



(RESEARCH ARTICLE)



## Characterization of seasonally generated municipal solid wastes in Nnewi metropolis, Anambra State, Nigeria

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International Journal of Science and Research Archive, 2025, 16(03), 423–430

Publication history: Received on 01 August 2025; revised on 07 September 2025; accepted on 10 September 2025

Article DOI: <https://doi.org/10.30574/ijrsra.2025.16.3.2573>

### Abstract

The key challenge confronting urban cities in most developing economies is municipal solid waste (MSW) management. To abate this, waste separation is critical to a successful waste management. Reliable data on waste generation, composition and characterization that apprise effective planning on waste management in Nnewi is absent. In order for this community to formulate an integrated solid waste management program, accurate and reliable data on waste composition and quantities that will encourage well-organized and smoothly functioning recycling programs and keep the overall waste management costs low are essential. In this study, the composition and characterization of waste from Nnewi Municipal town waste was estimated by segregating it into different components, to obtain this data, selected households in the four quarters of the town were engaged to obtain data on physical composition, sorting and separation of waste. These waste components were categorized into biodegradable and non-biodegradable waste (plastics, glass and combustibles). It was observed that the waste contains around 48.18% biodegradable waste, and the remaining is non-biodegradable waste. The biodegradable content of MSW is a good source of compost for agriculture purpose whereas non-biodegradable content can be recycled for reuse.

**Keywords:** Biodegradable Waste; Characterization; Composition; Municipal Solid Waste; Waste Segregation

### 1. Introduction

Wastes are materials that are disposed-off or intended for disposal [1]; differ from one place to another depending on the source [2]. [3] opined that solid wastes are generally very diverse and are usually made up of complex mixtures of biodegradable and non-biodegradable matters. The World Bank in 2017 reported that about 1.3 billion tons of solid wastes are generated in different cities of the world per year, and the situation amounts to 1.2 kilograms per person per day, and the case may be worsened due to an estimated rise of 2.2 billion tons of wastes by 2025 [5]. Currently Nigeria generates more than 32 million tons of solid waste annually, out of which only 20-30% is collected [6] and the rest end in "Open Dump Site". [7] reported that the rate of waste generation exceeds collection capacity, as one to two thirds of the solid waste generation in developing countries is not collected and there is no regular routine collection [8].

Solid waste management in Nigeria is characterized by inefficient collection methods, insufficient coverage of the collection system and improper disposal despite huge budgets that are committed to Municipal Solid Wastes Management (MSWM). Solid waste management has emerged as one of the greatest challenges facing municipal authorities worldwide especially in developing nations. Solid waste in Nigeria poses many problems including blockage of drainage and channels causing flooding and presenting breeding grounds for vectors [9] and [10]. Contributory factors to this challenge include inadequate regulatory framework that has manifested in lack of interest of private sector investment in service delivery; uncoordinated institutional functions; low political will, low capacity to discharge duties, poor data information for planning, and wrong attitude of waste generator amongst others [11]. The

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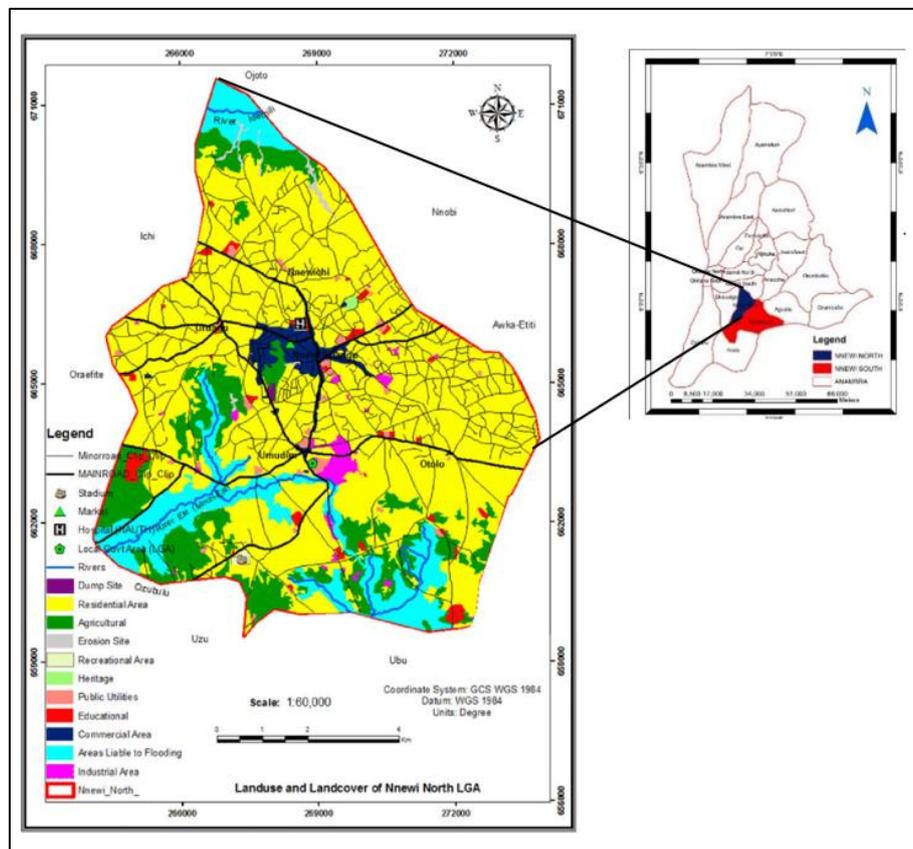
volume of solid waste been generated has continually increased at faster rate than resources available to contain it. A hygienic and efficient system for collection and disposal of solid waste is therefore fundamental for any community [12].

### 1.1. Sources, Composition and Characterization of Solid Waste

The first step towards a sustainable solid waste management is to gain understanding of the nature and composition of the waste being generated in time and space. Knowledge of the sources and types of waste in an area is required in order to design and operate appropriate solid waste management systems because waste management planning needs reliable data concerning waste generation [13]. This information is necessary for planning, designing and establishing appropriate and more sustainable collection, transportation and final disposal strategies for the waste. Urban solid waste is heterogeneous in nature and its generation rate and composition vary from place to place and from season to season; more so the composition and volumes differ between high and low-income locations [14]. Therefore, an efficient system for MSW management requires a good knowledge of the characterization of solid wastes to be disposed [15]. According to [16] a good knowledge of solid wastes characterization before disposal is also important for appropriate MSW collection, selection of transportation equipment, energy transformation and recovery of reusable matter, as well as the proper design and implementation of optimal disposal routes and methods. The municipal solid waste (MSW) characterization depends on social structure and a number of other influences like dwelling types, lifestyle, and climate of a particular place [17] and personal characteristics such as education, awareness of consequence and moral norm [18]. Accurate information on the area (residential, commercial) [19]; the economic level differences between high- and low-income areas [20]; the season, weather and culture of people living or doing business in the area [21] are all necessary in order to monitor and control existing waste management systems and to make regulatory, financial, and institutional decisions.

## 2. Materials and Methods

### 2.1. Description of study area



**Figure 1** Map of Nnewi North LGA (inset map of Anambra state)

Nnewi is a commercial and an industrial city in Anambra state of Nigeria. It is located on 6.01050 N and 6.91030 E about 15 miles south of Onitsha. The city spans over 1,076 square miles (2,789km<sup>2</sup>) [22]. It is the only town in Nnewi North

LGA; with four autonomous quarters (sub-towns) that make up the one-town local government. This includes: Otolo, Uruagu, Umudim and Nnewi-Ichi. Geographically, Nnewi falls within the tropical rain forest region of the world [23]. It has two major seasons namely: Raining and Dry seasons [24]. The city is known for producing a diversified range of transportation entrepreneurs from transporters, to spare parts dealers and manufacturers.

## 2.2. Materials

The following materials were used

- Black polythene bags (80litres) in different coloured laundry basket bins
- Weighing balance
- Shovel
- Hand gloves

## 2.3. Methods for Sourcing, quantification and characterization of wastes

The wastes samples were collected from the four quarters of Nnewi (Latitude: 6.0167 Longitude: 6.9167) namely Otolo (60 25' 60" N and 60 10' 60" E), Uruagu (60 12' 18" N and 60 54' 33" E), Umudim (60 0' 18" N and 60 54' 36" E), and Nnewichi (60 01' 10" N and 60 55' 60" E), including the central Motor and Motorcycle spare parts markets (located at the center of the town where the four quarters have boundary with one another). Black polythene bags of 80 liters placed inside different coloured 80 liters Queen Laundry Basket (Pentagon Plastic Industries Limited) were distributed to 20 households (5 from each quarter of the town). Five streets were selected from each quarter for the SYPAS (Separate Your Plastic At Source) Initiative. One household was randomly chosen from each street. Two other baskets were also respectively placed at that Motor Spare parts and Motorcycle (Machine) Spare parts markets. This brought the total number of Baskets for the project to 24. The streets chosen from Otolo were Nwafor Orizu Avenue, Ndiakwu, Obiego Street Okofia, Ezekwuabo- Umuzu road, Igwe Orizu road Ogbe and Agbakagu Street, Enem. From Uruagu, the streets chosen were Okpunoeze- Umudimkwa road, Ogbufor road, Amukor-Nwafor uruagu road, Nkwo to Nkwo road and Okpunoeae-Oraifite road. These roads / streets were taken from Umudim namely Lasel/ Ukpore road, Inyaba/ Nkwo akwu road, Ukwaka/ Obi umudim road, Inyaba, Eme court road Okpunoegebu and Uru Road. From Nnewichi the following streets were selected: Mmilikwe road, St Peter Claver Road, St Mark/ Obiofia road, Umu ezize/ Umu ogbo road and Ozulu - Akabo road.

The collected wastes were sorted out into five (5) as follows: Putrescible (organic wastes), Combustible (papers, textiles), Plastics / "pure" water sachets, broken Glass and others. This study employed quantification at the point of waste collection. The study on the characterization of MSW was conducted in six months periods (March to August) with the purpose of evaluating dry and raining seasonal conditions. The [25] (Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste) method developed by the American Society for Testing and Materials (ASTM) was used. This test method describes procedures for measuring the composition of unprocessed municipal solid waste (MSW) by employing manual sorting. Samples were collected and sorted out on weekly basis every Saturday between 4 and 6 pm throughout the study at the respective locations for the period (March, April, May, June, July and August). The weight of each sorted composition was measured with a weighing balance and recorded. Afterwards, the weights of the individual components were added to give the quantity of waste at a particular dumpster/collection site.

The percentage of each component (ci) was calculated by this formula

$$\text{percentate } (c1) = \frac{m1}{m} \times 100 \quad 1$$

Where  $M_i$  is the weight of a certain component (kg) and  $M$  is the total weight of the waste sample (kg).

## 3. Results and Discussion

### 3.1. Sample characterization and quantification

The solid waste characterization process in Nnewi was completed after a period of six months from March to August, 2023. The result for the season's sampling, sorting and characterization is presented in table 3.1. Information on the characteristics of solid waste showed that it was heterogeneous for different locations as shown. From the total solid wastes of 119.527 kg/day (836.688 kg/wk) generated during the study period, Otolo had an average weight of

23.621kg/day (20.36%); Uruagu had 24.369 kg/day (20.39%); Umudim generated 20.48 kg/day (17.13%); from Nnewichi was 24.36kg/day (20.38%), while the Market had 26.690 kg/day (22.34%).

**Table 1** Characterization of wastes according to the areas

Area	Biodegradables	Plastics	Combustible	Glass	TOTAL (kg/wk)	%Age
Tool	97.783	33.412	22.138	12.013	165.346	20.36
Uru Agu	94.703	35.903	26.470	13.510	170.586	20.39
Mudimu	80.390	32.375	18.014	12.600	143.379	17.13
Nnewi chi	103.253	34.620	20.626	12.046	170.545	20.38
Motor parts Market	27.009	52.972	96.799	10.052	186.832	22.34
TOTAL (kg/wk)	403.138	189.282	184.047	60.221	836.688	100%

The quantity of wastes collected (table 3.1) depicts the picture of the activities going on in the areas. Otolo with a largest land area did not generate the highest waste. Rather the market area though smallest in land area has the largest quantity of waste because of the human activities going on there on daily bases. Again, the Motor and Machine parts market generated greater number of combustible (96.799 kg/wk) and plastic (52.972kg/wk). From the quantification and characterization, it is observed that Nnewichi, though the smallest in land mass, produced the largest quantity of biodegradables (103.253kg) because the area houses a greater number of non-indigene when compared to the other quarters. The non-indigenes do not have farms where wastes are managed. This was followed by the Otolo (97.783kg) and Uruagu (94.703kg) communities. The motor part market generated the least biodegradable (27.009kg/wk) because there was no much activities that could produce the biodegradables there. Rather, it produced the highest quantity of the combustibles (papers and cardboard, 96.80kg) that came out of the unwrapped motor and motorcycle parts. The market area also produced the highest number of plastic 52.972kg/wk. This could be because many people in the market area consume much quantity of sachet and bottled water daily. Uruagu and Nnewichi produced the second highest number of plastics. This is attributed to the spread of the market area into the two quarters. Otolo and Umudim produced the least number of plastics. This is also because of the fact that most of the inhabitants are indigenes and landlords who have access to streams or boreholes in respective villages. The market produced the largest number of combustibles because of the large quantity of used cartons from the wrapped motor and motorcycle parts.

**Table 2** Quantity of Waste Generated in kg/week and the percentages

Type of waste	Quantity	Percentage
Biodegradable	394.138	48.18
Plastic	189.282	22.62
Combustible	184.047	22.00
Glass	60.221	7.20
TOTAL	836,688 kg/wk (119.527kg/day)	100%

The solid waste being generated in the study area was made up of five major components (biodegradables, plastics, the combustible, glass and Metal). The number of metals were not recorded because the project was limited only to the four solid wastes as shown in table 3.2. Analysis of the waste type shows that Nnewi's solid waste consists to a large extent of organic biodegradable matter (48.18%) and the non-biodegradable (52%) [Plastics 23% and combustible 22%, glass 7%] which is typical of low-income developing economy. The result is also in agreement with the findings of [26] in the assessment of municipal solid waste management practices in Akure, Ondo State, Nigeria. Information on the nature and composition of urban solid waste in Akure showed that a greater part of the respondents 37.8% created squander from vegetable and food remains. This was trailed by 28.3% of the respondents that produced polythene bags. Other waste generated includes plastic (19.1%), paper (8.2%) and metal waste (6.6%). It could be deduced that vegetable and nourishment remain were the most widely recognized waste produced by the respondents in the study area. The result is in tandem with the findings of [27] and [28], who reported food wastes having the highest percentage MSW dumpsite. Biodegradables (20.59%) ≥ Thermosets (17.40%) ≥ Metals (5.63%) ≥ Others (0.54%). The result of ordering is in

tandem with the report by [29]. The result of biodegradable materials of about 21% is greater than 9% of MSW treated for composting in cities [30]. The result of the biodegradable is consistent with the report that, the organic waste in municipal solid waste is the largest component of the waste stream. The most report of the European Environmental Agency highlighted that approximately 85 million tons of biodegradable waste were generated in European Union member states; the greatest portion (around 60%) was composed by food scraps and leftovers, while green waste accounted for approximately 34% [31]

The non-degradable wastes are recyclable materials, plastics that can be de-polymerized [32], while the degradable materials could be composted [33]. Also, in the solid waste generation and disposal in Owerri municipality, Imo State, Nigeria, [34] reported that at household level, 71% of waste generated were biogenics made up of food wastes, sweepings and other biodegradables. The study also recorded high percentage of non-degradable materials such as plastics (11.9%) papers (11.3%), bottles (3.3%), metals (2.3%) and miscellaneous (2.0%). The practice of waste separation is not common among subjects, especially residents in Old Owerri district but poorly practiced at Ikenegbu and World Bank Estates, Imo state, Nigeria. The reason for this result could probably be because of the way of life of the respondents in the study area. The high percentage of organic waste may be attributed to the consumption of unprocessed food as compared to processed food consumed in more developed countries [35]. The biodegradable nature that characterizes solid waste in Nigeria is similar to what is obtainable in countries with similar economic and demographic characteristics including India, Bangladesh and Ghana [36] and [37]. In nations like United States of America, Germany and Japan, the waste streams are usually dominated by paper, plastics and glass [38]. This is in-line with previous research work by [39] where it was found out that waste stream is more of organic materials in developing countries.

[10] while studying the municipal solid waste characterization and quantity as a measure of effective management in Doda region of Jammu and Kashmir, India, indicated that the results obtained showed that the composition of the waste generated in study area is dominated by food wastes, grasses and leaves (91.69%) followed by plastic and wood (8.31%). In Lagos, according to [40], the daily per capita MSW generation was 0.63 kg/capita/day with putrescible matter making up 68% of the total MSW generated. [41] reported waste generation rate of 0.22 - 0.48 kg/capita/day, with the composition of the garbage waste as 61%, polythene 13%, 2.8% plastics, 4.2% paper and cardboard, 0.9% metals, 1.6% glass, 2.2% textile and 14% residues in Bauchi, Nigeria.

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#### 4. Conclusion

The problems affecting municipal solid-waste management in Nigeria are diverse and numerous, and a healthy environment in most places in Nigeria has been compromised by an indiscriminate disposal of solid waste. Improved solid waste management systems have the potential to address multiple SDGs, both directly and indirectly. To achieve success in management in Nnewi, waste should be managed at the local level so that local variations can be taken into account instead of the current practice of having a large centralized agency. Thus, for any waste management framework for Nnewi town, a careful consideration of all these factors in relation to local conditions must be the basis of a sound and sustainable programmed. Based on the analysis, the biodegradables (the organic fraction) has 48.18%. This percentage of biodegradables could be used as raw material for biological conversion processes like composting, biogas and bioethanol refinery process while the plastics and glass (29.8%) recyclables should be sent for recycling within the Nnewi.

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#### Compliance with ethical standards

##### *Disclosure of conflict of interest*

There was no conflict of interest to be disclosed.

##### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study.

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