

# Assessment of Polyethylene Terephthalate (PET) Recycling Practices in Keffi Metropolis, Nasarawa, Nigeria

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## ABSTRACT

The research paper focuses on assessment of recycling PET activity in the city of Keffi Metropolis, the state of Nasarawa with the purpose to develop a more sustainable and friendly waste management model. A survey design of quantitative descriptive study was used that utilised 399 respondents chosen through stratified and simple random sampling methods. The data were collected via structured questionnaires and analysed descriptively using statistical analysis as well as thematically. The results show that the consumption rate of PET bottles is high in Keffi with little formal recycling systems. The waste management of PET is organised mostly through informal sources, which include waste pickers, small scale pickers, and household level reuse of the waste to local beverages. Over half of the participants were found to have limited knowledge of official techniques of PET recovery, and recycling operations in general are still mostly unorganised. Even though 44.7% of the respondents attributed the economic value of PET collection and resale, 55.3% indicated that they were not directly involved when it comes to recycling, highlighting the imbalanced presence in the value chain of recycling. Spatial inequalities on the waste management infrastructure also led to indiscriminate dumping and burning especially in the peripheral neighbourhoods. However, inadequate infrastructure, lack of awareness by people, coordination of policies and formalisation of the integration process of the PET recycling hinder the overall benefits of PET recycling. In conclusion, the PET waste management improvement in Keffi requires the development of the formal collection system, unification and formalisation of informal recyclers, the increase of the public awareness campaign, and the support of the policy that aligns with the principles of the circular economy. The solution to these shortcomings will allow Keffi to streamline towards a more inclusive, efficient, and sustainable process of PET recycling.

## BACKGROUND OF THE STUDY

Plastic packaging constitutes approximately 70% of the consumer product market. Within the beverage industry, packaging systems are generally categorized into cold-fill (e.g., aseptic), carbonated soft drinks, and hot-fill formats. When selecting suitable packaging materials for beverages, the chosen material must demonstrate the ability to endure the thermal and mechanical conditions associated with filling and handling processes, preserve the sensory and nutritional integrity of the beverage throughout its intended shelf life, and withstand the internal pressure that may be generated by the product. Thermal stability is largely dependent on whether the beverage and its container undergo sterilization. Cold-fill products, such as bottled water and high-acid beverages, do not require sterilization<sup>1</sup>.

Polyethylene terephthalate (PET or PETE), a polymer belonging to the polyester family, is one of the most extensively utilized materials for beverage packaging. Its widespread adoption is attributed to its excellent clarity, lightweight nature, effective barrier performance against gases and moisture, strong impact resistance, ultraviolet (UV) protection, and superior durability compared to glass<sup>2</sup>. PET is a recyclable polymer offering

functional advantages not easily replicated by alternatives such as glass, aluminum, paperboard, or other plastic materials. According to data from a review article citing PMC, PET packaging accounted for 44.7 % of single-serve beverage packaging (<1 L) in the U.S. in 2021, with aluminum cans at 39 %, glass at 11 %, and HDPE at 3.4 %<sup>3</sup>.

Nigeria produces an estimated 2.5 million tonnes of plastic waste annually, making it one of the largest generators on the African continent, with plastics accounting for a significant share of the total waste<sup>4</sup>. Less than 10 % of this plastic waste is effectively recycled, and a large proportion is mismanaged, ending up in landfills, drainage systems, or waterways<sup>5</sup>. As with most synthetic polymers, PET is derived from petroleum and is highly resistant to natural degradation. When disposed of in landfills, plastic packaging waste contributes to air, water, and soil pollution, while occupying substantial landfill space. Although incineration may conserve landfill capacity and enable energy recovery, it carries significant risks of emissions and atmospheric pollution. The accumulation of plastics in marine environments (e.g. ocean gyres) underscores the global scale and severity of plastic pollution<sup>6</sup>.

Solid waste management is a particularly acute challenge in developing nations, where municipal solid waste volumes have grown rapidly alongside urbanization. Poor infrastructure, limited technical capacity, regulatory gaps, and weak enforcement hamper effective PET waste management. The adverse consequences include contamination of surface and groundwater via leachate, air pollution from open burning or methane release, and health and ecological risks<sup>7</sup>. In many Nigerian cities, a substantial portion of generated waste remains uncollected, contributing to open dumping, flooding, and degraded urban environments<sup>8</sup>. In Nigeria, households and businesses are estimated to generate about 230,000 tons of end-of-life PET waste annually, with PET plastics constituting approximately 29% of total plastic waste in some assessments<sup>9</sup>. Recycling, especially mechanical recycling, remains the dominant approach, but it is constrained by sorting inefficiencies, polymer degradation over cycles, and contamination issues<sup>10</sup>. Chemical recycling (pyrolysis, depolymerization) shows promise as a complementary route, potentially converting plastic waste into feedstocks for virgin-quality polymers or fuels<sup>11</sup>. In light of these challenges, the present study aims to investigate PET recycling practices in Keffi, with the goal of fostering a more sustainable waste management culture in the area.

The growing dependence on polyethylene terephthalate (PET) bottles in Nigeria has raised critical concerns about their collection and disposal methods. Previous studies in Nigerian cities such as Lagos and Ilorin have shown that PET bottles are often collected through informal scavenging, open dumping, or indiscriminate disposal in drainage channels, leading to flooding, visual pollution, and public health risks<sup>12, 13</sup>. While these studies highlight the environmental hazards of improper PET collection, they provide limited insights into context-specific practices in smaller urban centers like Keffi, where waste infrastructure is weaker. This study, therefore, investigates the unique patterns of PET collection and disposal in Keffi to fill this gap.

Scholars have documented the categories of recyclable waste streams in Nigerian urban centers, identifying plastics, metals, paper, and organic waste as dominant components<sup>14, 15</sup>. However, much of this research focuses on metropolitan cities such as Abuja and Lagos, with little empirical attention given to mid-sized cities like Keffi. The lack of localized data makes it difficult for municipal authorities to design effective recycling programs tailored to Keffi's specific waste composition. This study addresses that shortcoming by examining the categories of recyclable solid waste in Keffi metropolis with particular attention to PET.

PET resource recovery, which includes collection, sorting, cleaning, and reprocessing into new materials, has been studied in Nigeria mainly from the perspective of large-scale recycling facilities and formal initiatives<sup>16, 17</sup>. These studies recognize mechanical recycling as the dominant approach while noting the potential of chemical recycling. Yet, there is limited understanding of how PET resource recovery is practiced in smaller Nigerian towns where industrial recycling facilities are scarce and reliance is largely on informal actors. This study seeks to bridge this knowledge gap by documenting PET recovery practices in Keffi metropolis. This study thus seeks to assess current PET recycling practices in Keffi, identify the barriers and enablers, and propose strategies for more sustainable waste management in Keffi, North-Central Nigeria. The aim of this study is to examine the PET recycling practices in Keffi Metropolis with a view to providing information towards engendering an eco-friendly waste management culture in the study area. The objectives of this study

are to: examine the current methods of collection and disposal of PET bottles in Keffi Metropolis; identify and categorize the types of recyclable solid waste in the study area; assess the PET resource recovery practices in the study area; and evaluate the economic, environmental, and social contributions of the informal recycling sector to waste management in the study area. Keffi Local Government Area is located in the north central Nigeria between longitude  $7^{\circ}.49'03''$  and latitude  $8^{\circ}.46'; 8^{\circ} 53'5''$ . It stands at an elevation of 400 meter above sea level. It was created in 1976 and is undergoing rapid population growth and infrastructural development due to its proximity to the Federal Capital Territory, Abuja. Keffi has a population of 142,900<sup>20</sup>. Over the years, solid waste disposal has become a major problem in Keffi Local Government Area of Nasarawa State. Indiscriminate dumping is predominant in the area, irregular collection of waste generated and inadequate resources are the key problems facing solid waste management in the area<sup>21</sup>.

## METHODOLOGY

This study adopted a quantitative descriptive research design using a cross-sectional survey approach to assess PET recycling practices in Keffi Metropolis, Nasarawa State, Nigeria. The design enabled the systematic collection and analysis of data to address the study objectives related to PET collection, disposal, recycling, and informal sector contributions. The study population comprised residents of Keffi aged 18 years and above, estimated at 142,900 persons. Using Yamane's (1967) sample size formula at a 95% confidence level and 5% margin of error, a sample size of 399 respondents was determined. A probability-based sampling approach was employed, combining stratified random sampling across residential areas with simple random sampling to ensure representativeness and reduce bias. Data were collected using primary and secondary sources. Primary data were obtained through a structured, closed-ended questionnaire divided into five sections covering socioeconomic characteristics, PET disposal practices, recyclable waste types, PET resource recovery, and the role of the informal recycling sector.

Data analysis combined descriptive statistical techniques including frequencies, percentages, cross-tabulations, tables, and charts with thematic analysis for qualitative data. Descriptive statistics were used to examine PET disposal methods, recyclable waste composition, and recovery practices, while thematic analysis provided insights into the economic, environmental, and social contributions of the informal recycling sector. This mixed analytical approach enhanced the robustness and validity of the study findings.

## RESULT AND DISCUSSION

### Socioeconomic Characteristics of Respondents

The socioeconomic characteristics of respondents in Keffi Metropolis were analyzed based on gender, age, educational attainment, residential location, occupation, and religion to contextualize PET waste generation and recycling behavior. Gender distribution was relatively balanced, with 52.1% females and 47.9% males, indicating inclusive household participation in waste management activities. Age distribution showed a strong youth dominance, as 65.5% of respondents were below 30 years, reflecting the central role of young people in PET usage, disposal, and informal recycling activities in the metropolis. Educational attainment revealed a relatively high literacy level among respondents: 39.6% possessed BSc/HND qualifications, 37.6% completed secondary education, and 12.3% held postgraduate degrees, suggesting a population with substantial awareness potential for environmental management and recycling initiatives.

Respondents were drawn from diverse residential areas across Keffi, including GRA, Sabon Gari, and other notable neighborhoods, ensuring spatial representativeness and capturing variations in waste generation patterns linked to settlement characteristics. Occupationally, students constituted the majority (58.1%), consistent with Keffi's status as a university town, followed by civil servants and self-employed individuals, highlighting the influence of youth and formal-sector workers on consumption and waste disposal trends. Religious affiliation was dominated by Christianity (64.4%) and Islam (33.6%), reflecting the prevailing religious composition of Nasarawa State. This distribution underscores the potential role of faith-based institutions in promoting environmental awareness and community participation in sustainable waste management. Overall, the socioeconomic profile indicates a youthful, relatively educated, and socially diverse

population, which presents both opportunities and challenges for improving PET recycling and circular economy practices in Keffi Metropolis.

Table 1 Socioeconomic Characteristics of Respondents

Variables	Categories	Frequency (N)	Percentage (%)
<b>Gender</b>	Male	191	47.9
	Female	208	52.1
	<b>Total</b>	<b>399</b>	<b>100</b>
<b>Age (Years)</b>	Below 30	261	65.5
	30 – 39	68	17
	40 – 49	48	12
	50 and above	22	5.5
	<b>Total</b>	<b>399</b>	<b>100</b>
<b>Level of Education</b>	Primary	13	3.3
	Secondary	150	37.6
	OND/NCE	7	1.8
	BSc/HND	158	39.6
	Master	49	12.3
	PhD	6	1.5
	No Formal Education	16	4.0
	<b>Total</b>	<b>399</b>	<b>100</b>
<b>Residence (Location)</b>	Manhattan Park and Gardens	45	11.3
	GRA	90	22.6
	Sabon Gari	87	21.8
	Anguwan Jaba	32	8
	Jigwada	23	5.8
	Other Notable Areas	122	30.6
	<b>Total</b>	<b>399</b>	<b>100</b>
<b>Occupation</b>	Students	232	58.1
	Civil Servant	77	19.3

	Privately Employed	13	3.3
	Self Employed	58	14.5
	Artisan	8	2
	Unemployed	11	2.8
	<b>Total</b>	<b>399</b>	<b>100</b>
<b>Religion</b>	Christianity	257	64.4
	Islam	134	33.6
	Traditional	8	2
	Others	-	-
	<b>Total</b>	<b>399</b>	<b>100</b>

### Description of PET Recovery Practices by Keffi Residents

The table presents respondents’ descriptions of PET bottle recovery practices in Keffi Metropolis. The findings indicate a generally low level of awareness and direct involvement in formal PET recovery processes among residents. A substantial proportion of respondents reported no recovery activity, with 35.7% indicating “None”, while 14.0% stated “I don’t know” and 7.2% selected “N/A”. Together, these responses suggest that more than half of the respondents lack clear knowledge of what happens to PET bottles after disposal, highlighting limited public awareness of PET recovery chains in the metropolis.

Among respondents who demonstrated awareness of recovery processes, several informal and formal practices were identified, although each accounted for relatively small proportions. Informal reuse practices included the reuse of PET bottles for local beverages such as kunu, zobo, tiger-nut drinks, and liquid soup (each 2.4%), reflecting household-level and micro-enterprise reuse activities common in urban Nigeria. Additionally, 3.1% noted that some collectors rinse bottles before sale to improve resale value, indicating rudimentary value-addition practices within the informal sector.

Formal recycling-related activities were mentioned by a limited number of respondents. These included manual sorting and cleaning after collection (2.7%), removal of labels and caps (2.9%), crushing or baling for transportation (1.7%–3.1%), and washing and flaking at recycling plants (2.4% each). Furthermore, 2.7% indicated that sorted PET bottles are sold to middlemen or aggregators operating within Keffi or nearby towns, while 3.1% reported that PET bottles are transported to recycling facilities within Nasarawa State or major industrial hubs such as Abuja, Ogun, and Lagos. Overall, the results reveal that while multiple PET recovery pathways exist, including reuse, informal collection, and formal recycling, resident awareness and participation remain low. PET recovery in Keffi is largely driven by waste pickers, informal collectors, and external recycling agents, rather than by structured household-level engagement. This underscores the need for improved public sensitization, organized collection systems, and policy support to strengthen PET recovery and recycling practices in the metropolis.

Table 2 Description of PET Recovery Practices by Keffi Residents

Description recovery by Keffi residents	Frequency	Percent
After collection by residents, waste pickers, or companies like Zero-Waste Management Konsult, PET bottles are sorted manually and cleaned properly.	11	2.7

At the recycling plant, PET bottles are crushed into flakes	10	2.4
At the recycling plant, PET bottles are washed thoroughly	10	2.4
Crushing	13	3.1
For putting of Kunu	10	2.4
I don't know	58	14.0
It is used for local bottled drinks	10	2.4
It is used for refilling of zobo drink, tigernuts drink, and liquid soup	10	2.4
Labels, caps, and other non-PET parts are removed	12	2.9
N/A	30	7.2
No idea	13	3.1
None	148	35.7
Some collectors rinse the bottles before selling to increase their res	13	3.1
Some people gather PET bottles and re-used it to sell Kunu and zobo drinks.	10	2.4
Sorted PET bottles are sold in bulk to middlemen or aggregators, who operate either within Keffi or in nearby towns like Masaka or Karu.	11	2.7
The collected PET bottles are compressed or baled for easier transport.	7	1.7
They are sent to recycling facilities, either within Nasarawa State (e.g., some local processing points in Karu or Lafia) or in industrial hubs like Abuja, Ogun, or Lagos	13	3.1
They sell it	10	2.4
Total	399	100.0

### Benefit Description of PET waste in Keffi Metropolis

The data reveals that a minority (44.7%) of respondents acknowledged economic benefits related to PET bottle collection and sale, while a majority (55.3%) reported no such involvement or gains. Among those benefiting, diverse actors contribute to the PET value chain ranging from individual collectors (e.g., “Mr. Bala,” “Mr. Joseph”), informal groups (often referred to as Hausa boys or bola-bola), women vendors collecting PET bottles during market days, to small-scale intermediaries operating micro-enterprises. This underscores the informal and decentralized structure of Keffi’s recycling economy, where everyday citizens exploit PET recovery as a means of livelihood through low-capital, accessible activities.

Small-scale traders and intermediaries who buy PET waste in bulk for resale to recycling firms represent a multi-layered informal value chain, mirroring patterns observed across African cities <sup>14</sup>. The involvement of women in PET recovery, often as a supplementary income-generating activity, reflects findings from, which highlighted that women in urban markets frequently engage in small-scale recycling as part of their informal economic strategies.

Notably, the engagement of youths trained by Zero-Waste Management Konsult, who transform PET into products such as interlocking bricks, marks a transition from informal collection toward structured, value-added recycling. This development aligns with global shifts toward upcycling and circular economy practices, as advocated by<sup>31</sup>, who emphasized the integration of community training, innovation, and green technology in sustainable recycling systems.

The 55.3% of respondents indicating “none” or no awareness of PET-related economic activities may point to limited information flow, infrastructure gaps, or socio-economic exclusion from the recycling sector. Similar to observations by<sup>31</sup> and<sup>32</sup>, this finding suggests that awareness campaigns, public sensitization, and inclusive policy frameworks are essential to foster broader participation and equitable access to the economic opportunities within PET recycling.

Table 3 Benefit Description of PET waste in Keffi Metropolis

Description of the economic benefits of collecting and selling PET waste by Keffi residents	Frequency	Percent
A friend sells PET bottles weekly to random kunu/zobo sellers for livelihood.	10	2.4
Hausa boys (funnily called bola-bola)	10	2.4
I have not and I don't know of anyone	20	4.8
Mr. Bala sold the PET bottles waste to people that reuse it to package kunu drinks.	10	2.4
Mr. Joseph (the waste collector)	13	3.1
Mrs. Ivy (Manager in a recycling company)	10	2.4
No one	26	6.3
None	229	55.3
Some people resell it	10	2.4
Some residents run small businesses that involve buying PET waste in bulk from collectors and reselling to recycling firms.	11	2.7
Some women collect and sell PET bottles as a side hustle, especially during market days.	12	2.9
Terry (the respondent, a resident in Keffi)	10	2.4
Through Zero-Waste Management konsult’s training programs, some Keffi and Nasarawa youths have learned to recycle PET waste into products like interlocking bricks or eco-friendly construction materials	7	1.7
Waste Pickers and Local Collectors	11	2.7
Yes, the Hausa boys (called bola-bola), they collect and sold it to recycling companies.	10	2.4
Total	399	100.0

**Support reasons for Informal recycling in Keffi Metropolis**

The responses reveal diverse views on why informal recyclers in Keffi should be supported, with recurring themes centered on environmental protection, livelihood generation, formal sector integration, and social inclusion. A majority of respondents recognized that informal recyclers play a vital role in minimizing open dumping and plastic burning, two major sources of urban pollution. Supporting these actors not only improves waste collection efficiency but also contributes to achieving cleaner and more sustainable urban environments.

Furthermore, respondents emphasized that informal recycling offers crucial income opportunities for marginalized populations, particularly unemployed youth and women, who often depend on recycling as a survival strategy. Studies <sup>2</sup>in developing nations affirm that the informal recycling sector serves as an economic buffer, fostering social resilience by creating employment within low-income urban communities. The findings, therefore, underscore the need to institutionalize and support informal recyclers through recognition, policy inclusion, and access to recycling infrastructure, as this can enhance environmental sustainability while addressing socioeconomic inequalities.

Table 4 Support reasons for Informal recycling in Keffi Metropolis

<b>Reasons for informal recycling support by Keffi residents</b>	<b>Frequency</b>	<b>Percent</b>
By integrating them into the formal system, the government can help create stable income streams through cooperatives, training, and fair pricing models.	10	2.4
Encouraging informal recycling reduces open dumping and burning of plastics like PET, which harms the environment.	10	2.4
Equip them to do more.	13	3.1
For informal recyclers to be supported, it will help the environment clean as well.	10	2.4
I think they should not be supported because they steal peoples' properties or belongings.	10	2.4
In Keffi, a significant portion of recyclable PET waste is recovered by informal waste pickers and small-scale collectors.	10	2.4
Informal Recyclers Are the Backbone of Waste Recovery	11	2.7
Informal recyclers have deep knowledge of local neighborhoods and access to areas where government waste services may not reach.	8	1.9
Informal recycling provides livelihoods for unemployed youth, women, and low-income households.	7	1.7
Integrating them improves coverage and efficiency, helping the system become more inclusive and responsive.	10	2.4
It helps to keep the environment clean and safe.	10	2.4
It will help the community	10	2.4
Keep the environment clean and it creates employment opportunity for the jobless Hausa boys.	12	2.9

Local governments and recycling companies (e.g., NASWAMB) can partner with informal actors to create a hybrid waste management structure.	10	2.4
Local governments and recycling companies (e.g., Zero-Waste Management Konsult) can partner with informal actors to create a hybrid waste management structure.	13	3.1
N/A	11	2.7
No	35	8.5
None	43	10.4
Not sure	13	3.1
So that they can be formalized	13	3.1
They will stop roaming around and stealing people's belongings in the community.	13	3.1
They work daily without formal recognition yet significantly reduce waste in streets, markets, and landfills.	13	3.1
To have a clean environment	10	2.4
To keep the environment clean and safe.	12	2.9
To make a living	13	3.1
To make the environment clean.	13	3.1
To support in keeping the environment clean	10	2.4
To support in keeping the environment clean.	13	3.1
Training programs and incentives can transform informal pickers into trained, traceable contributors within the circular economy.	13	3.1
When recognized and supported, these actors can help increase overall recycling rates in Keffi and promote sustainable waste management.	10	2.4
Yes, they should because they work daily without formal recognition yet significantly reduce waste in streets, markets, and landfills	10	2.4
Total	399	100.0

## CONCLUSION

The study reveals that PET bottle consumption in Keffi Metropolis is high, while formal systems for collection, disposal, and recycling remain inadequate. PET waste management is largely dominated by informal mechanisms, with households mainly engaging in reuse practices rather than structured recycling. Although informal collectors are widely recognized, actual household engagement with them is limited, exposing a gap between awareness and practice. Significant spatial disparities exist, as residents in peripheral neighborhoods often resort to burning or open dumping due to insufficient waste management infrastructure. Findings further indicate that PET bottles constitute the primary recyclable waste stream in Keffi. However,

recycling activities are largely informal and characterized by household-level reuse, such as repurposing bottles for local beverages. Awareness of formal recycling entities and technical recovery processes is low, limiting the transition from informal reuse to industrial-scale recycling. Consequently, the potential economic and environmental benefits of PET recycling remain underutilized.

Despite these limitations, the informal recycling sector plays an important social and environmental role, supporting household sustainability and providing livelihood opportunities. The predominantly youthful and relatively educated population presents a strategic opportunity for strengthening PET recycling through targeted education, technological engagement, and policy integration. The study concludes that improving PET waste management in Keffi requires strengthened formal infrastructure, integration of the informal sector into structured recycling systems, and enhanced public awareness. Policy interventions should promote circular economy practices, equitable urban waste infrastructure, digital monitoring tools, and effective regulatory enforcement.

The study contributes to knowledge by providing empirical evidence on PET waste management in a medium-sized Nigerian city, highlighting the interplay between informal practices and formal system gaps. It recommends further research on lifecycle environmental impacts, gendered recycling behavior, non-PET recyclables, digital engagement strategies, long-term policy effectiveness, and spatial mapping of informal recycling networks.

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