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A Model Municipality in Sustainable Solid Waste Management: Insights from Attingal, Thiruvananthapuram, Kerala

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Abstract

Scrap waste management is an important part of municipal solid waste systems, especially in fast-growing towns where a lot of recyclable materials are produced. This study looks at how scrap waste is managed in Attingal Municipality, Kerala, using field surveys, direct observation, and interviews with stakeholders. The research gathered information from scrap dealers, municipal officials, and residents living near scrap collection units to understand their awareness, satisfaction, environmental concerns, and views on economic benefits. The results show that scrap collection units help with recycling and provide jobs, but there are still problems with waste separation, regulatory checks, and public awareness. Residents often mentioned noise, soil pollution, and worries about long-term health effects. The study points out the need for better oversight, clearer public communication, and including informal scrap workers in the official waste management system. These findings add local evidence to the limited research on scrap waste management in small and medium-sized towns in India.

Keywords: Scrap Waste, Municipal Solid Waste, Recycling, Attingal Municipality, Informal Sector

Introduction

Waste can be defined as a useless byproduct of various activities that often contains substances found in useful products and is regarded as unwanted or valueless by the producer (Brunner and Rechberger, 2015) .The generation of waste has remained a significant concern since prehistoric times (Amasuomo and Baird, 2016). Waste is an inevitable consequence of human activities (Rincy and George, 2026). Waste can be broadly classified into three main types based on physical state: solid, liquid, and gaseous(White et al., 2020; White et al., 1995). Waste disposal results in both direct and indirect environmental impacts, including land occupation, resource depletion, increased global warming due to methane and other greenhouse gas emissions, water contamination from landfilling, and acidification and toxic effects from air emissions during incineration. The amount and complexity of solid waste have become much bigger as a result of rapid population increase, economic prosperity, the level of commercial activity, cultural tradition, and the specificity of the city or region, and all human activities such as hospitals, agriculture, markets, workshops, food processing, urbanization, changing patterns consumption and economic growth (Abah and Ohimain, 2011; Rincy and George, 2026). Solid Waste Management (SWM) is a serious concern both from environmental and public health perspectives in Urban Local Bodies (ULBs) (Hoornweg, 2012; Meena et al., 2023; Sharma and Jain, 2020). The inefficient capture and limited source segregation of solid waste often results in environmental pollution, soil and water contamination, public health hazards, and social unrest (Sharholy et al., 2008; Gupta et al., 2015). When managed effectively, scrap waste supports resource recovery, reduces landfill pressure, and promotes circular economy practices. Conversely, improper handling and prolonged storage of scrap materials may lead to soil contamination, noise pollution, visual nuisance, and potential human health risks.

Source segregation, door-to-door collection, recycling and resource recovery and scientifically managed (processed) landfilling of remaining waste are the key goals as per the Solid Waste Management Regulations, 2016, that have been laid down by the Government of India for handling solid waste generated in urban areas (MoEFCC, 2016). In spite of these legislation and regulations, a majority of the municipalities have struggled for improvement due to infrastructure limitations, financial constrain and most importantly due to lack of knowledge among publics (Joshi and Ahmed, 2016). In particular, small and medium-sized cities find it difficult to manage integrated solid waste management systems.

Kerala's waste management systems are under increasing strain because of its dense population, urban sprawl, and scarcity of disposable land, despite the state's high literacy rate and social development indicators.(Joseph and Sagar, 2020; The State of Decentralised Solid Waste Management in Kerala Report, 2021) The state has embraced decentralized waste management strategies and encourages community involvement, recycling, and source segregation. Nonetheless, local community opposition, insufficient monitoring, and operational inefficiencies continue to be problems (Harikrishnan G, 2014; KSPCB, 2020). In Kerala's Thiruvananthapuram District, Attingal Municipality is a fast-growing semi-urban area where rising living standards, commercial activity, and residential growth have all contributed to an increase in solid waste generation. Door-to-door collection, decentralized waste management, scrap collection units, and transportation of residual waste to approved processing and disposal facilities are all used by the municipality. The presence of scrap dealers and informal waste handlers plays a significant role in recycling activities, yet their operations often occur close to residential areas, raising concerns related to noise, environmental pollution, and health impacts. It is becoming more widely acknowledged that community involvement and public opinion are important factors in determining efficient solid waste management.

Waste management refers to the various approaches and procedures developed to identify, control, and handle different types of waste from generation to disposal. Comprehensive implementation of waste management processes, including waste prevention, reuse, and recycling where feasible, can significantly reduce environmental impacts when evaluated from a life-cycle perspective. This includes both direct effects, such as emissions, and indirect effects, such as resource depletion (Ameer Mubaslat, 2021). The success of municipal waste management programs is significantly influenced by residents' awareness, satisfaction, and environmental concerns, according to survey-based research (Wilson et al., 2006; Bansal et al., 2024). Therefore, identifying service delivery gaps and enhancing policy implementation requires an understanding of community responses. In this regard, the current study uses a survey-based methodology to evaluate the state of solid waste management in Attingal Municipality. Waste collection methods, public awareness, satisfaction levels, health and environmental issues, and the perceived function of scrap waste management are the main topics of the study. The study aims to improve planning, policy formulation, and sustainable solid waste management practices in Attingal Municipality and comparable urban settings by offering localized empirical evidence. The objective of the present study is to identify the types and nature of scrap materials, estimate the quantity of scrap generated at collection units, and assess the current status of solid waste management practices in Attingal Municipality.

Study Area

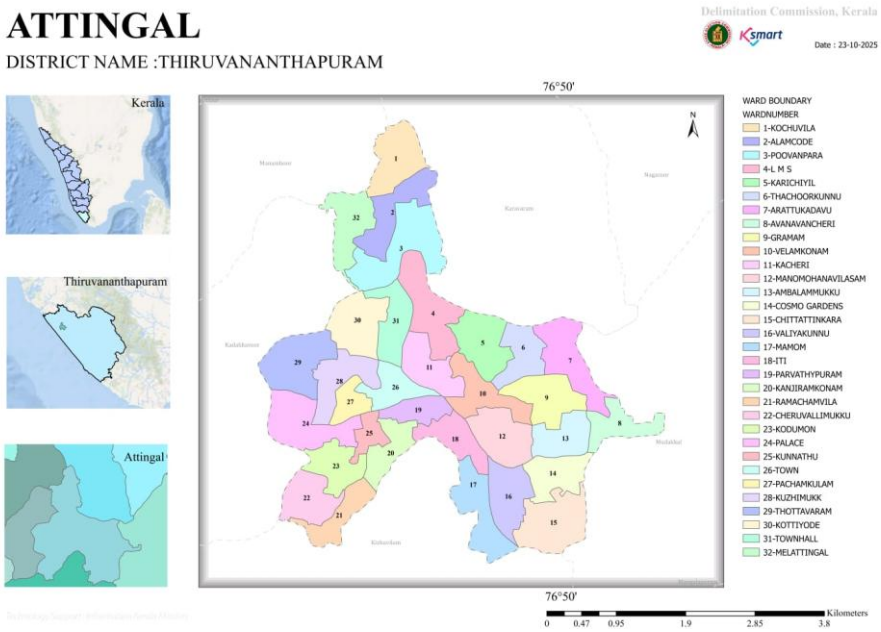


Fig. 1. Map of Attingal Municipality

Attingal Municipality is located in Thiruvananthapuram district, Kerala, India, at latitude 8°41′34″ (approximately 8.6928°N) and longitude 76°48′55″ (approximately 76.8152°E). The municipality spans between 8°34′30″ N and 8°49′38″ N in latitude and between 76°43′47″ E and 77°12′08″ E in longitude. The total area is approximately 16.87 square kilometres, with an average elevation of 23 meters above mean sea level. Attingal Municipality comprises 32 wards and, according to the 2011 Census, has a population of 38,838, including 17,009 males and 20,337 females. The topography is characterized by a sloping terrain with a height variation of about 8.5 meters. Attingal Municipality faces mounting waste challenges as its population grows and urban life intensifies.(Subha et al., 2021) The area is dotted with scrap collection units that handle everything from metals and plastics to glass, batteries, and electronic waste.

Material and methods

Data Collection

Both primary and secondary data were used in the study. Primary data were collected through field visits, visual observation, structured questionnaires, and interviews. Separate questionnaires were designed for (i) municipal authorities and (ii) scrap dealers. A pilot survey was conducted prior to final data collection to ensure clarity and reliability of the questionnaire.

Sample Size

The survey included 100 residents living near the solid waste management plant and scrap collection units and 10 scrap dealers operating within the municipality. Respondents were selected considering variations in age, education, occupation, and proximity to scrap sites.

Data Analysis

Survey responses were analyzed using percentage-based descriptive statistics to assess awareness levels, satisfaction, environmental concerns, and economic perceptions related to scrap waste management.

Results

Solid Waste Management

Waste Generation

Role of Municipality in Biodegradable Waste Management *(Action Plan on Municipal Solid Waste Management of the Municipality 2023-2024)*

Attingal Municipalities play a pivotal role in ensuring effective management of biodegradable solid waste through organized collection, transportation, and treatment systems. In Attingal Municipality, Kerala, biodegradable waste management follows a structured and decentralized approach aimed at minimizing environmental impacts while promoting resource recovery. The process begins with door-to-door collection of biodegradable waste, carried out daily by Haritha Karma Sena Members (HKSMs). Approximately 15-20 tonnes per day (TPD) of biodegradable waste is collected from residential households, shops, hotels, markets, and public institutions (Subha et al., 2021).

Table 1. Quantity of scrap wastes collection in tonnes per day (tpd) from different institutions in Attingal Municipality, 2018-2019 (Source: Sabah et al., 2021; Action Plan on Municipal Solid Waste Management of the Municipality 2018-19)

Sl.No.	Type of Institutions	Nos.	Expected Generation Rate (tpd)
1	Households	15633	1.2
2	Schools	19	0.209
3	Colleges	5	0.055
4	Offices	46	0.506
5	Halls	8	0.088
6	Hotels	40	0.44
7	Hostels	5	0.044
8	Hospitals	11	0.121
9	Restaurants	15	0.165
10	Markets	6	2.83
11	Shopping malls	6	3.00
12	Housing Colonies	7	0.5
13	Housing Towers	2	0.5
14	Slums	5	1
TOTAL SCRAP WASTE COLLECTION (TPD)			10.658

A total of 21 HKSMs are responsible for collecting biodegradable waste on a daily basis. They are collecting user fees from each house (75-100 Rs/-) and commercial (100-150 Rs/-) mainly based on the quantity of waste collected.

About 600 houses and 350 shops were currently covered by HKSMs from Attingal Municipality. The Municipality provided collection bins to houses, but some of the households did not utilize these bins because they have extensive land area for disposal of biodegradable waste.

Collected waste is transported using municipal lorries, with three vehicles responsible for transferring the collected biodegradable waste. These vehicles operate across different routes, making six to eight trips daily, ensuring timely removal and preventing waste accumulation at collection points. This one vehicle is also used to collect street sweeping waste in the morning. The collection vehicles are equipped with designated cans and trays that facilitate the segregation of waste into liquid and dry waste categories during transportation. The biodegradable waste is transported to the Solid Waste Management Plant of Attingal Municipality, which covers an area of approximately four acres. At the facility, waste is treated using biological processing techniques, mainly windrow composting and vermi-composting. The windrow composting unit has a treatment capacity of 12 TPD, where organic waste is aerobically decomposed under controlled conditions. Additionally, a vermi-composting unit with a capacity of 0.5 TPD is used to convert selected organic waste into nutrient-rich compost through earthworm activity.

The municipality is primarily responsible for waste collection and transportation, which is carried out through Haritha Karma Sena Members (HKSMs). Segregated biodegradable waste collected from households, commercial establishments, markets, and public places is transported to the municipal solid waste management plant by the municipal system. Once the segregated biodegradable waste reaches the waste management facility, it is handed over to the private sector agency, Qurex Biox Solution Pvt Ltd, which is entrusted with the complete responsibility of waste processing and resource recovery. Qurex Biox Solution Pvt Ltd operates and manages the windrow composting and vermicomposting units within the Attingal Municipality waste management plant. The company undertakes the scientific processing of organic waste, including sorting, biological treatment, compost maturation, and quality control of the final compost product. The entire composting process, from waste stabilization to the production of marketable compost, is executed by Qurex Biox Solutions Pvt Ltd. The generated compost is subsequently marketed and sold by the private agency, and the economic benefits and profits derived from compost production are retained by the company, as per the operational agreement. This arrangement reduces the operational burden on the municipality while promoting efficient waste treatment through private sector expertise. This model demonstrates a functional example of outsourced biodegradable waste processing, where the municipality acts as a facilitator by ensuring a steady waste supply, while the private operator focuses on technological efficiency, operational management, and financial sustainability. Such partnerships contribute to improved waste diversion from landfills, enhanced compost production, and the promotion of circular economy principles at the municipal level.

Role of Municipality in Non-Biodegradable Waste Management

According to the action plan submitted by the Municipality, the total quantity of waste collected each day is approximately 16-18 tonnes per day (TPD), comprising different categories that are managed through separate systems. The major share of this waste is biodegradable in nature, accounting for about 13.25 TPD, primarily generated from households and market areas. In addition, around 3 TPD of non-biodegradable waste is collected daily. The municipality also collects nearly 1 tonne of plastic waste per day, along with approximately 0.4 tonnes of other non-recyclable materials, such as discarded bags and footwear. A very small quantity of biomedical and hazardous waste, amounting to less than 60 kg per day, is generated and is handled separately with strict safety measures to ensure proper disposal.

The types of scrap waste collected by Attingal Municipality, contributing to the 3 TPD of non-biodegradable waste, along with their estimated quantities, are presented in the following graph.

Fig. 2. Quantity of scrap wastes collected by HKSMs (TPD) (Source: Sabah et al., 2021; Action Plan on Municipal Solid Waste Management of the Municipality 2023-24)

The municipality collects scrap waste like plastic, paper, leather, glass, metals, and e-waste through a door-to-door system run by the Haritha Karma Sena (HKS), usually once a month, quarterly or yearly. HKS is made up mostly of women, informal waste collectors, and trained volunteers who help sort, collect, and direct recyclable waste from homes, businesses, and institutions. Each ward typically has two HKS workers for non-biodegradable waste collection. Households pay a monthly fee of ₹50 to ₹75, and institutions pay ₹100 to ₹150, no matter how much scrap they give. Since there is no direct payment for the materials, some residents choose to sell recyclables to private traders for quick cash. Collected non-biodegradable (scrap) waste is transferred to ward-level Mini Material Collection Facilities (Mini MCFs) where primary segregation is done by Mini MCF. Every ward feature two Mini MCFs, making it easy to sort and store recyclables like plastics, metals, glass, and paper right where the waste is generated. By handling materials at the ward level, the system shortens transport routes, boosts efficiency, and allows for closer tracking of waste streams. Five electric autos travel through five wards each day, collecting scrap waste and delivering it to the central facility. This green fleet not only streamlines logistics but also helps the municipality cut down on carbon emissions.

Waste collected from Mini Material Collection Facilities (Mini MCFs) is transported to the central Material Collection Facility (MCF) and the Resource Recovery Facility (RRF), which operate in an integrated manner at the Solid Waste Management Plant of Attingal Municipality for advanced sorting and processing. Secondary segregation is carried out at the MCF, which has a handling capacity of approximately 2 tonnes per day and performs additional sorting to ensure material purity. The RRF processes about 1 tonne of waste per day and enhances material quality through operations such as baling, shredding, and cleaning, thereby facilitating recycling and improving the market value of recovered materials.

Following processing, segregated recyclable materials are transferred to authorized agencies, including Clean Kerala Company Limited (CKCL), Green Worms, and Eco Solution. These agencies collect materials from the municipality two to three times per month according to an annual schedule. The municipal health section supervises the collection and transportation processes in accordance with the schedule prescribed by CKCL (Table 2). Revenue generated from the sale of recyclable materials is shared with the municipality, while the processed materials are supplied to authorized recyclers, cement plants for the production of refuse-derived fuel (RDF), road construction projects utilizing polymer modified bitumen, and other approved recycling units. Residual and non-recyclable wastes are disposed of in an environmentally sound manner by authorized agencies such as Kerala Infrastructure and Environment Limited (KINFRA/KIEL), in compliance with prevailing regulations, thereby supporting sustainable solid waste management in the region.

Table 2. Calender schedule set by Clean Kerala Company Limited (CKCL) for transportation

Sl.No.	Type Of Material	Period
1	Paper, Plastic, Plastic covers	Every month
2	Footwears, bags and belts	January, April, July, October
3	Glass, Glass bottles, Glass waste	February, May, August, November
4	E-Waste (tubelight, CFL, Battery Included)	March, June, December
5	Medicine Strips	January, March. June, September, December
6	Cloth Waste	April, September

The salaries of Haritha Karma Sena Members (HKSMs) are primarily financed through user fees collected from households and institutions, supplemented by revenue generated from agencies such as Clean Kerala Company Limited (CKCL) and Green Worms Eco Solution under annual tender agreements with the municipality. These funds are mainly utilized for providing annual personal safety equipment to HKSMs and for meeting operational expenses, including payments to drivers of e-autos and other vehicles used for waste transportation within the Haritha Karma Sena (HKS) system. Capacity building is strengthened through two training programmes conducted annually by subject experts, focusing on efficient waste handling and occupational safety. For operational management and transparency, HKSMs use the HARITHAMITHRAM mobile application on their personal smartphones to record present data on material collection, ward wise coverage, household level services, and user fee transactions, which are monitored and supervised by the municipal health wing, particularly the Health Inspector, to ensure accountability and effective oversight of scrap waste management activities.

Role of scrap dealers in scrap waste collection and recycling

Scrap dealers have major role in informal and semi-formal scrap waste management system. Their activities significantly contribute to material recovery, resource efficiency, and reduction of waste reaching landfills. The distribution of scrap waste by type collected by scrap dealers are summarized in the following graph.

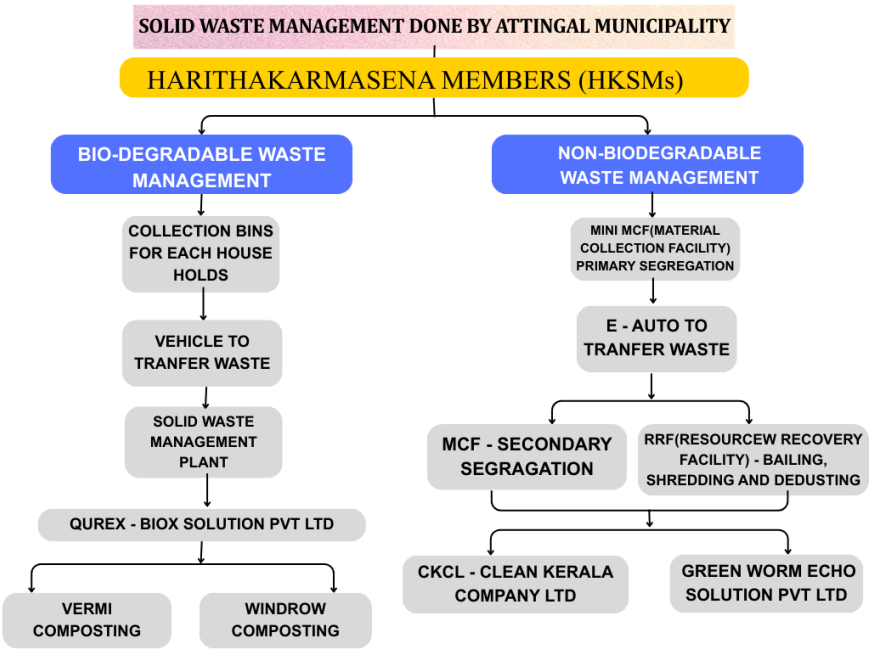
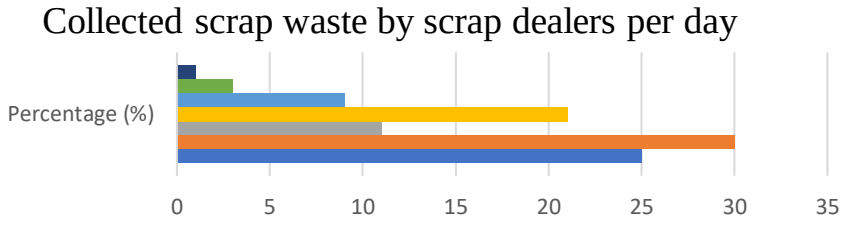


Fig. 3. Solid Waste Management in Attingal Municipality



	Percentage (%)
Textile	1
Rubber and Leather	3
E-Waste	9
Metals	21
Glass	11
Plastic	30
Paper	25

Fig. 4. Scrap dealers collected scrap waste per day in %

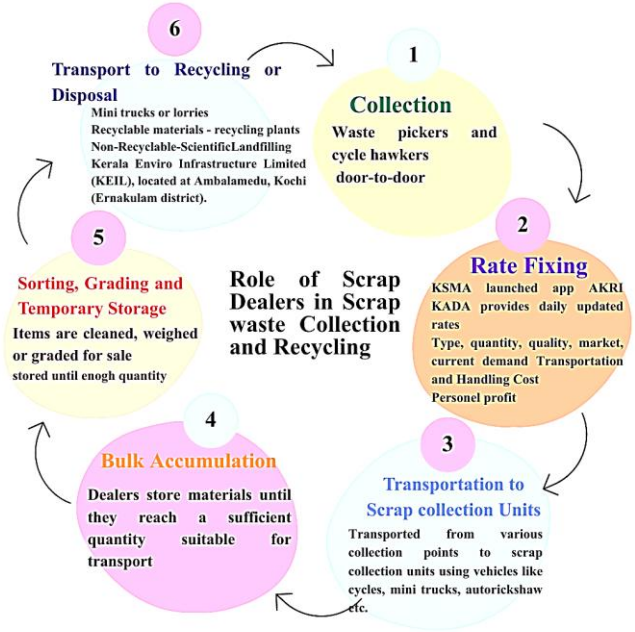


Fig. 5. Scrap dealer's role in scrap waste management

Scrap waste management is a multi-stage process that begins with door-to-door collection by waste pickers and cycle hawkers (Moreno-Sanchez and Maldonado, 2006). These individuals collect recyclable materials, including metals, plastics, paper, glass, and e-waste, from households and commercial establishments and sell them to local scrap dealers. The collected materials are accumulated at scrap collection units until they reach economically viable quantities for transport and recycling. Scrap material pricing is primarily determined by market forces, including material type, quality, weight, and demand. Digital platforms such as the AKRIKADA mobile application support transparent price discovery and facilitate the integration of informal collectors into organized recycling chains. Scrap is transported using low-cost vehicles to collection units, where it is sorted, graded, and temporarily stored to increase material value. The processed materials are then transported to authorized recycling or reprocessing facilities. Non-recyclable residues are disposed of through scientifically managed systems under regulatory supervision, supporting efficient and sustainable scrap waste management.

Discussion

Recent studies (2020-2025) show that current municipal solid waste management systems are evolving toward more integrated, decentralized, and climate-aware models. However, challenges such as inconsistent source segregation, uneven service coverage, financial constraints, and limited technology adoption persist. Successful municipalities combine strong policy enforcement, community engagement, inclusive informal sector integration, and innovative financing to achieve higher recycling rates and lower landfill dependence.

Key Feature / Challenge	Discussion	Reference
Source Segregation at Household Level	Many municipalities mandate segregation into biodegradable, recyclable, and inert waste. However, actual compliance varies widely. Households often lack awareness or proper segregation bins, leading to mixed waste streams that hinder treatment and recycling efforts. Successful programs combine education, incentives, and monitoring.	Al-Khatib et al., (2010); UNEP & ISWA (2022)
Collection Efficiency and Coverage	Urban local bodies typically provide collection services, but performance differs by zone. High-income areas often have better services than peri-urban or low-income zones. Gaps in staffing, vehicles, and route planning lead to delays, overflowing bins, and illegal dumping in some municipalities. Urban IoT deployments improve collection efficiency, but adoption is hindered by upfront costs and technical capacity.	Hoque et al. (2021); World Bank (2024); Tran et al., (2021)
Decentralized Processing (Composting & Recycling)	Decentralized composting and material recovery facilities (MRFs) are recognized as effective for reducing landfill load. Municipalities implementing ward-level composting and local scrap collection report reduced transport costs and increased material recovery. Yet, uptake remains uneven.	The State of Decentralized SWM in Kerala (2021); Schubeler et al., (2023)
Role of Informal Sector in Scrap Recycling	In many municipalities, informal waste pickers play a critical role in recovering recyclables. Formal recognition and integration (e.g., access to sorting centres, fair pay) improve recovery rates and reduce municipal burdens. Lack of integration often marginalizes these contributors, reducing overall efficiency.	Dias et al. (2021); Scheinberg et al., (2010)
Policy Framework & Governance	National and state policies provide guidelines, mandates, and performance targets. However, municipalities often struggle with enforcement and inter-agency coordination. Strong governance structures and clear roles improve implementation of source segregation and waste processing targets.	UNEP & ISWA (2022); Kabir et al., (2022)
Financial Sustainability & Cost Recovery	Municipal budgets for waste management are often constrained. Cost recovery through user fees, waste tariffs, and producer responsibility schemes improves financial viability. Without sustainable financing, municipalities struggle to upgrade infrastructure and services.	World Bank (2024); UNEP (2021)
Technology Adoption (Smart Systems)	Smart technologies (e.g., IoT sensors, AI sorting, route optimization) are increasingly used in some municipalities to improve collection efficiency and segregation quality. Barriers include high upfront costs, technical expertise shortages, and maintenance challenges in smaller towns.	Tran et al., (2021); Singh et al., (2024)
Environmental & Climate Considerations	Modern municipal systems are increasingly evaluated on climate impacts (e.g., methane from landfills). Prioritizing recycling, composting, and landfill gas capture aligns municipal waste strategies with climate mitigation goals.	Kaza et al., (2025); Singh et al., (2022)
Public Awareness & Behaviour Change	Municipal success is tied to public participation. Outreach campaigns, school programs, and local champions improve awareness and participation in segregation and recycling. Lack of ongoing engagement often results in persistent improper disposal practices.	Bansal et al. (2024); UNEP & ISWA (2022)

Infrastructure & Logistics Gaps	Many municipalities still depend on legacy landfills with minimal processing. Logistics challenges-such as insufficient fleet size, poor road access to remote wards, and inadequate transfer stations-limit the efficiency of municipal waste systems.	Hoque et al. (2021); Al-Jubouri et al., (2022)
Municipal inclusion strategies	Case studies demonstrate that formalizing informal recyclers boosts recovery rates and enhances social equity.	Schubeler et al., (2023)

Conclusion

The generation of substantial volume of scrap materials such as plastics, glass, aluminium, e-waste, cardboard, metal, wire, copper, brass, steel, paper, wood, construction and demolition materials, vehicles parts, lead, leather, rubber, and more, is a significant environmental concern. Despite the presence of numerous of metals, e-waste and plastic scrap collection units within municipality and cooperation in densely populated areas, the improper disposal of these materials remains a critical issue. Nobody is worried or nobody is bothered. So, this study is crucial to make sure the scrap is not dumped for prolonged period and it's a relevant subject due to its environmental impact and very limited research focusing specifically on this issue. The findings indicate that although scrap collection units offer economic benefits and support recycling initiatives, challenges such as inadequate segregation, irregular collection practices, and insufficient regulatory monitoring contribute to environmental and social concerns. Therefore, strengthening public awareness programmes, improving operational practices, and enhancing regulatory oversight are essential to ensure effective, sustainable, and publicly acceptable scrap waste management systems.

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Author Contributions

AR, conceptualized the study, conducted the field investigations, collected data, performed laboratory analyses, carried out formal data analysis, prepared visualizations and figures, and drafted the original manuscript. AG, supervised the research, strengthened the methodological framework, reviewed and edited the manuscript, validated the findings, and approved the final version for publication.

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