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Characterisation and Composition of Municipal Solid Waste (MSW) Generated in Rahata City, District Ahilyanagar, Maharashtra, India

Sahebrao R. Gagare[1], Dr. Prasaddu Peddi[2], Dr. Baban B. Amale[3]

[1]Research Scholar, [2]Research Guide, [3]Research Co-Guide, Department of Computer Science, Shri JJT University, Jhunjhunu, Rajasthan, India

Abstract-- **This study presents a detailed analysis of the composition and physicochemical characteristics of municipal solid waste (MSW) generated in Rahata city, Maharashtra, India. Rahata, located near the pilgrimage town of Shirdi, faces unique waste management challenges due to seasonal tourism. Waste samples were collected from various sources over eight months, segregated into eleven functional components, and analyzed. The results indicate that organic waste constitutes the largest fraction (68.4%) of Rahata's MSW, dominated by kitchen waste (51.2%) and market/yard waste (12.5%). The inorganic fraction (31.6%) is primarily composed of plastics (18.7%) and inert materials (7.2%). Physicochemical analysis of the organic fraction revealed a near-neutral pH (7.3), high moisture content (62.5%), and a Carbon/Nitrogen (C/N) ratio of 32:1, indicating high suitability for biological processing like composting. The findings underscore the necessity for a robust waste management strategy focusing on source segregation, decentralized composting for the organic fraction, and material recovery facilities (MRFs) for recyclables to achieve sustainable waste management in the city.**

Keywords-- **Municipal solid waste, Composition, Characterisation, Rahata, Waste management, Composting**

I. INTRODUCTION

Municipal Solid Waste (MSW) management is a critical environmental challenge for urban local bodies in developing countries like India. MSW is a heterogeneous mixture of discarded materials from domestic, commercial, institutional, and community activities, including biodegradable waste, plastics, paper, metal, glass, and inert materials [1]. The quantity and composition of MSW are influenced by population density, socioeconomic status, lifestyle, cultural practices, and seasonal variations [2].

India generates approximately 160,000 metric tons of MSW per day, with per capita waste generation ranging from 0.2 to 0.6 kg [3].

A significant problem is that over 80–90% of this waste in small and medium Indian cities is disposed of in unscientific dump sites, leading to severe environmental and public health issues such as groundwater contamination through leachate percolation, greenhouse gas (methane) emissions, air pollution from open burning, and proliferation of disease vectors [4, 5].

Rahata, a municipal council in Ahilyanagar District, is experiencing rapid urbanization and a constant influx of pilgrims and tourists due to its proximity to Shirdi. This places immense pressure on its existing, often inadequate, solid waste management infrastructure. A lack of data on waste composition and characteristics hinders the development of efficient, scientific waste processing and disposal systems. This study aims to fill this gap by providing a detailed characterization of MSW in Rahata, which is a fundamental prerequisite for designing an appropriate, sustainable, and cost-effective waste management plan.

II. STUDY AREA

Rahata is a rapidly developing municipal town in the Ahilyanagar District of Maharashtra, India, situated approximately 15 km from the world-renowned pilgrimage center of Shirdi.

- *Geographical Coordinates:* 19.77°N, 74.48°E
- *Area:* ~14.5 km²
- *Population (2023 estimate):* ~55,000 (permanent residents). The floating population, especially during festivals and holidays, can increase this number by 20-30%, significantly impacting waste generation.
- *Climate:* Semi-arid, with three distinct seasons: summer (March–May), monsoon (June–September), and winter (October–February).

- *Major Waste Generation Sources:* Residential households, hotels and lodges, restaurants, the Saibaba Temple Trust's facilities in Rahata, commercial markets, a large vegetable and fruit market, hospitals and clinics, and meat/fish shops.

Based on municipal records and this study's surveys, Rahata generates approximately **18-22 metric tons of waste per day**, which can surge to over 30 tons per day during peak pilgrimage seasons.

III. METHODOLOGY

3.1. Waste Sampling and Segregation

A comprehensive waste sampling and analysis protocol was followed over an eight-month period (January to August 2023) to account for seasonal variations.

1. *Source Identification:* The city was divided into five zones based on land use: Residential (R), Commercial/Market (C), Institutional (I), Religious/Hospitality (H), and the open dump site (D).
2. *Sample Collection:* From each zone, fresh MSW samples were collected weekly. A total of 120 composite samples (2 kg each) were collected using the quartering and coning method to ensure representativeness [6].
3. *Manual Segregation:* The collected samples were immediately transported to a designated site and manually segregated into the following eleven components:
   - *Organic Fraction:* Kitchen waste, Market/yard waste, Wood/leaves.
   - *Inorganic/Recyclable Fraction:* Plastics (hard and soft), Paper/cardboard, Textiles, Rubber/leather, Glass, Metals.
   - *Inert & Others:* Inert materials (construction debris, silt, ash), and Miscellaneous (hazardous household waste like batteries, medicines).

The wet weight of each component was recorded. The percentage composition was calculated on a wet-weight basis.

3.2. Physicochemical Analysis

The organic fraction of the waste (a composite of all zones) was analyzed for key parameters to assess its potential for composting. All analyses were performed in triplicate as per standard methods [7, 8].

- *pH and Electrical Conductivity (EC):* Measured in a 1:10 (w/v) waste-to-water extract using a digital pH and conductivity meter.
- *Moisture Content:* Determined by drying a known weight of sample at 105°C in an oven to a constant weight.
- *Organic Carbon (OC):* Determined by the Walkley-Black wet oxidation method.
- *Total Nitrogen (N):* Analyzed by the Micro-Kjeldahl method.
- *Total Phosphorus (P) and Potassium (K):* Digested with di-acid (HNO_3 : $HClO_4$ in 9:4 ratio) and analyzed using a spectrophotometer and flame photometer, respectively.
- *Carbon/Nitrogen (C/N) Ratio:* Calculated from the OC and N values.

IV. RESULTS AND DISCUSSION

4.1. Physical Composition of MSW in Rahata

The average physical composition of MSW in Rahata is presented in Table 1. The data reveals a predominantly organic waste stream.

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Table 1:
Physical Composition of MSW in Rahata

Component Type	Category	% Composition (Wet Weight)
Organic	Kitchen Waste	51.2%
	Market/Yard Waste	12.5%
	Wood/Leaves	4.7%
	Total Organic	**68.4%**
Inorganic	Plastics	18.7%
	Paper/Cardboard	3.1%
	Textiles	1.5%
	Rubber/Leather	0.8%
	Glass	2.3%
	Metals	1.0%
	Total Inorganic	**28.4%**
Inert & Others	Inert (Ash, Silt, etc.)	7.2%
	Miscellaneous	1.0%
	Total Inert & Others	**8.2%**

The high organic content (68.4%) is consistent with the findings of other studies in Indian cities [9, 10] and is attributed to dietary habits rich in fresh produce and a significant amount of food waste from the hospitality sector. The plastic content (18.7%) is considerable and poses a major challenge, often clogging drains and being openly burned, releasing toxic fumes.

The recyclable fraction (paper, glass, metal ~6.4%) has economic potential if recovered efficiently.

4.2. Physicochemical Characteristics of the Organic Fraction

The results of the physicochemical analysis of the organic fraction of MSW are summarized in Table 2.

Table 2:
Physicochemical Characteristics of the Organic Fraction of MSW

Parameter	Average Value	Significance / Implication
pH	7.3	Near-neutral pH is ideal for microbial activity in composting processes.
EC (dS/m)	3.8	Slightly high EC; may require monitoring or co-composting with bulking agents to avoid salinity issues in final compost.
Moisture Content	62.5%	High moisture is typical for kitchen waste, aiding microbial decomposition but can lead to leachate formation. Requires bulking agents (e.g., dry leaves, paper) for composting.
Organic Carbon (OC)	38.5%	High organic carbon indicates good energy source for microorganisms.
Total Nitrogen (N)	1.2%	Indicates good nitrogen content for plant growth.
C/N Ratio	32:1	A C/N ratio of 25-35:1 is considered optimal for composting. The value of 32:1 is excellent, promising efficient decomposition without nitrogen loss or odor issues.
Total Phosphorus (P)	0.85%	Indicates a good source of phosphorus for compost quality.
Total Potassium (K)	0.52%	Provides a valuable source of potassium for the final compost product.

The analysis confirms that the organic fraction of Rahata's MSW is a valuable resource. The near-neutral pH and an ideal C/N ratio make it highly suitable for biological treatment methods like windrow composting, vermicomposting, or biomethanation. The high nutrient (N, P, K) content further underscores its potential to produce high-quality compost for agricultural use, closing the nutrient loop.

V. Conclusion And Recommendations

This study provides a critical baseline dataset on the composition and characteristics of MSW in Rahata city. The key findings are:

1. *Organic Dominance:* MSW in Rahata is predominantly organic (68.4%), with kitchen waste being the single largest component (51.2%).
2. *High Recycling Potential:* The combined recyclable and combustible fraction (plastics, paper, textiles, etc.) is significant (~28%), presenting an opportunity for material and energy recovery.
3. *Excellent Compostability:* The organic fraction possesses ideal physicochemical properties (C/N ratio of 32:1, high nutrient content) for conversion into stable compost.

Based on these findings, the following scientific and sustainable waste management strategy is recommended for Rahata:

1. *Mandatory Source Segregation:* The municipality should enforce segregation at source into at least three streams: **Biodegradable (Wet), Recyclable (Dry), and Inert/Others**. Public awareness campaigns are crucial for success.
2. *Decentralized Composting:* Given the high organic content, establishing decentralized composting units (windrow or vermicomposting) across city zones can significantly reduce transportation costs and volume directed to landfills. The final compost can be used in municipal gardens or sold to farmers.
3. *Material Recovery Facility (MRF):* A centralized MRF should be established to sort, bale, and sell dry recyclables (plastics, paper, metal, glass), creating a revenue stream and formalizing the informal recycling sector.
4. *Biomethanation for High-Risk Organic Waste:* Large generators like hotels, restaurants, and pilgrimage sites could install small-scale biomethanation plants to manage their wet waste and generate biogas for cooking or electricity.
5. *Engineered Sanitary Landfill:* The residual inert and non-processable waste (~8-10%) must be disposed of in a scientifically engineered sanitary landfill to prevent environmental pollution. The existing dump site should be remediated.

Implementing this integrated approach will transform Rahata's waste management system from a linear "collect-and-dump" model to a circular, sustainable, and resource-efficient one.

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Corresponding Author: Sahebrao R. Gagare, Email: gagaresr19@gmail.com