iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: VIII Month of publication: August 2026

DOI: https://doi.org/10.22214/ijraset.2026.84640

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

Development of Low-Cost Decentralized Waste Processing Model for Sustainable Urban Waste Management in Sakoli-Sendurwafa, Maharashtra, India

Priyanka Tembhurkar[1], Laxmi Gupta[2], Dilip Budhlani[3], Manthan Banerjee[4]
[1]PG Scholar, [2, 3, 4]Assistant Professor, Department of Civil Engineering, Swaminarayan Siddhanta Institute of Technology, Nagpur (MH)

Abstract: Rapid urbanization, increasing municipal solid waste generation, poor segregation practices, and inadequate treatment infrastructure have intensified environmental and operational challenges in small urban local bodies. Conventional centralized waste management systems are associated with high transportation cost, low recyclable recovery efficiency, excessive landfill dependency, and environmental pollution. The present study focuses on the development and experimental evaluation of a low-cost decentralized municipal solid waste processing framework for Sakoli–Sendurwafa.

Municipal solid waste samples were collected from residential, commercial, institutional, and market regions for waste characterization and resource recovery studies. The proposed decentralized framework integrated wet and dry waste segregation, windrow composting, Material Recovery Facility (MRF), recyclable recovery systems, reject waste stabilization, and low-cost municipal processing infrastructure. Experimental evaluation included segregation efficiency assessment, compost stabilization studies, recyclable recovery efficiency, landfill diversion analysis, and sustainability performance evaluation. The developed system achieved segregation efficiency of 92.4%, recyclable recovery efficiency of 84.8%, compost stabilization efficiency of 81.6%, and landfill diversion efficiency exceeding 90%. Aerobic windrow composting effectively stabilized biodegradable waste and generated mature compost suitable for agricultural application. The decentralized framework significantly reduced transportation burden, landfill dependency, and environmental pollution compared to conventional centralized municipal systems. The proposed model demonstrated strong technical feasibility, environmental sustainability, and economic applicability for small municipalities and semi-urban urban local bodies. The framework provides a scalable circular economy-based municipal solid waste management strategy suitable for sustainable urban environmental management in developing regions.

Keywords: Circular Economy, Resource Recovery, Windrow Composting, Material Recovery Facility, Sustainable Municipal Systems, Landfill Diversion, Environmental Sustainability.

I. INTRODUCTION

Municipal solid waste generation has increased significantly due to rapid urbanization, population growth, industrialization, and changing consumption behavior. Improper segregation, inefficient collection systems, low recyclable recovery, and unscientific disposal practices have created severe environmental and public health concerns. India generates approximately 160,000–170,000 tonnes of municipal solid waste daily, with a significant fraction remaining untreated or disposed of through open dumping and uncontrolled landfilling. Small municipalities such as Sakoli and Sendurwafa face additional operational limitations due to inadequate treatment infrastructure, financial constraints, and increasing waste generation.

Recent studies have emphasized decentralized waste management systems as sustainable alternatives to centralized municipal waste processing approaches. Decentralized systems promote:

1) Source segregation
2) Localized processing
3) Composting
4) Recyclable recovery
5) Circular resource utilization
6) Reduced transportation burden

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

However, integrated decentralized municipal waste processing frameworks combining segregation, composting, recyclable recovery, landfill diversion, and sustainability assessment under real municipal operational conditions remain limited.

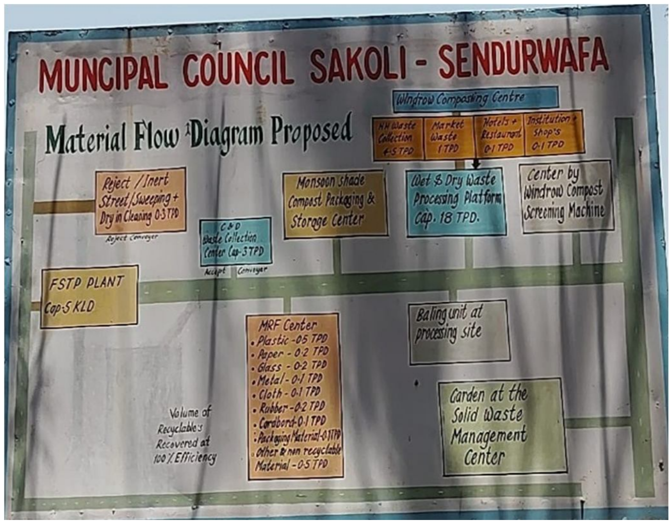


Figure 1: Existing Municipal Waste Management site in Sakoli–Sendurwafa Region

II. PROBLEM STATEMENT

Improper municipal solid waste management within Sakoli–Sendurwafa Municipal Council has resulted in increasing environmental pollution, open dumping practices, low recyclable recovery, inadequate scientific processing, and growing landfill dependency. Existing centralized waste collection systems require high transportation cost and operational expenditure while providing limited resource recovery and environmental sustainability. absence of decentralized segregation, composting, recyclable recovery, and scientific stabilization infrastructure significantly affects sustainable municipal environmental management. Therefore, there is a need to develop a low-cost decentralized municipal waste processing framework capable of improving waste treatment efficiency, resource recovery, landfill diversion, and environmental sustainability under practical municipal operational conditions.

III. AIM AND OBJECTIVES

A. Aim

To develop and experimentally evaluate a low-cost sustainable decentralized municipal solid waste processing framework for effective treatment, resource recovery, and environmentally safe disposal of municipal waste in Sakoli–Sendurwafa Municipal Council, Maharashtra, India.

B. Objectives

1) To characterize municipal solid waste generated from residential, commercial, institutional, and market regions.
2) To develop a low-cost decentralized waste processing framework integrating segregation, composting, recyclable recovery, and reject waste stabilization.
3) To evaluate segregation efficiency, recyclable recovery performance, compost stabilization efficiency, and landfill diversion potential.
4) To assess the environmental and economic sustainability of the proposed decentralized municipal waste processing system.
5) To develop a scalable circular economy-based municipal waste management framework suitable for small municipalities and semi-urban urban local bodies.

IV. MATERIALS AND METHODS

A. Study Area

The study was conducted within:

- Sakoli
- Sendurwafa

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

Selected sampling zones included:

Zone	Description
Residential Area	Household waste
Commercial Area	Shop and market waste
Institutional Area	School and office waste
Public Utility Area	Street sweeping waste

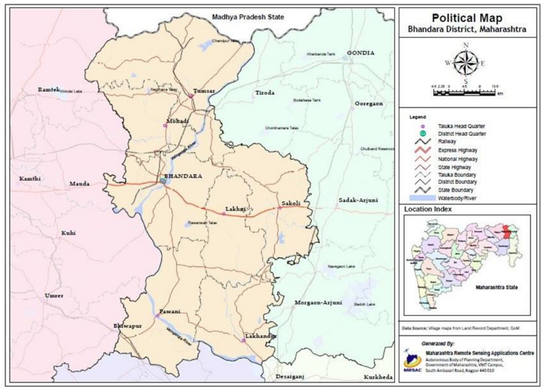


Figure 2. Location Map of Study Area

B. Experimental Setup

The decentralized waste processing framework consisted of:

1) Segregation platform
2) Windrow composting unit
3) Material Recovery Facility (MRF)
4) Recyclable storage section
5) Reject waste stabilization area

Figure 3: Decentralized waste processing framework infographic

The system was developed using low-cost locally available materials:

Material	Purpose
Brick masonry	Segregation platform
PVC pipes	Aeration system
HDPE bins	Waste storage
GI mesh	Segregation screen
Bamboo supports	Composting structure
Tarpaulin sheet	Moisture protection

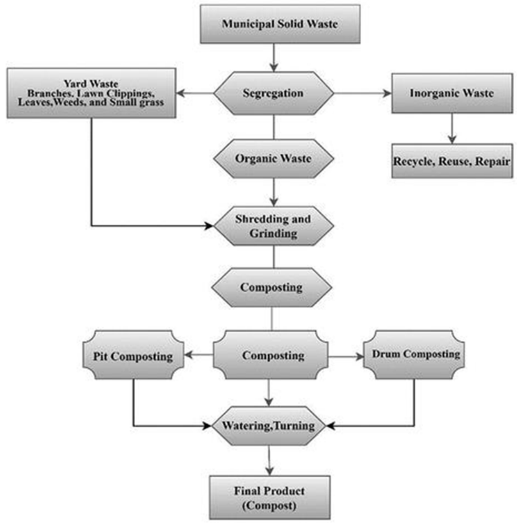


Figure 4. Proposed Decentralized Waste Processing Framework

Flow Diagram

Municipal Waste Collection
↓
Source Segregation
↓
Organic Waste → Windrow Composting
↓
Dry Waste → Material Recovery Facility
↓
Recyclable Recovery
↓
Reject Waste Stabilization
↓
Scientific Disposal

Figure 5. Experimental Windrow Composting Setup

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

Components
- Compost bed
- Aeration pipes
- Turning arrangement
- Moisture control
- Leachate collection

C. Municipal Waste Characterization
Municipal waste samples were collected manually for seven consecutive days.

Table 1. Municipal Waste Composition

Waste Fraction	Percentage (%)
Organic Waste	55
Plastic Waste	15
Paper/Cardboard	11
Glass Waste	4
Metal Waste	3
Textile/Rubber	5
Inert Waste	7

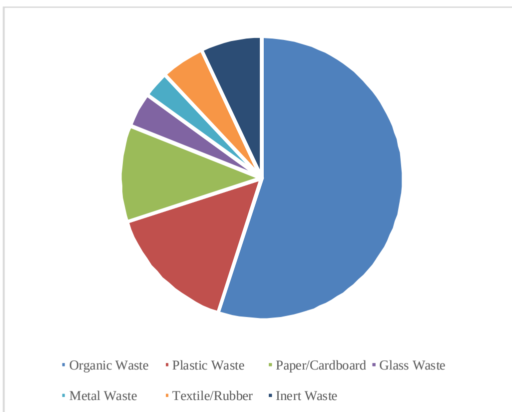


Figure 6. Municipal Waste Composition Distribution (Pie chart representing municipal waste fractions)

D. Windrow Composting
The biodegradable waste fraction was treated using aerobic windrow composting.

Operational Parameters

Parameter	Range
Moisture Content	50–60%
Temperature	40–65°C
pH	6.5–8
Composting Duration	40–50 days

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

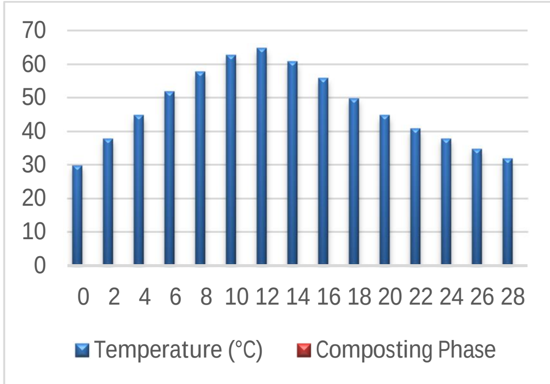


Figure 7. Temperature Variation During Composting

E. *Statistical Analysis*

Experimental data were analyzed using:

- Microsoft Excel
- SPSS Version 26
- Python graphical analysis

Statistical significance was evaluated at:

$$p < 0.05$$

V. RESULTS AND ANALYSIS

A. *Segregation Efficiency*

Table 2. Recyclable Recovery Efficiency

Waste Fraction	Recovery Efficiency (%)
Plastic	86
Paper/Cardboard	82
Glass	84
Metal	91
Organic Waste	95

Overall segregation efficiency achieved: 92.4%

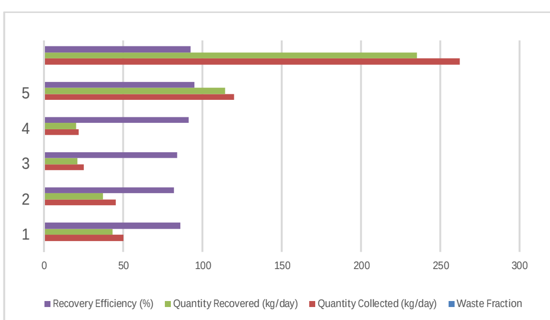


Figure 8. Recyclable Recovery Efficiency
(Bar graph comparing recovery efficiencies of recyclable fractions.)

B. Compost Stabilization Performance

Table 3. Composting Performance

Parameter	Initial	Final
Moisture Content	58%	26%
Organic Matter	62%	35%
C/N Ratio	31	14
Compost Yield	—	45%

The aerobic composting process successfully stabilized biodegradable waste and produced mature compost suitable for agricultural application.

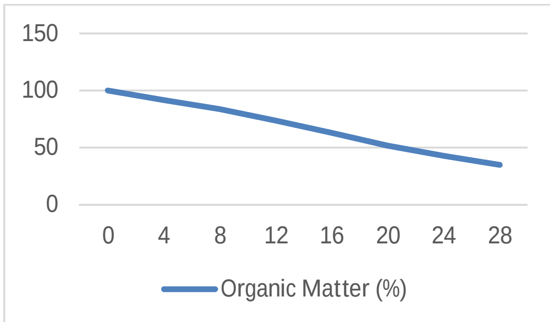


Figure 9. Organic Matter Reduction During Composting

C. Waste Reduction Analysis

Waste reduction efficiency was calculated using:

$$\text{Waste Reduction} = \frac{W_i - W_f}{W_i} \times 100$$

Experimental observation:

- Waste reduction efficiency: 72–78%
- Reject waste generation: <10%

Composting Day	Initial Waste Volume (kg)	Final Waste Volume (kg)	Waste Reduction Efficiency (%)	Reject Waste Generation (%)
0	100	100	0	0
4	100	88	12	2
8	100	76	24	3
12	100	63	37	4
16	100	51	49	5
20	100	39	61	6
24	100	28	72	8
28	100	22	78	9

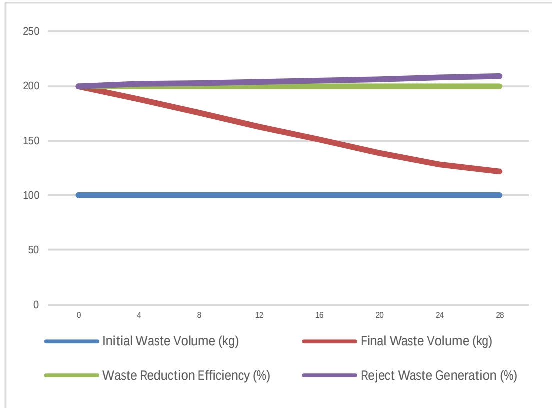


Figure 10. Waste Volume Reduction Analysis

Before and after comparison of municipal waste treatment.

Before

After

D. *Landfill Diversion Efficiency*

Table 4. Landfill Diversion Performance

Parameter	Value
Organic Waste Treated	55%
Recyclables Recovered	35%
Reject Waste	8–10%
Landfill Diversion Efficiency	91%

The decentralized framework significantly reduced landfill dependency through composting and recyclable recovery.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

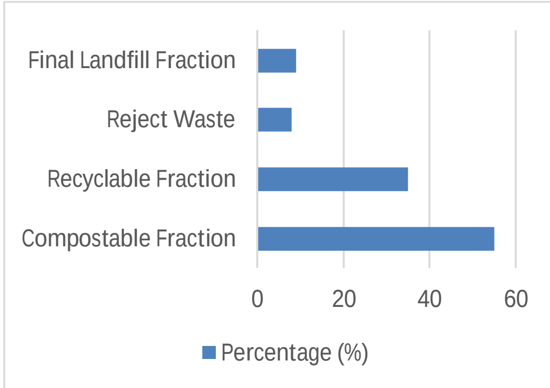


Figure 11. Landfill Diversion Efficiency

Stacked bar graph showing:
- Compostable fraction
- Recyclable fraction
- Reject waste
- Final landfill fraction

VI. DISCUSSION

The developed decentralized waste processing framework demonstrated high segregation efficiency, recyclable recovery performance, and landfill diversion capability under practical municipal operational conditions.

The segregation efficiency observed in the present study was significantly higher than values reported in conventional centralized municipal systems. Improved performance may be attributed to localized segregation, reduced waste mixing, and integrated recyclable recovery systems.

The proposed framework significantly reduced:
1) Transportation burden
2) Fuel consumption
3) Open dumping
4) Environmental pollution
5) Landfill dependency

The developed decentralized system further demonstrated strong circular economy potential through recyclable recovery and compost stabilization.

VII. CONCLUSION

The present study successfully developed and experimentally evaluated a low-cost decentralized municipal solid waste processing framework for Sakoli–Sendurwafa Municipal Council, Maharashtra, India.

The developed framework achieved:
1) High segregation efficiency
2) Effective compost stabilization
3) Significant recyclable recovery
4) Substantial landfill diversion
5) Improved environmental sustainability

The proposed decentralized system demonstrated strong technical feasibility, environmental sustainability, and economic applicability for small municipalities and semi-urban urban local bodies.

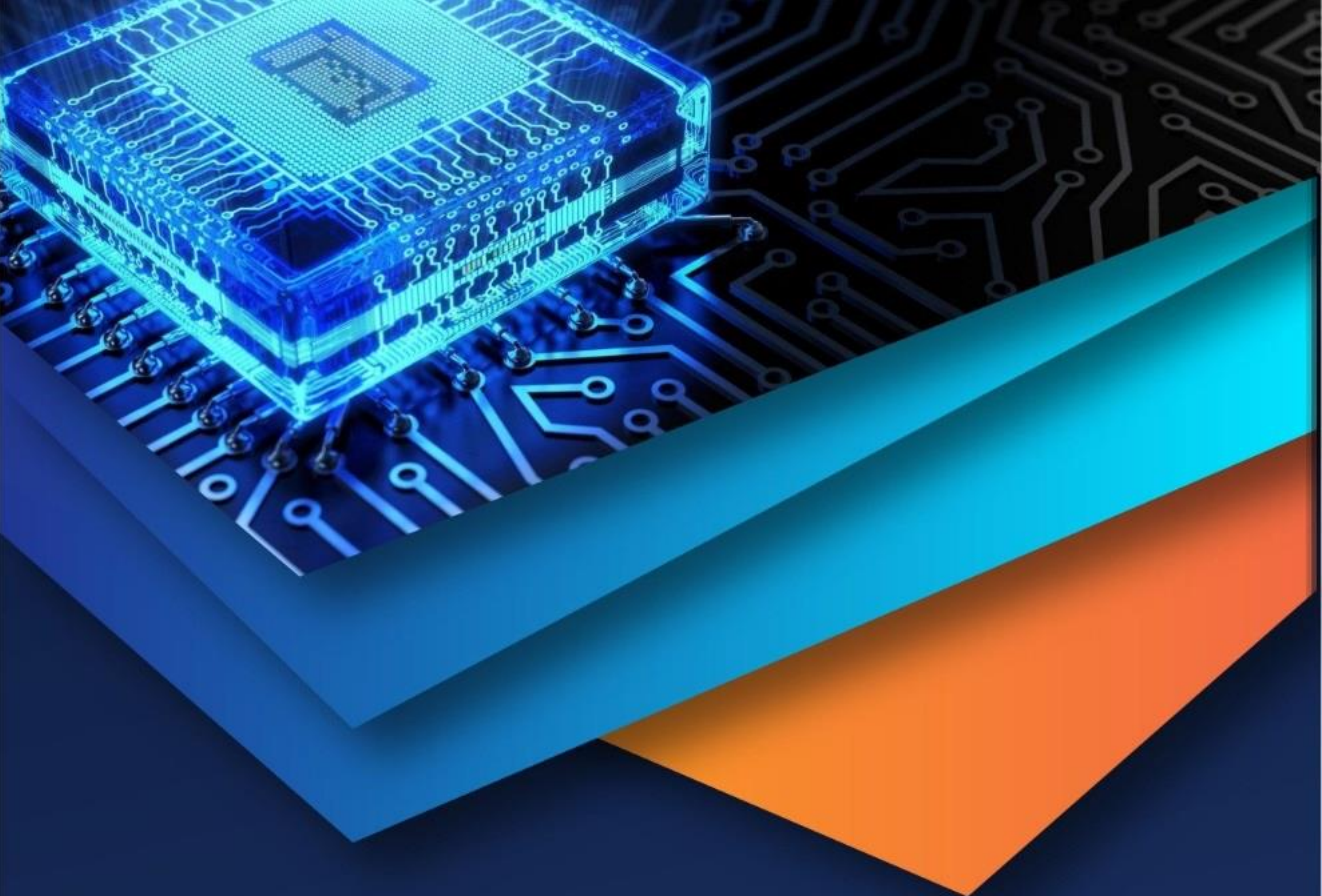
The study confirms that decentralized circular economy-based municipal waste processing systems can significantly improve sustainable urban environmental management while minimizing landfill dependency and environmental pollution.

VIII. FUTURE SCOPE

1) IoT-based smart segregation systems
2) GIS-based waste collection optimization
3) AI-based recyclable recovery prediction
4) Biomethanation integration
5) Waste-to-energy applications
6) Carbon footprint assessment
7) Life Cycle Assessment (LCA)
8) Smart circular economy framework development

REFERENCES

[1] Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank Publications.
[2] Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review. International Journal of Environmental Research and Public Health, 16(6), 1060.
[3] Das, S., Lee, S.H., Kumar, P., et al. (2019). Solid Waste Management: Scope and Sustainability Challenges. Journal of Cleaner Production, 228, 658–678.
[4] Chaturvedi, B., & Arora, R. (2020). Decentralized Composting for Sustainable Urban Waste Management. International Journal of Environmental Science and Technology, 17(5), 2413–2424.
[5] Kumar, A., Agrawal, A., & Singh, P. (2021). Resource Recovery Potential from Municipal Solid Waste. Environmental Technology & Innovation, 24, 101892.
[6] Bhardwaj, A.K., & Pal, Y. (2022). Circular Economy Approaches in Municipal Solid Waste Management. Journal of Cleaner Production, 330, 129809.
[7] Gour, A.A., Singh, S.K., & Mandal, A. (2023). Sustainable Municipal Solid Waste Management Practices in India. Environmental Engineering Research, 28(4), 220249.
[8] Kapoor, A., & Chakma, N. (2024). Urban Municipal Waste Management Challenges in Developing Regions. Journal of Environmental Management, 352, 119845.
[9] Sharholy, M., Ahmad, K., Mahmood, G., & Trivedi, R.C. (2008). Municipal Solid Waste Management in Indian Cities – A Review. Waste Management, 28(2), 459–467.
[10] Annepu, R.K. (2012). Sustainable Solid Waste Management in India. Columbia University, Earth Engineering Center Report.
[11] Joshi, R., & Ahmed, S. (2016). Status and Challenges of Municipal Solid Waste Management in India: A Review. Cogent Environmental Science, 2(1), 1139434.
[12] Mor, S., Ravindra, K., Dahiya, R.P., & Chandra, A. (2006). Leachate Characterization and Assessment of Groundwater Pollution near Municipal Solid Waste Landfill Site. Environmental Monitoring and Assessment, 118, 435–456.
[13] Gupta, N., Yadav, K.K., & Kumar, V. (2015). A Review on Current Status of Municipal Solid Waste Management in India. Journal of Environmental Sciences, 37, 206–217.
[14] CPHEEO (2016). Manual on Municipal Solid Waste Management. Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India.
[15] Singh, R.P., & Agrawal, M. (2008). Potential Benefits and Risks of Land Application of Sewage Sludge. Waste Management, 28(2), 347–358.
[16] Sarkar, P., & Chourasia, R. (2017). Bioconversion of Organic Solid Wastes into Biofortified Compost using Indigenous Microbial Consortium. Waste and Biomass Valorization, 8, 1287–1299.
[17] Gupta, S., Mohan, K., Prasad, R., Gupta, S., & Kansal, A. (1998). Solid Waste Management in India: Options and Opportunities. Resources, Conservation and Recycling, 24(2), 137–154.
[18] Kumar, S., Smith, S.R., Fowler, G., et al. (2017). Challenges and Opportunities Associated with Waste Management in India. Royal Society Open Science, 4(3), 160764.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY