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The study of waste composition in Joe Slovo Township, Nelson Mandela Bay Municipality, South Africa

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Abstract - *Household waste (HW) forms a vital part of municipal solid waste (MSW), and the inadequate management of HW poses a serious challenge in many developing cities. A study of the composition of HW is therefore vital in designing an effective solid waste management plan for cities and towns. A waste composition study is also important as estimating waste types produced and treatments applied can be an important tool for discerning what technology can be utilised for waste management trends. The study evaluated the composition of household solid waste generation in Joe Slovo township (JST) using a mixed-method research design to identify waste characteristics. The study's methodology included evaluating literature and administering structured questionnaires. The data were analysed using SPSS and presented in simple tables and charts. The waste typology produced by the residents are metals, papers, bottles, plastic materials, and food remains, among others. In addition, most waste typology produced by JST is recyclable. The results revealed that JST has no significant difference in the type of waste produced when comparing male and female respondents. The study recommends that the waste typology generated by JST can be utilised as a resource to develop economic income through recycling.*

Keywords – *Waste, waste composition, household waste, municipal solid waste*
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1. Introduction

Household wastes (HW) comprise a large part of municipal solid waste (MSW). Suthar and Singh (2015) indicated that the characterisation of HW is vital in designing effective solid waste management (SWM) plan for a town. Rapid population, urbanisation, and industrial growth have resulted in serious waste management issues, with the typical structure, scale, and scope of city economic development having unintended consequences for environmental safety (Oyelade, 2019). Oyelade further stated that waste disposal in developing cities is characterised by indiscriminate dumping, ineffective collection and sorting, inadequate recording of waste composition and creation rate, and poor management by the informal sector (2019).

The characterisation of household waste helps to shape an operational waste management structure. For example, the characterisation of HW will typically separate non-hazardous waste from hazardous waste (see figure 1) and be categorised as compostable, recyclable and inert (Ranjith, 2012). Annepu (2012) stated that 75% of non-biodegradables are ineligible for energy recovery, recycling or composting. Therefore, 25% of biodegradable waste should be prevented from landfills. This action will reduce landfilling, the space required, and the landfill cost. Furthermore, by employing proper technology, the biodegradable organic waste could be converted into green energy or bio-fertilisers, preventing the degradation of the urban environment and encouraging sustainability.

By incorporating the philosophies of sustainability and efficiency of resources into a household way of life, the current waste disposal habits of containing, rectifying, and controlling pollution can be transformed (Maiyaki, Marzuki and Mustafa, 2018). This transformation is a procedure that maximises resource recovery, eliminates toxic elements, prevents contamination, reduces associated costs and subsequently aids the integration of the city's overall health (Thakur et al., 2021). Yu et al. (2021) also indicated that it might help minimise the significant amount of municipal funds committed to waste disposal system management and thus move the focus to resource recovery and development measures.

Figure 1. Type of waste source (Source: National Audit Office of Estonia, n.d.)

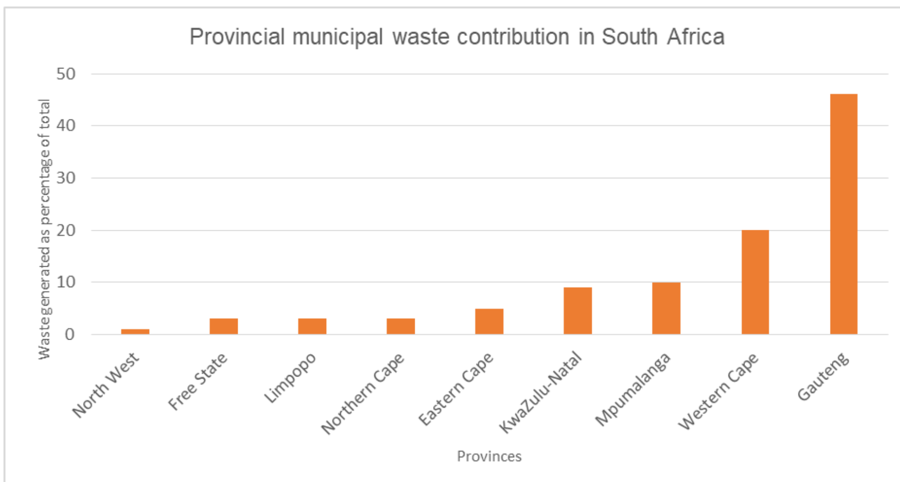

Figure 2. Provincial, municipal waste contribution in South Africa (adapted from Nkosi et al. 2013)

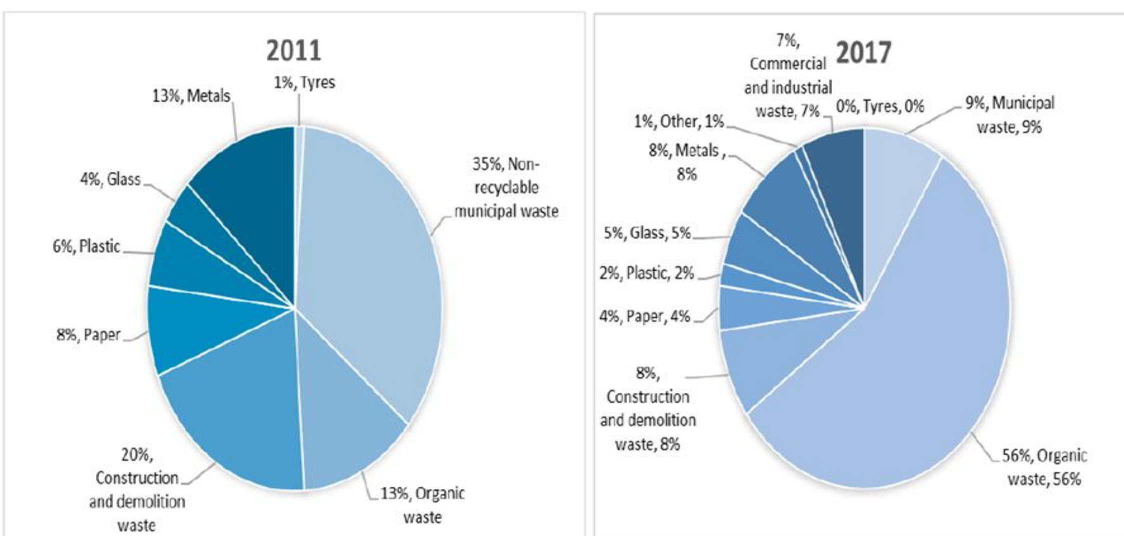

Figure 3: Comparison between 2011 and 2017 baseline report of general waste in South Africa (Source: APWC, compiled from DEA 2011 & DEA 2018a, b)

Furthermore, Joel and Fansen (2013) stated that recyclable materials such as paper, cardboard, plastics and metals, among others, make up a large part of the waste, and their renewal can generate economic development, as seen in industrialised countries. Also, Chen et al. (2020) observed that estimating waste types generated and disposed of can be a critical tool for forecasting future trends in waste and its management method. To this end, this paper seeks to ascertain the composition of HW at JST.

2. Literature review

Solid waste characteristics research is necessary to highlight the current condition of municipal solid waste management and design a sustainable waste management system with appropriate treatment solutions (Giang, Takeshi & Toan, 2016). Solid waste generation rates and materials composition vary substantially across regions and cities due to shifting socio-economic and climate variables that vary by time and location (Isa et al., 2015). With this background, this section will discuss the municipal solid waste generation and composition, waste trend and generation in South Africa, municipal solid waste properties and solid waste management policies.

2.1. Municipal solid waste generation and composition

Waste generation continues to negatively impact the environment and the healthy living of humans, thus impeding sustainability (Brusseau, 2019). Municipal solid waste (MSW) is a concept that refers to a unified collection of waste generated in urban areas, the nature of which varies considerably from city to city (Abdel-Shafy and Mansour, 2018). As a result, the solid waste composition is alluded to as every unit of waste composition (Chen et al., 2020). The attributes and volume of waste produced in an area are determined not only by the inhabitants' lifestyle and standard of living but also by the vast quantities and categories of natural resources in the area (Chen, 2010). Organic and inorganic wastes are the principal components of urban waste (Kucbel et al., 2019).

Organic components of urban solid waste can be divided into degradable and non-degradable (Ren et al, 2022). Degradable wastes could decompose quickly and produce offending odours and visual discomfort or ferment without the offending smell and visual, while non-degradable wastes are resistant to decomposition and thus disintegrate slowly (Jiang et al., 2022).

Crop and market debris, food preparation and consumption generate a significant amount of degradable waste, which is influenced by way of life, the standard of living, and seasonal fluctuations of components (Abdel-Shafy and Mansour, 2018).

The amount and composition of municipal solid waste (MSW) are critical for planning waste management (Kundariya et al., 2021). While the majority of the previous study, such as Cervantes et al. (2018), Ezeudu and Ezeudu (2019), Kulkarni and Anantharama (2020) and Adeleke et al. (2021), among others, focused on the characteristics of municipal solid waste at final disposal sites, it is important to investigate waste composition in communities because the strategies of waste management are shifting towards zero waste, more recycling and defining the quantity and composition of waste at the point of generation.

2.2. Waste generation and its properties in South Africa

South Africa, a subtropical location, is the southernmost country in Africa, with a land area of 1,220,813 km2 (471,359 sq mi). The country is separated into nine provinces: Eastern Cape, Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, North West and Western Cape. South Africa, being in the milder Southern hemisphere, generally possesses a temperate climate because the Atlantic surrounds it and Indian Oceans on three sides and its average elevation rises steadily toward the hinterland equator.

South Africa's waste generation rate is growing relative to its commercial, institutional, industrial, and market activities related to the economic level of informal settlers and low-income, medium- income and high-income residential neighbourhood sectors (Muzenda, 2014). Depending on the economic status of the area, the per capita solid waste generation rate varies from 0.60 to 4.5 kg per capita per day (Adeniran and Shakantu, 2021).

Figure 2 presents the contribution of each South African province to waste generation, and the Gauteng province, the economic hub of South Africa with a population of approximately 15.45 million people (Statista, online), contributes the most to waste stream.

Figure 3 depicts a comparative evaluation of South Africa's most recent two national baseline assessments of 2011 and 2017. In 2011, non-recyclable municipal waste was the highest with 35%, closely followed by construction waste at 20% and by 2017, it was reported that organic waste generated was 56%, with not non-recyclable municipal waste dropping to 9% and construction waste following closely at 8%. By 2017 the government policy around waste had been established, which was in a bid for sustainable waste management.

2.3. Solid Waste Management Policies

Lee *et al.* (2020) observed that most waste management policies worldwide tend towards sustainability. According to WCED (1987), sustainable development is the development that "meets present needs without compromising the ability of future generations to meet their own needs". In 2014, member states of the United Nations adopted a set of Sustainable Goals (SDGs), which would replace the Millennium Development Goals (MDGs) as the international development community's reference goals for 2015–2030. Goals and targets are networks in which numerous goals are represented by multiple targets (Le Blanc, 2015). Rodić and Wilson (2017) argue that addressing the global waste crisis would significantly contribute to the UN SDG's definition of sustainable development. This may be achieved by ensuring universal access to adequate, safe, affordable solid waste collection services and eliminating uncontrolled dumping and open burning.

Efficient waste management will create a clean environment and preserve human health (Epstein, Elkington and Herman, 2018). It is in line with this thought that Deus *et al.* (2022) posited that the environmental driver as an indicator of a waste management system's effectiveness should be a key aspect of waste management systems. However, the significance of environmental conservation, according to Giang, Takeshi and Toan (2016), necessitates strong government actions, which may stimulate other drives such as institutional, economic, and personal forces

A Greenland study characterised household waste by manually sorting collected waste bags into eleven material components. The survey found that biowaste (43%) and combustible waste (30%) made up the majority of household waste. The combustible fraction included anything flammable that did not belong in the other clean fractions, such as paper, cardboard, and plastic. Other notable material percentages of home garbage included paper (8%) dominated by magazine type paper; glass (7%; steel (1.5%); aluminium (0.5%); plastic (2.4%); wood (1.0 %); non-combustible garbage (1.8 %); and domestic hazardous waste (1.2%) made up the remaining 10%. (Eisted & Christensen, 2011). Also, the study by Ramachandra *et al.* (2018) in Bangalore, India, observed that food waste accounted for 62% of household solid waste (HSW), whereas 66% of the general waste was biodegradable. The Nelson Mandela Bay Municipality Integrated Waste Management Plan (NMBM-IWMP (2016) on waste generation states that approximately 700,000 tonnes of solid waste are generated annually, including paper, metal, and e-waste garden waste, food waste and other materials, among others.

According to NMBM IWMP (2016), solid waste created in the metro comprises 42% organic and other biodegradable stuff and 58% non-biodegradable matter. This volume is somewhat lower than reported for several developing countries, with 50–74% biodegradables in various Chinese cities (Tai *et al.,* 2011) and 51–58% biodegradables in India (Annepu, 2012). However, a study in Ota, Nigeria, another African city, conducted by Olukanni and Mnenga (2015) found that solid wastes consist of less biodegradable materials and more non-biodegradable correlates with the data from NMBM IWMP (2016).

From the preceding, the literature revealed that household waste typology differs between different locations and can be categorised into two items: biodegradable and non-biodegradable. The implication of this is that the technology that is required will differ from place to place.

3. Research Methodology

This section presents the research methodology used to describe waste composition in NMBM, specifically JST. In addition, the study area and data collection methods are described.

3.1. Description of the study area

3.1.1. NMBM

The case study focused on NMBM in the Eastern Cape Province, and it was named after Nelson Mandela, and Port Elizabeth is the capital city (YesMediaCC, 2019). Noted as the economic powerhouse of the Eastern Cape, it is located on the coast of Algoa Bay between Latitude 33°57′S and Longitude 25°36′E. With its main harbour and the heart of the automotive production centre, Port Elizabeth has a land area of 251 square kilometres. Port Elizabeth, also referred to as the 'Friendly City,' is the fifth-largest city in South Africa and a major metropolitan centre. The city receives more sunlight and wind than any other coastal town in South Africa.

3.1.2. Case study area

JST is located about 25 kilometres from the central business district of Port Elizabeth and midway between Uitenhage and Port Elizabeth. It continues to draw new residents from adjacent rural areas seeking a better life in the city. Hence, the township is a transitory location in fully integrating into the urban system. However, the municipality's capacity to provide services is overwhelmed due to its constant growth. In addition, the township faces several issues, such as the management of solid waste within the low-income neighbourhood, which relies largely on government subsidies and handouts to get by (Guérin *et al.*, 2015).

3.2. Sampling and data collection methods

Having obtained ethical clearance for the study from Nelson Mandela University, structured questionnaires were used to identify the characteristics of the waste. JST was indicated to have about 6500 households, and a sample size of 364 houses was used based on Krejcie and Morgan's (1970) formula, and we were able to retrieve 299 responses from household heads. The research adopted the probability sampling method in choosing the sampled houses. The Independent Samples t-Test was also used to compare the means of two independent groups to see if the related population means were substantially different (Hair, Black, Babin & Anderson, 2014).

4. Findings

This section presents the key findings on the demography of respondents (i.e., gender, education, period of residence) and waste typology generated.

4.1. Demography

Table 1 shows the gender distribution of the respondents, with 194 (64.9%) females, 97 (32.4%) males, and 8 (2.7%) respondents who did not indicate. Also, the survey data as presented in Table 1 indicated that 236 respondents (78.9%) have no formal education, while 63 respondents (21.1%) have a form of education of at least primary school. In terms of the length of residency in the area, 165 (55.1%) have been living in JST for over ten years, while 60 (20.1%) have been living there for seven (7) to ten (10) years. Only 29 respondents (9.7%) have stayed between zero (0) and two (2) years, whereas 45 respondents (15.5%) have stayed between three (3) and six (6) years.

Table 1. Demographics of respondents

Gender	Frequency	Percentage
Female	194	64.9
Male	97	32.4
Unspecified	8	2.7
Total	299	100
Education status of respondents		
Formal education	236	78.9
No formal education	63	21.1
Total	299	100
Length of time living in JST		
0-2 years	29	9.7
3-6 years	45	15.1
7-10 years	60	20.1
Above 10 years	165	55.1
Total	299	100

Table 2. Ranking table for waste items generated by JST inhabitants

Type of waste	**N**	**Mean Responses**	**Standard Deviation.**	**Ranking**
Cans and other metals	297	3.25	0.837	1
Paper materials	300	2.51	1.099	2
Bottles	297	2.19	1.015	3
Plastic materials	295	2.07	1.183	4
Human waste/pampers	300	1.91	1.307	5
Food remains	300	1.44	0.869	6
Old clothes	299	1.38	0.816	7
Households' hazardous waste	294	1.13	0.584	8
Oil	296	1.05	0.360	9
Old appliances	299	1.03	0.316	10

Table 3. Gender Versus Other variables

	t-Test for Equality of Means			**Levene's Test for Equality of Variances**	
	T	**df**	**p-value**	**F**	**p-value**
Food remains	-0.361	290	0.718	0.160	0.690
Plastic materials	1.417	285	0.158	1.805	0.180
Paper materials	0.887	290	0.376	0.097	0.755
Old clothes	-0.243	289	0.808	0.111	0.739
Bottles	-0.093	287	0.926	0.312	0.577
Cans and other metals	0.803	287	0.423	0.004	0.950
Human waste/pampers	-0.669	290	0.504	1.774	0.184
Oil	-0.359	286	0.720	0.516	0.473
Household hazardous waste	-2.690	280.558	0.008	19.343	0.000
Old appliances	-0.518	289	0.605	1.081	0.299

4.2. Waste items generated in JST

As retrieved from the field survey and ranked in Table 2, it is revealed that the inhabitants reported that with a mean value of 3.25, cans and other metals ranked first, meaning they were largely generated. On the other hand, with a mean value of 1.03, old appliances were ranked 10th as the least generated item, while the other waste items fall between these two items.

A t-Test was used to analyse if there was a significant difference in the responses of females and males. Table 3 shows that p-values are greater than 0.05, indicating no statistically significant difference between male and female responses except for household hazardous waste with a p-value of 0.008, which shows statistical significance. As a result, it can be inferred that there is no substantial variation in the waste items generated by men and women except for household hazardous waste. A further test using Levene's

Test for Equality of Variances returned the same result, with responses on the generation of items of household hazardous waste showing significant difference.

5. Discussion

According to the empirical data from Table 1, over 64% of the respondents were female household heads, and this aligns with the UNDP declaration that female-headed households outnumber male-headed households in South Africa. Several authors have researched how gender influences waste management. Kien (2018) observed that the effective presence of women in households had a bearing on waste generation and concluded that there is a gender angle to the generation and management of municipal waste. In addition, Scheinberg, Muller and Tasheva (1999) noted that a better understanding of the interrelations between community organisations and gender would strengthen women's voices and their waste management roles. Based on their study's findings, they concluded that women have a natural proclivity for cleanliness and hygiene in the home and that this spreads far beyond the household. Nanziri (2020) posited that women are more directly involved in household waste issues in a typical African setting than men. This study's findings agree with previous studies that established that in solid waste management, particularly in emerging economies, women are key players because they are primarily concerned with cleanliness in the household.

In terms of formal education, over 78% of the respondents indicated that they have no formal education. JST is populated by low-income groups predominantly reliant on government assistance and subsidies whose primary concern is generating revenue to survive (Guérin *et al.*, 2015, Myeko and Iwu, 2019), and they lack adequate skills, learning and knowledge (Mbonyane and Ladzani, 2011). However, Weiss, Hart and Pust (1991) observed that adult literacy skills in underdeveloped nations are often below average, and our study has confirmed this. Trang *et al.* (2017) also observed that socio-economic factors such as income, age, and educational status influenced household waste production and discovered a link between socio-economic factors and household waste generation. Their research found that whereas income significantly negatively affects household waste generation, household size has a positive effect.

Also, Ogwueleka (2013) revealed that education is perceived to increase earning power which could alter patterns of consumption, resulting in changes in the nature and volume of household waste. Furthermore, Intharathirat *et al.* (2015) also indicated that increased income might result in increased family size and improved dietary habits, positively impacting waste generation. Finally, Dou and Toth (2021) demonstrated that the quality and quantity of waste generated differed across economic and income groups and indicated that a critical, positive relationship existed between such family sizes and waste per capita. It can thus be inferred that the education level of the respondents in the case study affects their economic wherewithal and, in turn, the typology of waste they generate.

The Department of Human Settlements (2017), the area had existed for over a decade before government intervention. Most respondents have indicated that they lived in JST for over a decade and are knowledgeable about the issue in the area under study.

Municipal solid waste, according to the literature, comprises recyclables, garden waste, food, hazardous waste, and other items (NMBM IWMP, 2016). According to the respondents, the recognised wastes are metals, paper, bottles, and plastic items. This study supports Joel and Fansen's (2013) argument that, while waste composition varies by location and income group, most waste generated by residents in emerging nations is recyclable, resulting in economic benefits, especially for low-income groups. However, the findings disagree with the conclusion of Uddin *et al.* (2019) that food remains a significant component of the waste composition. This discrepancy can be attributed to Joe Slovo's residents' overall income level. According to these data, the sort of waste generated appears to be a function of income level.

In the study, while trying to understand if there was a significant difference in the waste typology generated by gender, it was observed that there was no significant difference in the waste typology generated by each gender save for household hazardous waste, which is indicated to have a statistical significance. Furthermore, Mintz *et al.* (2019) indicated that there is no significant difference in the waste generated by gender and the study of Cantaragiu (2019) found no differences in the actual amount of waste generated by the two genders. These two pieces of literature underscore the study's findings, although there is a need for further research to understand why there was a significant difference in the generation of household hazardous waste.

6. Conclusion and Recommendations

Over 90% of the respondents have lived in the township for over 3 years, making them aware of the subject matter and making them a valid sample for the investigation of the subject matter. While it is observed that the level of formal education in JST is very low, the study did not investigate if there is a correlation between education level and waste generation, which could be an item for further study.

From the statistical evaluation, the study observed no significant difference in the types of waste items produced along gender delineations except for household hazardous waste. However, further research could be carried out to underscore this rationale.

The study identified that the most waste-typology produced is recyclable, but the volume of such waste was not researched to understand the necessary technology types and extent. Therefore, this item could also be further researched.

It is recommended that sustained cooperation be developed among all key stakeholders involved in waste management towards implementing a sustainable management practice and generating potential resources from the waste materials. Such cooperation should be formed among all-important actors, such as the government, waste managers, public health workers, and residents, to implement cost-effective, long-term, and dependable management techniques. The above measures would assist in realising the potential riches that waste materials could generate.

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