

Sustainable Municipal Solid Waste Management: The Haritha Karmasena Model from Sorting to Recycling

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ABSTRACT

Effective waste management is a cornerstone of sustainable development, addressing the significant challenges posed by the increasing volumes of waste generated by human activities. This study explores the multifaceted importance of waste management, encompassing environmental protection, resource conservation, and public health. By preventing the pollution of air, water, and soil, waste management safeguards ecosystems and human health. Moreover, it promotes resource conservation through recycling and proper disposal practices, conserving valuable materials, energy, and water. Proper waste management also enhances community aesthetics, contributing to more pleasant living and working environments. Focusing on the Kannur district, this study analyzes the waste management practices facilitated by the Haritha Karma Sena, emphasizing their role in the collection and recycling processes. It examines the effectiveness of the Material Collection Facility (MCF) and the Resource Recovery Facility (RRF) in addressing waste-related issues within the municipality. By assessing the activities and impact of the Haritha Karma Sena, the study aims to provide insights into their contribution to efficient waste management and its benefits to the local community. Through this analysis, the study underscores the importance of structured waste management systems in mitigating environmental and health risks while promoting sustainability and resource efficiency.

Keywords: Local Self Government Bodies, Solid waste management, Clean Kerala Mission Micro Enterprise, Haritha Karma Sena, Material Collection Facility, Resource Recovery Facility

INTRODUCTION

The environment encompasses the intricate web of living and non-living elements that form the backdrop of our existence. It is the stage upon which life unfolds, comprising the air we breathe, the water we drink, and the ecosystems that sustain diverse life forms. In the economy, the environment is a foundation for various industries such as agriculture, forestry, and fisheries. Natural resources like water, minerals, and energy sources drive economic activities. Sustainable environmental practices are essential for maintaining these resources, ensuring a stable economy, and promoting long-term human prosperity. Ignoring environmental considerations can lead to ecological degradation, resource depletion, and economic challenges. Major environmental problems include climate change, deforestation, air and water pollution, loss of biodiversity, and overexploitation of natural resources. These issues result from human activities such as industrialization, overconsumption, and improper waste disposal. Addressing these challenges requires global cooperation, sustainable practices, and a commitment to environmental conservation to ensure a healthier and more sustainable future. Sustainable waste management looks for solutions that don't harm the environment or human health and focus on reducing natural resource consumption.

India's waste management faces challenges, producing 62 million tonnes of waste annually, with 70% collected, but only 30% properly sorted. Urbanization adds pressure, generating 62 million tons of solid waste, but only 43 million tons are collected. E-waste poses a growing concern. The solid waste management sector in India has experienced significant growth, largely driven by government initiatives such as the Swachh Bharat Abhiyan

(Clean India Mission). Rapid urbanization and population growth have increased waste generation, necessitating efficient and sustainable waste management solutions. The sector is projected to grow at a CAGR of 7.5% from 2021-2026 due to urbanization, growing awareness of waste management, and infrastructure investments. India generates over 62 million tons of waste annually, with only 43 million tons collected and 12 million tons treated, leaving 31 million tons discarded. Waste types include hazardous, plastic, e-waste, and biomedical waste, with total waste generation expected to reach 165 million tons by 2030. The market is segmented into collection, transportation, treatment, and disposal, with the collection and transportation segments holding the largest market share due to inadequate infrastructure. The treatment and disposal segments are expected to grow significantly, with a focus on sustainable practices. However, municipal authorities often lack proper waste processing centers and adequate disposal facilities due to financial, scientific, and technical constraints, leading to untreated and unaccounted waste, causing environmental and public health issues. Government projects like the Swachh Bharat Mission and the development of 100 smart cities, along with the 2016 amendment to SWM rules, emphasize circular economy principles and encourage integrated waste management systems, source-specific collection, home composting, and material and energy recovery from waste. Solutions include scientific studies, innovative technologies, and improved waste collection. Integrating formal and informal sectors, promoting recycling, and treating organic waste through composting are crucial. Waste-to-energy methods and common treatment facilities are encouraged. Strict enforcement of waste management rules and public awareness are vital. India must focus on long-term waste management strategies, 4 emphasizing source segregation, investing in treatment technologies, and fostering public-private partnerships. The current system's inadequacy, inefficient sorting, and improper disposal contribute to environmental and health hazards, making widespread improvements imperative.

1.1.Waste Management in Kerala

The Suchitwa Keralam Campaign in Kerala has significantly contributed to waste management by emphasizing local employment generation and income opportunities. The comprehensive assessment conducted in April 2021 highlighted key areas for improvement across various components of the waste management system, including the role of Local Self Government bodies (LSGs), infrastructure, community compost facilities, and innovative practices. Recommendations for action encompass expanding door-to-door collection, improving infrastructure, enhancing worker conditions, incentivizing composting, and enforcing regulations. Moreover, innovative initiatives like upcycling challenges and swap shops underscore the community's commitment to sustainable waste management. Moving forward, continued collaboration between government agencies, local communities, and stakeholders is crucial to further enhance Kerala's waste management efforts and achieve environmental sustainability. Kerala faces significant waste management challenges across various categories. In plastic waste management, insufficient collection from households, institutions, and commercial establishments has led to widespread burning and dumping in public places. Shredding and baling machines are often non-functional, and poor segregation of recyclable waste results in disposal as rejects. This mismanagement has caused incidents of fire outbreaks due to open burning of plastic waste. The lack of an Extended Producer Responsibility (EPR) system in Urban Local Bodies (ULBs) exacerbates the problem. Biomedical waste management is also problematic. E-waste management is hindered by the absence of an EPR mechanism and a lack of records on waste generation. Similarly, construction and demolition waste management suffers from the absence of facilities for processing, recycling, and disposal.

1.2. Waste Management in Kannur District

Kannur district in Kerala is actively working towards becoming a plastic-free zone with comprehensive waste management initiatives. Solid, wet, and e-waste management bylaws are being implemented, and the district is declared 'Flex Free Kannur.' Decentralized plastic collection includes roadside bins and regular drives, with recognition and benefits for those involved. Source-level management involves households handing over dry discards to rag pickers or Haritha Karma Senas. Schools participate in the "Collectors at School" program to instill segregation habits. Green Protocol is mandated for events, reducing disposable plastic use. Awareness campaigns, green elections, cloth bag distribution, swap shops, and sensitization programs contribute to fostering environmental consciousness.

LITERATURE REVIEW

Taenaz Shakir, N. C. Narayanan, Rene Veron (2020) study analyzes the initiative in Kerala that aims to analyze the municipal solid waste management governance structure at central, state, and local levels. It highlights the role of Haritha Karma Sena, comprised mainly of Kudumbashree women, in managing non-biodegradable waste for local self-governments. Tinto Tom and Dr. Raja Kamal's (2020) study points out the importance of waste management and sustainable practices. Current challenges include difficulty in waste management and adoption of unscientific disposal methods, particularly for non-biodegradable materials like plastic. To restore balance, it's crucial to prioritize scientific methods such as recycling and responsible waste collection. Maya Raveendran and Kirubabakaran Samuel's (2019) study reveals waste management schemes, household awareness, and the role of Neighborhood Groups (NHG) women. Their study proved that respondents differ in their level of women's environmental awareness among NHG women on the basis of practicing 10 environmental schemes. Dr. Rajeev S. R.'s (2023) study explains that the Green Army, a voluntary initiative led by Kudumbasree women, plays a crucial role in solid waste management in Kerala. The Green Army focuses on achieving a waste-free Kerala, controlled by the Kudumbasree and Swachh Mission; these trained volunteers specialize in green protocol, swap shop, and water conservation, embodying a comprehensive approach to sustainable waste management across the state.

Objectives of the research

1. To examine the role of Haritha Karma Sena (HKS) and Material Collection Facilities (MCF) in solid waste management practices in Sreekandapuram municipality, Kannur district, Kerala.
2. To assess the functions and operational activities of Resource Recovery Facilities (RRF) in promoting effective solid waste management.

METHODOLOGY OF RESEARCH

Research design:	The study is descriptive and analytical in nature., as it aims to assess the functions and operational activities of Resource Recovery Facilities (RRFs).
Population:	This study was conducted among HKS workers, Sreekandapuram Municipality, as they are directly involved in solid waste management activities.
Sampling Method:	Total enumeration (census method) was adopted , as the entire population of 30 eligible HKS workers was included in the study.
Sample size:	The study included all 30 eligible HKS workers in Sreekandapuram Municipality. Therefore, the sample size was 30, representing the entire study population.
Primary data:	Primary data were collected using a structured questionnaire to ensure uniform and reliable data collection.
Secondary data:	Secondary data were collected from books, journals, government reports, and authentic websites to provide theoretical support for the study.
Analysis tool:	The collected data were analysed using growth rate analysis, and the results were presented through tables and charts for better interpretation.

SIGNIFICANCE OF THE STUDY

Solid waste management is essential for environmental sustainability and public health. Effective waste disposal and recycling practices help prevent pollution, protect ecosystems, and minimize health risks associated with improper waste handling. Haritha Karma Sena plays a pivotal role in solid waste management through activities

such as waste collection, segregation, and awareness campaigns. Their efforts are instrumental in maintaining clean surroundings, reducing the burden on landfills, and fostering a culture of responsible waste disposal. By organizing and mobilizing communities, Haritha Karma Sena addresses immediate waste management needs while instilling a sense of environmental responsibility in individuals. This grassroots involvement is crucial for creating lasting changes in waste management practices and promoting sustainable habits within communities. Following the door-to-door collection process, local governments focus on Material Collection Facilities (MCFs) and Resource Recovery Facilities (RRFs). MCFs play a crucial role in local self-government waste management efforts. They ensure the source segregation of non-biodegradable waste, enhancing recycling and reducing landfill use. With a systematic work calendar, MCFs reduce manual labor, prevent pollution, and promote community involvement and regulatory compliance. Additionally, MCFs provide economic benefits by creating recycling opportunities and lowering waste management costs, contributing to an efficient and sustainable system. RRFs process municipal solid waste (MSW) and other types of waste to recover valuable resources, including recyclable materials and energy. The primary goal of an RRF is to reduce the amount of waste ending up in landfills by extracting useful materials and converting waste into energy. RRFs employ advanced sorting technologies, human labor, and specialised equipment to sort, process, and repurpose non-biodegradable waste. They play a critical role in promoting recycling, supporting sustainable production activities, and finding innovative uses for non-recyclable materials, such as in road tarring.

DATA ANALYSIS AND FINDINGS

Waste management is a critical aspect of maintaining environmental health and sustainability. It involves the collection, transportation, processing, recycling, and disposal of waste materials in a manner that minimizes their impact on the environment. Haritha Karma Sena is a volunteer group dedicated to waste management, while Material Collection Facilities (MCF) store waste temporarily. Resource Recovery Facilities (RRFs) recover resources from waste for recycling, reducing landfill waste. Together, they enhance waste management, promote sustainability, and maintain cleanliness in communities. Haritha Karma Sena has notably improved waste management in Sreekandapuram Municipality since 2018, engaging in community projects and raising environmental awareness. RRFs, established by local bodies and managed by Clean Kerala, segregate recyclable and non-recyclable waste, facilitating safe disposal and recycling, including e-waste. Additionally, it also covers the responsibilities of the Haritha Karma Sena and the tasks performed by the RRF in Sreekandapuram Municipality.

6.1. Role of mini MCF and Material collection facility (MCF) in waste management of Sreekandapuram municipality

In the Sreekandapuram municipality, the waste management process involves several structured steps to ensure efficient handling and recycling of waste materials. The waste management process in Sreekandapuram municipality has been updated according to the latest instructions from the municipality. Now, the sorting of recyclable materials is carried out at the mini Material Collection Facilities (mini MCFs) located in each ward, rather than at the central MCF. Here's an explanation of the updated process:

6.1.1 Door-to-Door Collection

Haritha Karma Sena: This team is responsible for collecting waste directly from households and businesses through door-to-door collection.

6.1.2 Sorting at Mini MCFs

Initial Sorting: The collected waste is first taken to the mini MCFs in each ward. At this stage, the waste is sorted into different categories, such as plastics, paper, metals, and glass.

This decentralized approach allows for more efficient and localized sorting.

Table 1: Sorting of plastic:

	Types
1	HM
2	CHM mix
3	PP
4	Print
5	LD 1
6	LD 2
7	Milma cover
8	Oil cover
9	MLP
10	Bottles

(Source; Primary data)

Table 1 presents the different types of plastic waste identified in the plastic module used by the Haritha Karma Sena for waste segregation. These are the categories of plastic items collected from households every month by the Haritha Karma Sena before being transported for recycling. Plastic waste is sorted in to ten categories, namely HM, CHM mix, PP, printed plastic, LD1, LD2, milma covers, oil covers, MLP and bottles. Among these, HM plastic which mainly includes carry bags and plastic covers, is the most commonly collected category, while the remaining categories are collected in comparatively smaller quantities.

6.1.3 Transportation to Central MCF

Municipality Vehicles: After the waste is sorted at the mini MCFs, the sorted materials are transported by municipality vehicles to the central Material Collection Facility in the village of Kavumbayi.

6.1.4 Further Processing

Central MCF Operations: At the central MCF, the already sorted materials are consolidated and prepared for further processing. The central MCF acts as a hub for temporarily holding the sorted recyclables before they are sent to recycling centres.

Transfer to Recycling Facilities: The sorted and consolidated recyclable materials are then sent to the Resource Recovery Facility (RRF) for further processing and recycling.

6.1.5 Key Functions of the Process

- **Receiving and Sorting at Mini MCFs:** The mini MCFs are now responsible for the initial sorting of collected waste, streamlining the process and reducing the workload at the central MCF.

- **Efficient Transportation:** With pre-sorted materials, transportation to the central MCF is more efficient, reducing the need for extensive sorting at the central location.
- **Temporary Storage and Consolidation:** The central MCF still plays a crucial role in temporarily holding and consolidating the sorted materials before they are sent to the RRF.
- **Supporting Municipal Waste Management:** The updated method supports a more decentralized and efficient approach to waste management, ensuring better recycling outcomes and more effective use of resources.

This updated process reflects a more streamlined and efficient approach to waste management in Sreekandapuram Municipality, ensuring that waste is sorted closer to the source and that the overall system is more effective in handling and recycling materials.

6.2 RRF in Sreekandapuram Municipality

The Resource Recovery Facility (RRF) of Sreekandapuram Municipality, situated in Kavumbayi village, has been operational since October 1st, 2020. It serves as a vital center for managing various waste materials, particularly plastics collected from households. The RRF is financially supported by the municipality and is under its control, with operational oversight provided by Haritha Karma Sena and other municipal staff. The process begins with Haritha Karma Sena delivering collected plastics from households to the Material Collection Facility (MCF). From there, these materials are transferred to the RRF for further processing. At the RRF, the plastics undergo bailing, sorting, and bundling. The facility is equipped with essential machinery to facilitate these operations, including a shredding machine, a baling machine, and two weighing machines. The Haritha Karma Sena members from all 30 wards will gather at the RRF (Resource Recovery Facility) on the designated days. Once there, they will be responsible for sorting the plastics collected from their respective wards. Additionally, they will assist in baling the sorted plastics, which involves compacting them into bales for easier storage and transportation.

Table 2: Collected waste in the year 2024

Month	Collected waste (in kg)	Growth rate(%)
April	7500	-
May	10000	33.33
June	20000	100.00
July	19200	-4.00
August	16250	-15.36
September	14800	-8.92
October	15000	1.35
November	14200	-5.33
December	13300	-6.34

(Source: primary data)



Figure 1. Collected waste in the year 2024 (Source: Primary data)

Table 2 shows the total waste collected by Haritha Karma Sena from April to June. The month- on -month growth rate analysis shows that waste collection increased by 33.3% in May and reached its highest growth of 100% in June, indicating a substantial improvement in collection activities. Therefore, the growth rate became negative from July to September, reflecting a decline in the quantity of waste collected. A marginal positive growth of 1.35% was observed in October, followed by negative growth in November (-5.33%) and December (-6.34%). Over all, waste collection peak in June (20,000 kg) and showed a gradual declining trend during the remaining months of the year. Plastic items and plastic bottles are collected regularly every month by the Haritha Karma Sena from households. However, in addition to these regular collections, a specific category of non-biodegradable waste such as textiles, glass, thermocol, electronic waste, etc., is selected for collection in different month. Since the quantity of these collected waste categories varies from month to month, the total quantity of waste collected also change accordingly. Therefore, the observed monthly fluctuations mainly reflect the variation in the type and volume of the additional waste category collected during each month, rather than any inconsistency in the waste collection system.

6.3 Operation of a Resource Recovery Facility (RRF)

6.3.1 Bailing

In an RRF, bailing machines compact recyclable materials like paper and plastics into bales. This process makes them easier to handle and transport to recycling facilities. After plastic is sorted and baled at the Resource Recovery Facility (RRF), it's sent to recycling facilities. These recycling facilities further process the plastics to turn them into new products, reducing the need for virgin plastic production and minimizing environmental impact. This closed-loop system helps maximize the value of plastic waste while promoting sustainability and circular economy principles.

6.3.2 Shredding of plastic

RRFs also employ shredders to break down non-recyclable plastics into smaller pieces. These smaller shreds can then be utilized in various alternative applications.

- **Road Tarring:** One innovative application of shredded non-recyclable plastics is in road construction. RRFs can mix the shredded plastic with bitumen, a common road-tarring material. This mixture enhances road durability and longevity while providing a sustainable solution for disposing of non-recyclable plastics. By

diverting plastics from landfills into road construction, RRFs contribute to reducing the environmental impact of plastic waste.

RRF, situated in Kavumbayi, In the last two years, received 36,000 rupees to Kavumbayi RRF which gave 1500 kg of shredded plastic for road tarring. But now it is not possible to do it because it is not getting enough orders.

RRFs (Resource Recovery Facilities) play a crucial role in the storage and treatment of segregated non-biodegradable waste, including hazardous waste. Clean Kerala Company's treatment processes further refine this waste, ensuring proper disposal or recycling methods are employed. This approach contributes to environmental sustainability by reducing the impact of hazardous waste on ecosystems and human health.

Haritha Karma Sena, Material Collection Facility, and Resource Recovery Facility are key to effective waste management. Haritha Karma Sena engages communities to segregate waste and raise awareness. MCF collects, sorts, and temporarily stores waste before it's processed. In the RRF, the plastics undergo baling, sorting, and bundling. Together, they create a sustainable system that promotes recycling and follows environmental regulations.

FINDINGS, SUGGESTIONS, AND CONCLUSIONS

7.1 Major findings of the research

Sorting waste is mostly complex, with 80% posing challenges due to diverse materials or contamination. Only 20% is easily sorted, likely simpler recyclables. Transporting waste from households to mini-MCF is also difficult.

- Most members of the Haritha Karma Sena work an 8-hour day, with only a small fraction working shorter or longer hours. The majority believe waste collection is increasing, but a minority see it differently, likely due to effective recycling and waste reduction efforts.
- Efforts to improve environmental quality and waste management, including programs like Haritha Karma Sena, have shown positive results. Cleaner air is a significant benefit, indicating progress in addressing pollution. The program also enhances social integration, though there's room for improvement. Overall, there's a positive impact on both the environment and community engagement.
- The Haritha Karma Sena workers believe that the most significant improvement needed in local waste management is to increase the use of environmentally friendly products, as this directly reduces waste at the source. Additionally, they emphasize that better financial incentives for waste reduction by businesses and households can drive substantial changes in waste habits. Lastly, they highlight the need for enhanced recycling education and infrastructure to improve recycling rates, indicating the importance of both improved facilities and increased public awareness.
- The updated waste management process in Sreekandapuram municipality features decentralized sorting at mini Material Collection Facilities (mini MCFs) in each ward, which reduces the burden on the central MCF. The Haritha Karma Sena team handles door-to-door collection, ensuring systematic waste collection from households and businesses. Pre-sorted waste is then efficiently transported to the central MCF in Kavumbayi for temporary storage and consolidation before being sent to the Resource Recovery Facility (RRF) for recycling. This streamlined, decentralized approach improves recycling outcomes and resource efficiency.
- The operations of a Resource Recovery Facility (RRF) demonstrate an innovative approach to waste management, emphasizing sorting, baling, and shredding techniques to maximize resource recovery and minimize environmental impact. By categorizing waste, compacting recyclable materials, and finding alternative uses for non-recyclable plastics like road tarring,

RRFs promote sustainability and contribute to a circular economy. However, challenges such as fluctuating demand for recycled materials highlight the need for continued innovation and market development in waste management practices.

7.2 Suggestions

1. Increase the number of Mini Material Collection Facilities: Local Self- Government Institutions should establish at least two or more mini MCFs in each ward, particularly in densely populated areas, to improve accessibility and encourage proper waste disposal practices.
2. Strengthen Awareness Programms: Regular awareness campaign, and household training should be organised to improve waste generation practices and increase public participation in solid waste management.
3. Promote market linkages for shredded plastic produced at the RRF: Local government should facilitate formal agreements with Public Work Department (PWD), contractors, and road construction agencies to ensure regular demand for shredded plastic used in road construction . This would improve the financial sustainability of the RRF.
4. Improve the employment conditions of Haritha Karma Sena workers: The Government should regularise the services of Haritha Karma Sena workers, provide social security benefits such as pensions, health insurance, and periodic skill development training, thereby improving their job security and motivation.
5. Strengthen recycling infrastructure: Modern recycling equipment, adequate storage facilities, and efficient transportation systems should be provided to improve the operational efficiency of Resource Recovery Facilities.
6. Introduce incentive for waste segregation and recycling: Local bodies may offer property tax rebates, user charge discounts, or reward scheme to household and commercial establishments that consistently practice source segregation and recycling.
7. Promote the use of eco- friendly alternatives: The government should encourage the use of cloth bags, reusable containers, biodegradable packaging materials, and other sustainable alternatives through awareness campaign and incentive programmes to reduce plastic waste generation.

7.3 Conclusions

Solid waste management serves as a cornerstone for sustainable development and environmental stewardship. It encompasses a range of practices aimed at reducing, reusing, and recycling waste materials to minimize their impact on ecosystems and human health. Through proper waste disposal methods, such as landfilling, recycling, composting, and waste-to-energy processes, we mitigate the adverse effects of waste on air, soil, and water quality. By preventing the accumulation of hazardous materials and pollutants in the environment, we safeguard public health and preserve the integrity of ecosystems. It also highlights the crucial role of Haritha Karma Sena in solid waste management, particularly in engaging a predominantly middle-aged, educated, and economically challenged workforce.

While facing challenges such as inadequate infrastructure and complex waste sorting, their efforts, alongside innovative practices like Resource Recovery Facilities (RRFs), contribute to sustainable waste management. Material Collection Facility (MCF) in waste management is a designated location where recyclable materials are collected, sorted, and stored before being sent for further processing or recycling. The RRFs' emphasis on resource recovery and minimizing environmental impact aligns with a circular economy approach, although challenges like fluctuating demand for recycled materials persist. Overall, targeted interventions focusing on inclusivity, education, infrastructure enhancement, and market development are essential to further improve waste management practices and foster environmental sustainability.

The study is confined to HKS workers in Sreekandapuram Municipality with a sample size of 30 respondents. Hence the findings may not be representative of all Municipalities. The study relies on primary data collected through a structured questionnaire and uses growth rate analysis for data interpretation. Furthermore, the study is limited to examining the role of Haritha Karma Sena workers in the collection, sorting and recycling process and does not include an assessment of their socio- economic and health status.

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