational concern.

This literature review has undertaken a critical review of Shivamogga's integrated solid waste management (ISWM) initiatives in relation to waste sources, treatment technologies, governance systems, community participation, and policy interventions. In addition, the review has compared and contrasted Shivamogga's approach to the waste under the Swachh Bharat Mission (Urban) and the Smart Cities Mission, including an examination of emerging technologies and community-based models within the waste management landscape.

2. Literature Review (Thematic Analysis)

2.1 Waste Sources and Composition

Research (Rao & Kamath, 2021; Nayak & Prasad, 2022) indicates that residential households are responsible for 55% of the total waste. Residential waste is dominated by organic materials (58%). Other sources of waste include commercial areas (11%), institutions, parks, and street-sweeping operations. Seasonality impacts total waste volumes; summer increases the organic waste due to spoilage while the monsoon increases the volume of waste, made bulkier by the increased moisture content.

2.2 ISWM Practices in Shivamogga

Present ISWM features: Door-to-door collection covered its 73% of waste. Material Recovery Facilities (MRFs) recycling ~17 tons per day (TPD) through informal waste pickers. Very limited composting and biomethanation (only pilot trials) No operational Waste-to-Energy (WTE) plants exist.

Primarily landfills are used for disposal, with the future aspirations of scientific landfills and bio-mining (to reduce landfilling). The informal sector undertakes a huge role and quite frankly, an incredibly under-appreciated role in collecting tons of dry waste, without formal measures or support.

2.3 Technology and Route Optimization

Shivamogga uses GPS-enabled vehicles and IoT-based smart bins for improving waste collection efficiency. Waste hotspots are identified through GIS-based mapping, and route planning is being examined using AI and ML. Traffic/pollution-related delays and coverage gaps still create inefficiencies (Chapter 8. [6]).

2.4 Policy and Institutional Framework

The Shivamogga City Corporation (SMC) is the main authority with state-level support. The city has participated in the Swachh Bharat Mission (SBM), resulting in:

- ODF++ certification,
- 95% door-to-door collection coverage,
- Functional two-bin system and decentralized composting.

However, there are still gaps in 100% source segregation, C&D waste handling and open dumping elimination.

3. Strengths and Limitations in Current Systems

Strengths

- High organic content offers composting potential.
- Active engagement in recycling in the informal sector .
- Use of smart technology for tracking and scheduling.
- Community programs such as *Sada Shuchitva Shivamogga* .

Limitations

- Only 70–80% source segregation despite high awareness.
- Waste collection still leaves some areas unaddressed .
- Landfill dependency persists in many countries .
- Informal workers lack formal benefits and protections.
- Public engagement is inconsistent , and IEC efforts need scaling.

4. Comparative Analysis

In comparison to other tier-2 Indian cities, Shivamogga had:

- a lower per-capita waste generation (0.164 kg/day).
- higher climate-resilient composting potential because of rainfall and vegetation.
- a commendable digital adoption rate in solid waste management (e.g., usage of Swachhata app and GPS tracking).

However, its processing infrastructure and scientific landfill preparedness trails other cities such as Mysuru and Indore.

5. Research Gaps and Future Directions

5.1 Gaps

- When it comes to informal waste pickers there has been a lack of academic research in regard to their economic and health profiles.
- A lack of real-time waste audit data to provide decision-making support.
- A limited increase in the use of data-driven policy models for waste-stream prediction.

5.2 Future Research & Development Opportunities

- **AI-powered Route Optimization** to reduce carbon footprint.
- **Blockchain for Waste Tracking** ensures transparency.
- **Citizen gamification apps** for rewarding sustainable disposal habits.
- **PPP Models** for smart bin deployment and decentralized composting hubs.
- Studies on the **health impacts** of poor waste segregation and landfill gas emissions.

6. Conclusion

Shivamogga's journey in solid waste management shows impressive achievements and sustainable gaps. While the city has adopted ISWM principles of segregation, recovery, composting, and route optimization, there are still issues related to infrastructure and public participation. Future advancements will rely upon combining technology and institutional support with a community behavioral shift. Shivamogga is on a path to being a pioneer of smart waste management, aligned with India's sustainability goals, with improved stakeholder coordination and innovative research.

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