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Environmental Impact Assessment of Municipal Solid Waste Management in the Trans Gomti Region

Sanchita Misra[1*], Vikas Srivastava[2], Atul[3] and Parah Salsabeel Jalal[4]

[1,4]Research scholar, [3]Assistant Professor,[2]Professor, Department of Civil Engineering,
Sam Higginbottom University of Agriculture, Technology and Sciences,Prayagraj, UP, India,*

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ABSTRACT: The growing population, swift economic development, and improvement in community living standards enhance municipal solid waste (MSW) production in Indian cities. Mismanagement of Solid Waste (SW) poses risks to residents. This research aims to identify SW's quantitative and qualitative features, gather essential information, and develop GIS maps for the Trans Gomti Region. The specimens were randomly gathered from different sites and examined to identify the traits of SW. A survey using a methodology has been conducted to gather information from residents regarding solid waste. The Geographic Information System (GIS) has been utilized to examine current maps and data, digitize the existing sanitary ward boundaries, and input data related to the wards and disposal locations. The overall amount of MSW has been noted as 800 tons per day, while the average generation rate of MSW is estimated to be 0.65 kg per person per day. The produced ArcGIS maps provide effective insights into static and dynamic aspects of the municipal solid waste management (MSWM) issue, including the MSW generation rates in various wards, locations of collection points, transportation methods and their paths, as well as the count of disposal sites and their characteristics.

Keywords: Pelletization, Bio-methanation, Incineration, Municipal Solid Waste, Geographic Information System, and Arc Toolbox.

I. INTRODUCTION

Waste classification can be based on various principles, including the type of material, its physical state, or its origin (Peng et al., 2023). It is necessary to decrease the existing amounts of waste production and enhance the recovery of materials and energy, seen as vital actions for an environmentally sustainable waste management system (US EPA, 2013). Among several management options, landfill is the most common waste disposal route globally due to the ease of implementation (Das et al., 2019).Landfill is no longer the primary option for disposal compared to methods like recycling, composting, and incineration; it has become a final measure after exhausting all potential material and energy recovery in solid waste management (Traven, 2022).

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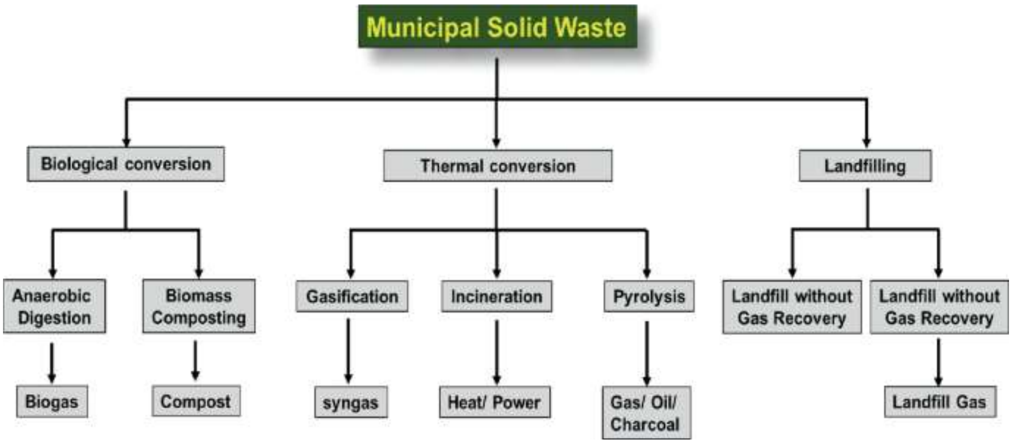

Figure 1. Types of Municipal Solid Waste (Khaire et al., 2024)

At first, incinerators worldwide were employed to diminish waste volume, but currently, energy is being harnessed from incinerators (Brunner and Rechberger, 2015). Electricity and heat are generated from the reclaimed biogas from landfills (Eia.gov, 2025). From a broad perspective on material recycling, the composting of organic waste is deemed the key system (Wei et al., 2017).

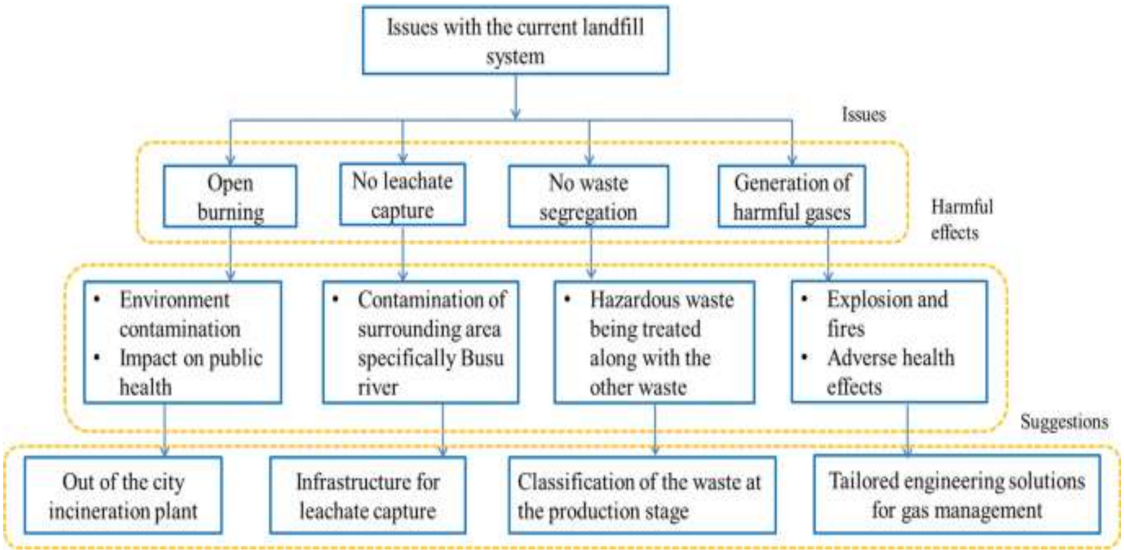

Figure 2. Issues with Landfill System (Doaemo et al., 2021)

Issues stemming from solid waste can be addressed through the application of innovative technologies (Lakhouit, 2025). Currently, various waste-to-energy (W-T-E) systems exist that enable the efficient recovery and utilization of energy, including anaerobic digestion (both dry and wet, thermophilic and mesophilic), thermal conversion (such as rotary kiln incineration, mass burn incineration, starved air incineration, fluidized bed combustion, pyrolysis, gasification, plasma technology, thermochemical reduction, and refuse-derived fuel), along with landfilling (including landfill gas utilization and bioreactor landfill) (Mnre.gov.in, 2025). Each form of technology manages the particular makeup and volume of solid waste (Czekała et al., 2023). Proposing appropriate waste management strategies and technologies appears challenging without assessing the amount and makeup of produced waste (Kapoor and Chakma, 2024).

Around 2.59 billion tons of waste are expected to be produced worldwide by 2030, with projections indicating a rise to 3.4 billion tons by 2050, twice the amount generated in 2016 and potentially three times as much by 2100 (Saadatlu et al., 2022).Globally, wastes are used to produce electricity and fertilizer or used for recycling (Peng et al., 2023). Recently, Europe and the United

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States (US) have been recycling waste about 41% and 32%, respectively (Forti et al., 2020). China is also investing US$ 6.3 billion dollars to achieve 30% recycling of its waste by 2030 (World Bank & Development Research Center of the State Council, 2013).

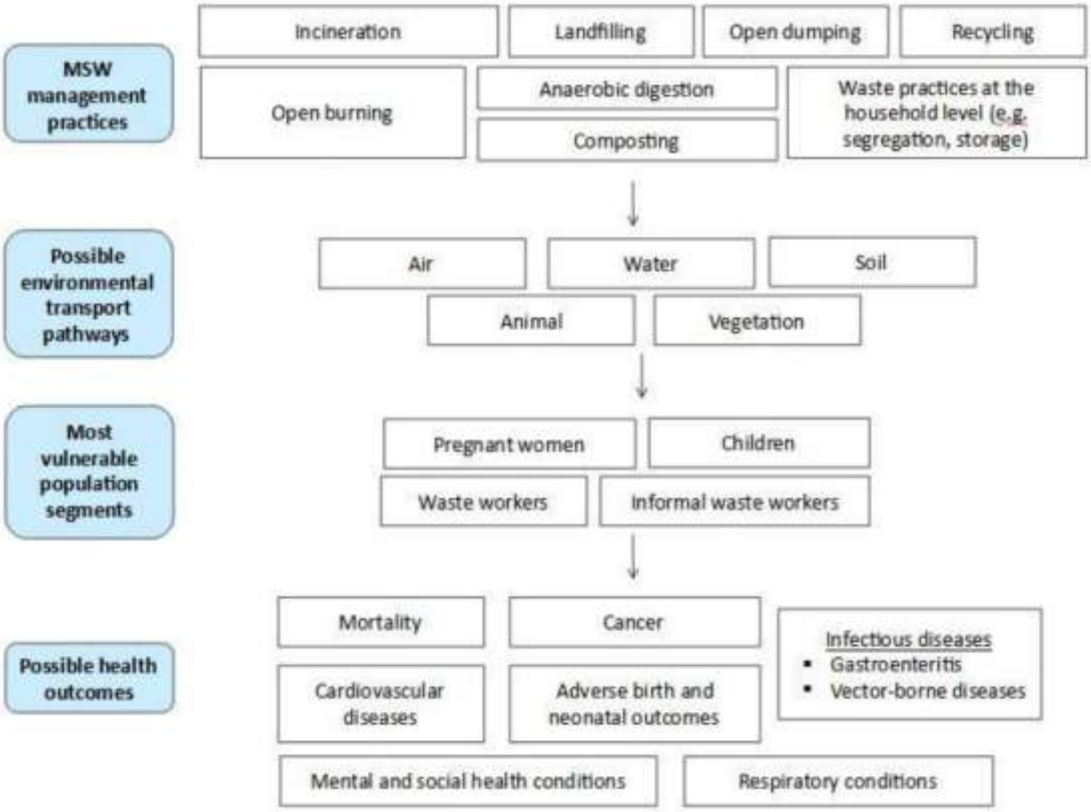

Figure 3. Illustration of the connection between solid waste management methods and their potential negative impacts on human health (Vinti et al., 2021)

Currently, out of more than 800 incineration plants operating worldwide, approximately 236 are located in Japan and 400 in Europe. The plants in Europe can provide electricity to approximately 27 million inhabitants (Chaurasia et al., 2017).There are two methods used for the treatment of solid waste in India, namely composting (vermin-composting and aerobic composting) and waste-to-energy technologies (pelletization, bio-methanation, and incineration) (Chaurasia et al., 2017). Although the latter method is working successfully in the developed world, it is relatively new in India.

Status of MSW: An Overview

Lucknow is a prominent city and the capital of Uttar Pradesh. It is located approximately 525 km from Delhi and around 920 km from Kolkata**.** Lucknow has consistently been recognized as a multicultural city, thriving as a cultural and artistic hub of North India during the 18th and 19th centuries, serving as the seat of power for the Nawabs**.** Today, it remains a significant hub for education, commerce, aerospace, finance, pharmaceuticals, technology, design, culture, tourism, music, and poetry. Lucknow is situated at an altitude of 123.45 metres above sea level and spans an area of 689.1 km². It is bordered on the east by District Barabanki, on the west by District Unnao, on the south by Raebareli, and on the north by the Sitapur and Hardoi districts. The city is located on the northwestern bank of the Gomti River, which runs through it.

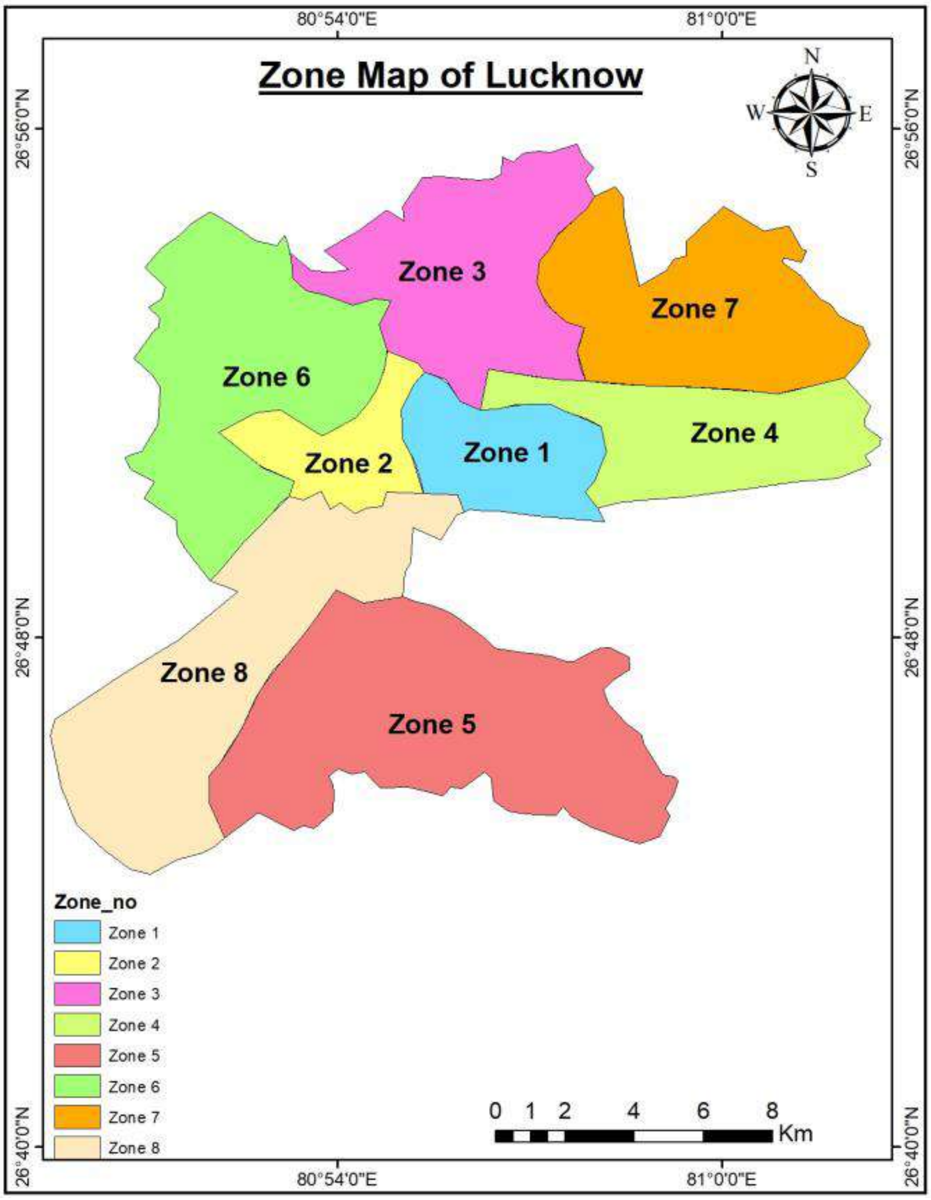

Figure 4: ArcGIS map of the 8 Zones of Lucknow city (Rawat et al., 2022)

The management of the MSW produced in the city falls under the jurisdiction of the Lucknow Municipal Corporation (LMC). The complete functioning of the solid waste management (SWM) system is conducted under four categories: cleaning, collection, transportation, and disposal (Rawat et al., 2022). In the city of Lucknow, the process of cleaning and collecting involves gathering MSW from the streets using wheelbarrows, which is then deposited into depots (52 depots) (Rawat et al., 2022). MSW is subsequently loaded onto vehicles that take the waste to various disposal locations.

II. METHODOLOGY

The study relies on both primary and secondary data gathering to address the research questions posed by the investigation. The secondary data were gathered directly from relevant offices and research institutions such as universities and non-governmental organizations, which are actively involved in addressing solid waste management challenges. Upon examining their reports, fundamental data were gathered on core issues that were either not addressed or not explicitly outlined in the reports via the “key informed consent approach.” The secondary data originates from a mix of both electronic and printed

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resources, including published books, research papers, journals, and articles etc. Both primary and secondary data include the composition and volume of solid waste, socio-economic and environmental issues about the solid waste stream, as well as information on waste-to-energy recovery technologies.

Methods for data collection

The subsequent approaches were utilized for gathering the necessary information:

- Comprehensive analysis of annual solid waste reports from relevant organizations.
- Interview with key personnel involved in solid waste management.
- Examination of previously published literature.
- Personally visit the city and the waste disposal locations to evaluate the solid waste management system.

III. RESULTS AND DISCUSSION

Composition of Solid Waste in Zone D (Trans Gomti Region)

Zone D is located in the eastern part of the city along the left bank of the Gomti River. The selected sampled wards in this zone are 8 in number because it has only 8 wards, namely - Chinhat 1 (35), Chinhat 2 (49), Colvin College (41), Rafi Ahmad Kidwai (45) Gomti Nagar (61), Paper Mill Colony (23), Rajiv Gandhi 1 (69) and Rajiv Gandhi 2 (96) ward. It is important to mention here that this zone represents the most planned settlement, as it is part of the new city. It includes the main commercial center of the city, dotted with many hospitals, restaurants, hotels, commercial establishments, and residential areas. The expansion of this region is continuing due to the development of new settlements and other activities. Zone D has a better waste management system in comparison to other zones, as high-profile and educated people are living in this zone. The detailed study regarding the composition of solid waste is shown in Table 3.5 and Figure 3.15. Table 3.5 and Figure 3.15 depict the composition of solid waste has 67.20 percent of biodegradable waste and 32.80 percent of non-biodegradable waste. Under biodegradable, 13.81 percent is paper, 33.28 percent is food waste, 8.84 percent is clothes, 16.30 percent is cardboard, and 27.77 percent is other biodegradable materials. Under the non-biodegradable category, 30.60 percent was plastic materials, 13.12 percent is polythene, 12.42 percent is glass, 16.52 percent is metal, and 27.28 percent is miscellaneous**.**

Table 1. Composition of Solid Waste in Zone D of Lucknow City (Gomti Region)

Zone D : Composition of Solid Waste in Percent During 2018,2019 and 2021									
Biodegradable	**2018 (%)**	**2019 (%)**	**2021 (%)**	**Average (%)**	**Non-Biodegradable**	**2018 (%)**	**2019 (%)**	**2021 (%)**	**Average (%)**
Paper	13.62	13.84	13.97	**13.81**	**Plastic Material**	29.62	29.76	32.44	**30.60**
Food Waste	32.36	32.63	34.84	**33.28**	**Polythene**	11.71	11.92	15.72	**13.12**
Cloth	9.76	9.18	7.58	**8.84**	**Glass**	13.4	13.38	10.47	**12.42**
Cardboard	17.38	16.84	14.68	**16.30**	**Metal**	17.54	16.92	15.28	**16.52**
Others	26.87	27.51	28.93	**27.77**	**Miscellaneous**	27.73	28.02	26.09	**27.28**

Field Survey, 2018, 2019, and 2021

Table 1 and Figure6 indicate that the composition of solid waste was almost identical in 2018 and 2019; however, during the COVID-19 pandemic in July to September 2021, both the composition and the amount of solid waste increased. The graph in Figure 6 illustrates that the paper waste composition is 13.62 percent (2018), 13.84 percent (2019), 13.97 percent (2021), the food waste composition is 32.36 percent (2018), 32.63 percent (2019), 34.84 percent (2021), the cloth composition is 9.76 percent (2018), 9.18 percent (2019), 7.58 percent (2021), the cardboard composition is 17.38 percent (2018), 16.84 percent (2019), 14.68 percent (2021), while the other wastes comprise 26.87 percent (2018), 27.51 percent (2019), 28.93 percent (2021).

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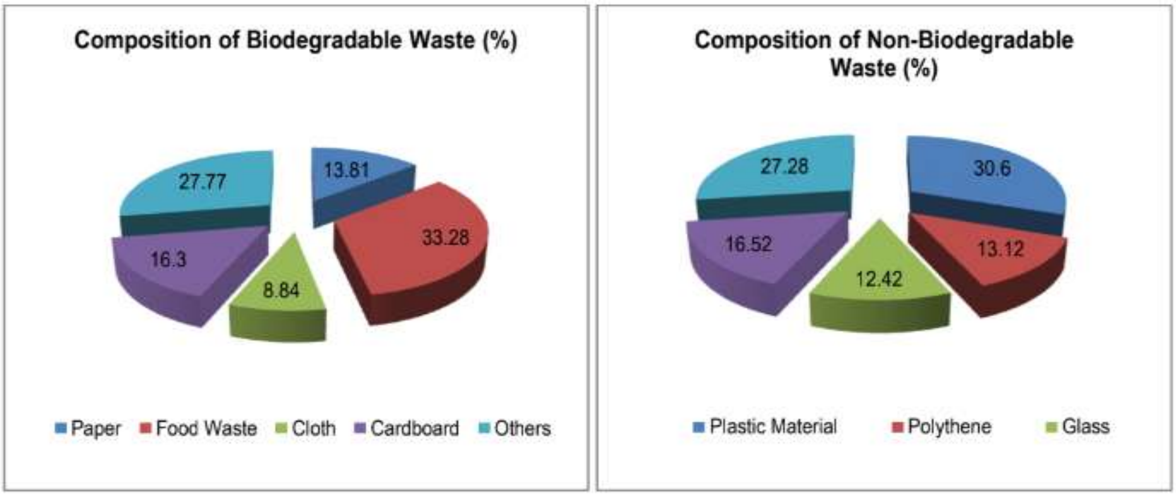

Figure5. Composition of Biodegradable and Non-Biodegradable Waste in Zone D (Field Survey, 2018, 2019, and 2021)

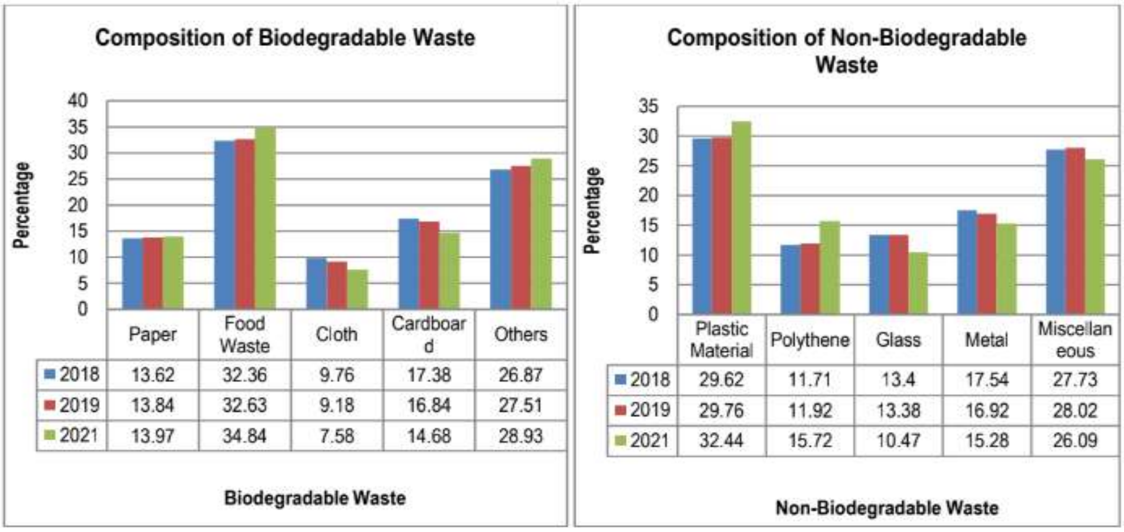

Figure 6. Composition of Solid Waste in Zone D (2018, 2019, and 2021) (Field Survey, 2018, 2019, and 2021)

Graph also shows that the composition of plastic waste is 29.62 percent (2018), 29.76 percent (2019), 32.44 percent (2021), composition of polythene is 11.71 percent (2018), 11.92 percent (2019), 15.72 percent (2021), composition of glass is 13.40 percent (2018), 13.38 percent (2019), 10.47 percent (2021), composition of metal is 17.54 percent (2018), 16.92 percent (2019), 15.28 percent (2021) and other miscellaneous wastes are 27.73 percent (2018), 28.02 percent (2019), 26.09 percent (2021). In 2021, the percentage composition of paper, food waste, plastic material, and polythene bags increased to 13.97, 34.84, 32.44, and 15.72 percent, respectively, while metals, glass, cloth, and other miscellaneous components decreased to 15.28, 10.47, 7.58, and 26.09 percent, respectively.

IV. CONCLUDING REMARKS

The separation of waste at its origin and the encouragement of recycling or repurposing of categorized materials decreases the volume of waste and the pressure on landfills, while supplying manufacturers with raw materials. The analysis of MSW primarily reveals vulnerability assessment, making composting an effective approach for treating waste and generating soil enhancement. The swift rise in the amounts of MSW and the failure to offer daily collection services lead to inconveniences and health risks. The research outlines the existing state of MSWM, which will aid in raising awareness among individuals. The MSWM data sourced from ArcGIS maps facilitates the acquisition, modification, and depiction of the necessary information.

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