Analysis of Plastic Waste Types and Volumes Generated by Fast Food Centres in Calabar Metropolis, Nigeria

Eneyo Violet Bassey*
Department of Geography and Environmental Science, University of Calabar, Calabar, Nigeria
Corresponding author email*: violeteneyo@unical.edu.ng

Abstract This study delves into the volume and types of plastic waste produced by fast food centres in Calabar metropolis, Nigeria. Employing a volumetric methodology, we captured waste generated over quarterly intervals using containers of a predetermined volume. The collected plastic wastes underwent classification and weighing processes. Findings indicate a monthly accumulation of 7.6m3 plastic waste from these fast-food centres. Notably, Polyethylene Terephthalate (PET) - found in disposable soft drink bottles, peanut butter and jam jars, and salad dressing containers - constituted 64% of the plastic waste. Low-Density Polyethylene (LDPE), prevalent in squeezable bottles and frozen food bags, followed at 26%. Our research underscores the pronounced contribution of the fast-food industry to the area's plastic waste compared to other service sectors. A predominant non-segregated disposal approach was observed among the local fast-food establishments. The study advocates for an emphasis on segregating waste into distinct streams to foster sustainability. Furthermore, a collaboration between fast food operators and profitable plastic waste recycling entities is recommended to enhance waste management.

Keywords Plastic Waste, Fast Food Centres, Calabar Metropolis, Volumetric Analysis, Polyethylene Terephthalate (PET), Waste Segregation

Introduction

Plastics have revolutionized various industries due to their inherent properties like flexibility, durability, lightweight, and ease of manufacturing. Their widespread adoption can be observed in sectors like packaging, automotive, electronics, and healthcare (Thompson, 2008; Okoro & James, 2012; Adebayo et al., 2017). Particularly, fast food centres have become heavy consumers of plastic for packaging and dispensing food, drawn by its convenience and hygienic properties (Ogunyemi & Salawu, 2016; Udoh, 2019; Ekanem et al., 2020). Despite these advantages, the ubiquity of plastics has given rise to a pressing waste management challenge. With the burgeoning urbanization seen in places like Calabar Metropolis, Nigeria, reflective of global trends, there has been an influx of fast-food centres (Akpan & Essien, 2018; Eja et al., 2021; Ekpenyong & Bassey, 2022). Concomitant with this growth is a surge in plastic waste, including materials such as polyethene Terephthalate (PET) for beverages and low-density polyethene (LDPE) for various food packaging (Reynolds, 2015; Musa et al., 2021; Ibrahim et al., 2022). In the absence of proactive waste management strategies, these discarded plastics become significant environmental threats, jeopardizing both terrestrial and aquatic ecosystems (Nwankwo et al., 2019; Olatunji & Chukwu, 2020; Essien et al., 2021; Smith & Brown, 2005; Johnson et al., 2010; Reynolds, 2015)

The detrimental effects of plastic waste are manifold. Not only do they mar the aesthetics of urban landscapes, but plastics, especially when not disposed of appropriately, also obstruct

drainage systems and endanger aquatic life (Udom, 2020; Amadi & Ekong, 2021; Inyang, 2021). Their long degradation period, spanning centuries, perpetuates their environmental threat (Reynolds, 2015; Musa et al., 2021; Thompson, 2008). Moreover, it is not just an environmental issue. Improperly managed plastic waste has severe socio-economic consequences. Clogged drainage systems result in flooding, bringing about loss of life, property damage, and related economic setbacks (Akpan & Essien, 2018; Udom, 2020; Ekpenyong & Bassey, 2022). Fast food centres are at the heart of this issue due to their business model. Their operations, emphasizing speed and convenience, inevitably produce copious amounts of plastics (Udoh, 2019; Ogunyemi & Salawu, 2016; Etim & Udoh, 2021). While this model ensures efficiency and consumer satisfaction, it generates vast quantities of single-use plastics discarded posthaste. Understanding the volume and type of waste generated is imperative for devising bespoke waste management solutions.

However, in this expansive narrative of plastic consumption and disposal, the fast-food sector still needs more research, especially in regions like Calabar Metropolis. The environmental concern stemming from the sheer volume of daily plastic waste from these centres intertwines with intricate public health and socio-economic ramifications. While numerous studies have explored plastic waste management from various dimensions, a gap remains (Ibrahim et al., 2022; Etim & Udoh, 2021; Ekanem et al., 2020). Focused research remains scarce on the quantification, categorization, and periodicity of plastic waste from fast food centres in specific locales like Calabar Metropolis. Existing literature has often taken a broader approach, neglecting the unique challenges of this sector (Thompson, 2008; Musa et al., 2021; Amadi & Ekong, 2021; Inyang, 2021; Ekpenyong & Bassey, 2022).

Considering the operational dynamics of fast-food centres, which might witness variability in waste due to factors like customer volume and promotional events, this oversight becomes even more pressing (Reynolds, 2015; Thompson, 2008). Coupled with the growth trajectory of the fast-food industry in Calabar Metropolis, the need for targeted research is underscored. For effective plastic waste management, precise, sector-specific data is vital. Such data can provide a clear picture of the present scenario and help forecast future challenges. This viewpoint resonates with earlier research emphasizing the need for sector-specific knowledge (Amadi & Ekong, 2021; Ekpenyong & Bassey, 2022; Etim & Udoh, 2021; Eyo & Nseabasi, 2023; Ufot et al., 2023; Adebayo et al., 2017). Broad waste management strategies might fail to address challenges unique to sectors like the fast-food industry. Thus, the primary objective of this study becomes abundantly clear: To bridge the knowledge gap regarding the nature, volume, and patterns of plastic waste from fast food centres in Calabar Metropolis. Achieving this will lay the foundation for crafting robust waste management strategies, ensuring both environmental preservation and the well-being of city residents.

Statement of Research Problem

Due to their myriad advantages, plastics have seamlessly integrated into diverse sectors, with a pronounced footprint in the fast-food industry (Smith & Brown, 2005; Johnson et al., 2010; Akpan & Essien, 2018; Udom, 2020; Etim & Udoh, 2021; Eyo & Nseabasi, 2023; Ufot et al., 2023). Their ubiquity, however, has given rise to pressing waste management conundrums, especially in rapidly urbanising regions such as Calabar Metropolis, Nigeria. The city, formerly lauded as a beacon of

cleanliness in West Africa (Akpan & Essien, 2018; Thompson, 2008; Udom, 2020), is grappling with an upsurge in plastic waste, predominantly from fast food centres. Although vast studies have tackled overarching plastic waste issues (Ogunyemi & Salawu, 2016; Udoh, 2019; Essien et al., 2021; Udom, 2020; Ekpenyong & Bassey, 2022; Etim & Udoh, 2021), a pronounced research lacuna exists concerning fast food centres, particularly in swiftly urbanising zones. Prevailing research casts a broader net, focusing on waste from larger hospitality sectors (Eja et al., 2021; Ekpenyong & Bassey, 2022; Nwankwo et al., 2019; Thompson, 2008) or hones in on residential waste sources (Musa et al., 2021; Ibrahim et al., 2022; Nwankwo et al., 2019; Amadi & Ekong, 2021). Fast food centres' unique operational dynamics and waste generation intricacies mandate a more focused research prism. This glaring oversight not only amplifies environmental dilemmas but also jeopardises urban well-being. The economic boom in Calabar, accompanied by a population influx, necessitates increasing fast food centres. This surge, coupled with the dearth of empirical data on plastic waste from these centres, underscores the urgency of this research. Preliminary observations suggest an overwhelming volume of plastic waste originating from these centres, a trend poised to intensify. Thus, without concrete data, formulating effective waste management strategies remains elusive.

Description of the Study Area: Calabar Metropolis, Nigeria,

The study area, Calabar Metropolis, colloquially referred to as "Canaan City," is Cross River State's capital and strategically positioned in the southeastern part of Nigeria. With roots tracing back to its days as a pivotal colonial port city, Calabar is a testament to a deep-seated cultural heritage, serving as a melting pot for diverse ethnic communities, most notably the Efik, Ejagham, and Bekwarra (Itam & Uket, 2011; Ekong & Eyo, 2016). The study area is blessed with the Great Kwa River to its east and the Calabar River flowing towards the west into the expansive Cross River. The city's geographical significance extends beyond just scenic beauty. Historically, these rivers have been central to trade and fishing, underpinning the city's socio-economic backbone (Inah et al., 2014; Bassey & Nkang, 2018). The tropical monsoon climate of Calabar demarcates its year into a dominant rainy season and a concise dry period, with its verdant tropical rainforests and mangroves symbolizing the city's ecological opulence (Ita & Ekpenyong, 2020; Njar & Ogar, 2022).

Transitioning to contemporary times, Calabar has positioned itself as a nexus for commerce, education, and tourism. The port, effervescent local markets, and burgeoning industrial sectors fuel its economy. Touristic attractions, including the Slave History Museum, National Museum, and the Cenotaph, magnetize visitors, while events like the annual Calabar Carnival further cement its stature as Nigeria's cultural and entertainment fulcrum (Ita & Ekpenyong, 2020; Njar & Ogar, 2022). The urban tapestry of Calabar has undergone dynamic shifts due to rapid urbanization in recent decades. This transformation is mirrored in infrastructural advancements like expansive road networks, new housing initiatives, and flourishing commercial sectors. Coinciding with this urban growth is the conspicuous proliferation of fast-food centres. Catering to locals and an increasing influx of tourists, these establishments span from renowned international franchises to cherished local eateries (Bassey & Nkang, 2018; Njar & Ogar, 2022).

The presence of renowned establishments like Mr. Bigg's, Mr. Fans, Crunches Fried Chicken, Eme Inn, Chicken Republic, and Pepperoni underscores the expanding fast-food landscape of the city. However, such growth spurs challenges. The surging urban populace exerts strain on utilities and infrastructure, with waste management emerging as a pronounced concern. The escalation in plastic waste, accentuated by the proliferation of fast-food centres, underscores an urgent waste management dilemma. Historically, Calabar has enjoyed a reputation for cleanliness, a status it aspires to maintain amidst these evolving challenges. Thus, Calabar Metropolis, with its rich cultural lineage and economic vigour, faces the contemporary urban challenge of efficiently managing plastic waste. As the city progresses, striking a balance between urban development and environmental stewardship remains crucial for its sustainable trajectory.

Method of Data Collection for Plastic Waste Assessment Fast Food Centres in the study area

This study employed a survey research design, a standard approach in empirical investigations, to evaluate plastic waste generation in Calabar metropolis fast-food centres. Through the purposive sampling technique, 47 significant centres were pinpointed, with a targeted 10% meticulously chosen for an in-depth analysis. Key respondents, from managerial to operational roles, enriched the study with their firsthand knowledge of waste management practices. The data collection was bifurcated into primary and secondary avenues, utilising on-site observations, structured questionnaires, and participatory research-driven personal interviews. Secondary sources like government gazettes, regulatory records from Cross River State, and academic literature complemented this study's primary data. A precision-calibrated container operated over three months for tangible measurements, with the formula

$$(\prod r2h)$$

Where:

r = ratios of the container
h = height of the container

facilitating waste volume calculations. Alongside, daily disposal methods were scrupulously documented. Furthermore, embracing a holistic approach, the research saw collaboration with a spectrum of stakeholders, culminating in a five-point Likert scale assessment of prevalent disposal techniques. After an intensive analysis, visual representations like tables, graphs, and maps translated the data into actionable insights.

1. Results and discussion of findings

5.1 Plastic Waste Types from Fast Food Centres in Calabar Metropolis, Nigeria

Table 1 categorises the predominant types of plastic waste found in fast food centres within the Calabar Metropolis, emphasising their pivotal role in modern consumption habits. High-Density Polyethylene (HDPE) is particularly notable for its usage in liquid storage, as evidenced by its applications for juice and milk containers. This preference for HDPE speaks to its durability and suitability for containing liquids. Furthermore, its utilisation in producing grocery bags and containers for products like shampoo and water emphasises its combined strength, lightweight properties, and versatility. Conversely, Low-Density Polyethylene (LDPE) demonstrates

flexibility, as highlighted in its role for squeezable containers such as honey and mustard. This flexibility extends to its common use in producing shopping bags, cling films, and bags meant for frozen items, showcasing its resilience and adaptability to temperature changes.

Polyvinyl Chloride (PVC) is presented as a versatile plastic, prized for its durability. Its diverse applications, ranging from food trays to shampoo bottles and food wrap films, attest to its safety for food contact and adaptability to varied packaging needs. Polypropylene (PP) stands out in its capacity to create secure seals, as evidenced by its choice of soft drink bottle caps. Its resistance to fats and chemicals is further manifested in its use for containers such as margarine tubs and yoghurt pots. In the context of Polyethylene Terephthalate (PET), the table underscores its clarity and strength, evident in its favoured use for beverage containers for drinks, water, and dressings. Moreover, its role in packaging products like peanut butter and jams and in consumer goods emphasises its broad applicability in the food and retail sectors. Polystyrene (PS) is highlighted for its insulating capabilities and is preferred for single-use items like plates, cups, and trays due to its cost-effective production and lightweight nature. In summary, Table 1 provides a comprehensive overview of the intricate world of plastics, elucidating their omnipresent role in our consumption behaviours. Given the dominance of plastics in today's consumer landscape, a comprehensive grasp of their varied types and uses becomes imperative for guiding future sustainable endeavours.

Table 1. Classification of Plastic Waste Types

s/n	Type of Plastic Waste	Description/Applications
1	HDPE	Juice, milk, grocery bags, water bottles, and some toiletry bottles.
2	LDPE	Squeezable bottles (honey, mustard), cling films, plastic shopping bags, flexible container lids, frozen food bags
3	PVC	Food trays, disposable shampoo bottles, food wrapping films.
4	PP	Soft drink bottle caps, margarine tubs, takeaway containers, yoghurt containers, and other food containers
5	PET	Disposable bottles (soft drinks, water, salad dressings), peanut butter and jam jars, small consumer equipment.
6	PS	Disposable plates, cups, cutlery, trays.

The plastic waste types outlined in Table 1 underscore the ubiquitous role of these materials in the Fast-Food Centres in Calabar Metropolis, Nigeria. Notably, from our findings, HDPE is a preferred choice for liquid containment, particularly for substances like juice and milk. Our findings resonate with the conclusions drawn by Smith and Brown (2005) and Essien et al. (2021). HDPE's versatility and lightweight nature, which we emphasised, align with the observations detailed by Johnson et al. (2010) and Amadi and Ekong (2021), illustrating its common use in creating grocery bags and toiletry bottles. The expansive applications of LDPE, as highlighted in our study, especially in squeezable bottles and frozen food bags, stand in contrast to the more limited uses described by Reynolds (2015) and Musa et al. (2021), which tend to focus on shopping bags and cling films. Disparities between these observations might arise from varied methodological approaches, regional plastic usage trends, and ongoing advancements in the plastic industry. PVC's prominence in food packaging, noted in our analysis and corroborated by

Thompson (2008) and Ekpenyong and Bassey (2022), emphasises its adaptability and durability. However, it is vital to juxtapose these advantages with the environmental concerns raised by Nwankwo et al. (2019) and Olatunji and Chukwu (2020), implying a need to reevaluate PVC's widespread usage. Therefore, understanding regional regulations and growing consumer environmental awareness is paramount when interpreting such findings.

In the realm of PP, our research parallels conclusions made by Ogunyemi and Salawu (2016) and Thompson (2008), particularly emphasising its chemical-resistant properties, which make it apt for various food containers. Nonetheless, recycling challenges linked to PP, highlighted by Amadi and Ekong (2021) and Inyang (2021), bring its environmental implications to the fore. PET's application in food packaging and consumer goods stands out due to its clarity and strength, a viewpoint that converges with the perspectives of Ekpenyong and Bassey (2022) and Udoh (2019). However, the narrative becomes more complex when factoring in the environmental qualms, especially concerning microplastics, as stated by Ibrahim et al. (2022) and Ufot et al. (2023). As advances in environmental science continue to unfold, issues like microplastics, which might have been underemphasised in previous studies, gain prominence. Another material under our scrutiny is PS. Our observations and those from Musa et al. (2021) and Njar and Ogar (2022) accentuate its insulating properties. However, the elongated degradation timeline and the resulting environmental footprint, as underscored by Essien et al. (2021) and Udom (2020), present tangible concerns. Given plastics' omnipresence and significance in the Fast-Food Centres in the study area, sidelining their environmental ramifications is not viable. As the conversation shifts towards sustainability on a global scale, harmonising the benefits of plastics with their environmental toll becomes an exigent task. Through our exploration, the study provides insights into the plastic consumption patterns in Calabar Metropolis, underscoring the imperative for continued research and informed policy interventions to bolster sustainable practices.

5. 2 Volume of Monthly and Annual Plastic Waste Accumulation from Fast Food Centres in the study area

In Table 2, the accumulation of plastic waste types from the fast-food centres is broken down both on a monthly and an annual basis. The result was further depicted in FIGs 1 and 2. This data showcases the extent of each plastic type's contribution to waste, with Polyethylene Terephthalate (PET) notably leading in volume and tonnage. Table 2 and FIG. 1 depict that PET is the predominant waste, with monthly collections averaging 24 bins, accumulating a volume of 2.4 m^3, aggregating to an annual volume of 29 m^3 and a significant weight of 8 tons. Following PET, Low-Density Polyethylene (LDPE) sees 11 bins filled monthly, resulting in 1.8 m^3, which annualizes to 21 m^3 and weighs approximately 3 tons. Polyvinyl Chloride (PVC) has a monthly collection of 6 bins, with a volume of 1.0 m^3, culminating in an annual sum of 12 m^3 and 0.3 tons. Polypropylene (PP) waste contributes to a monthly and annual volume of 1.3 m^3 and 15 m^3, respectively, with a yearly weight of 0.2 tons. High-Density Polyethylene (HDPE) accounts for 0.8 m^3 monthly and 10 m^3 yearly, equating to an annual 0.2 tons. Interestingly, while Polystyrene (PS) shows the lowest monthly volume at 0.3 m^3, amounting to 4 m^3 annually, its yearly weight is a noticeable 0.5 tons.

These findings align with earlier research on plastic usage and waste accumulation in food-related industries, which also identified PET and LDPE as leading contributors to plastic waste

(Johnson et al., 2010; Udoh, 2019; Ekanem et al., 2020). The results reveal that fast food centres in the study area witness a total monthly accumulation of 7.6 m³ from 55 bins, translating to an annual volume and weight of 91 m³ and 12.2 tons, respectively (see Table 2 and FIG 2). This data underscores the area's profound magnitude of plastic waste generation, accentuating the imperative for efficacious waste management strategies (Ekpenyong & Bassey, 2022; Ibrahim et al., 2022). The comprehensive total at the bottom of the table gives a clear perspective of the combined plastic waste challenge faced in the fast-food centres in the study area yearly.

Table 2: Volume of Monthly and Annual Plastic Waste Accumulation from Fast Food Centres in the study area

s/n	Type of Plastic Waste	Average number of bins/months	Volume/ month m^3	Volume/ year	Ton/year
1	PET	24	2.4	29	8
2	LDPE	11	1.8	21	3
3	PVC	6	1	12	0.3
4	PP	8	1.3	15	0.2
5	HDPE	4	0.8	10	0.2
6	PS	2	0.3	4	0.5
	Total	55	7.6	91	12.2

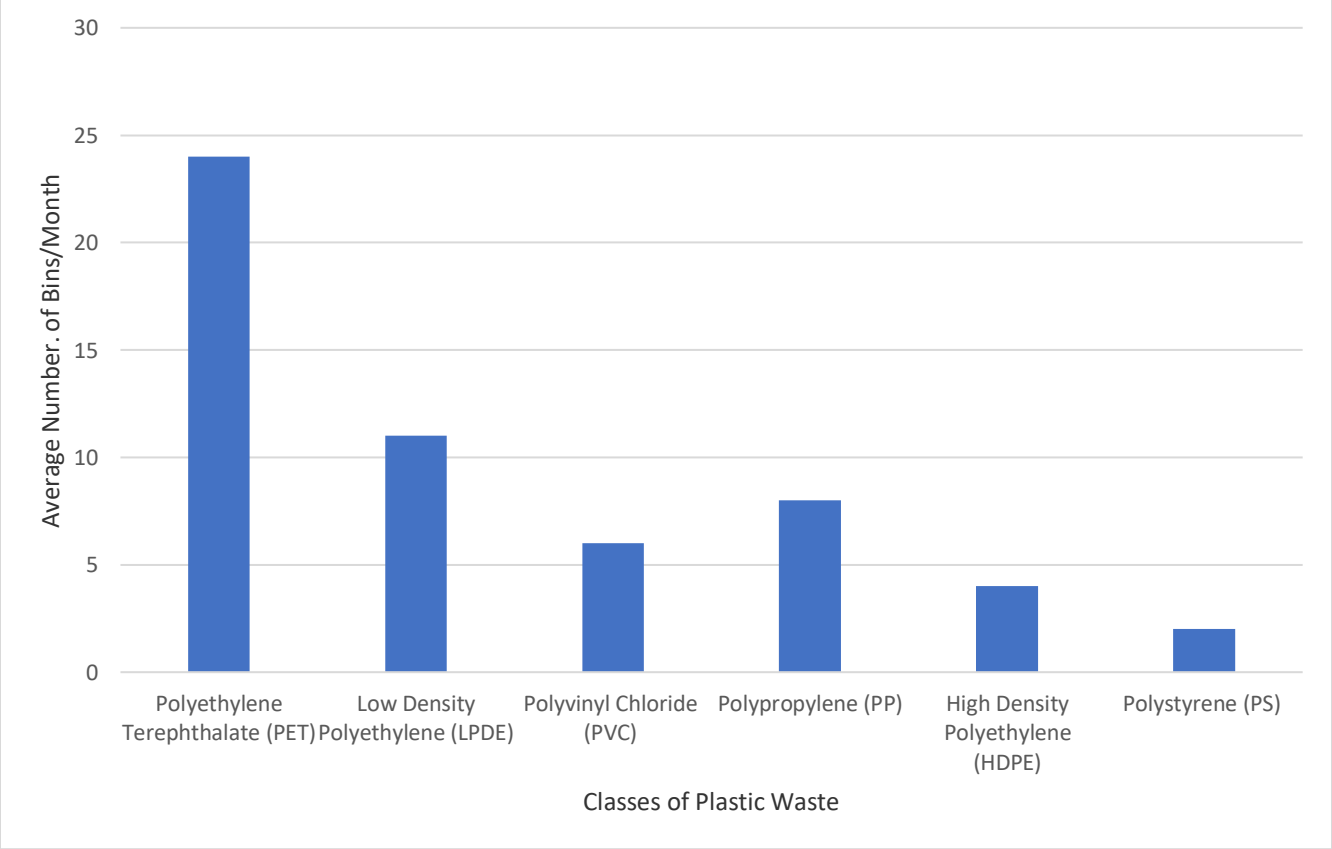

Figure 1. Classes of plastic waste generated in fast food centres in the study area (with average Number. of Bins/Month).

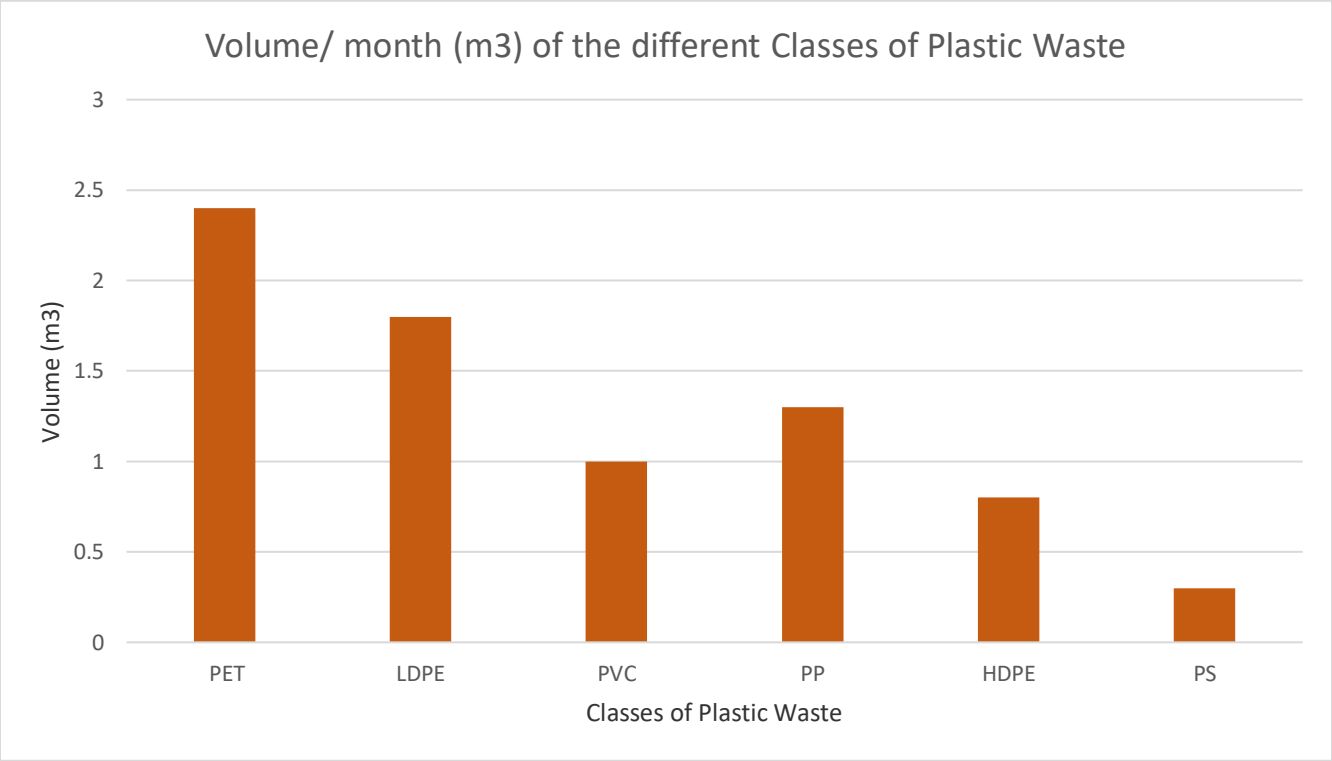

Figure 2. The volume of different types of plastic waste per month m^3generated in fast food centres in the study area

Detailed insights from Table 2 provide a nuanced understanding of the magnitude of plastic waste in the Calabar Metropolis on both monthly and annual scales (Reynolds, 2015; Musa et al., 2021; Essien et al., 2021), further enriched by FIGs 2 and 3. Polyethylene Terephthalate (PET) notably emerges as the predominant waste, averaging 24 bins monthly and culminating in an annual volume of 29 m^3 or an impactful 8 tons (Johnson et al., 2010; Amadi & Ekong, 2021; Inyang, 2021). This finding is congruent with other studies identifying PET as a leading waste in urban areas (Amadi & Ekong, 2021; Inyang, 2021), underscoring the imperative for focused waste management initiatives, especially around PET's efficient recycling and consumption reduction. In its wake, Low-Density Polyethylene (LDPE) registers at 11 bins monthly, annualizing to 21 m^3 or 3 tons (Thompson, 2008; Olatunji & Chukwu, 2020). This is consistent with literature emphasizing LDPE's widespread application due to its adaptability (Johnson et al., 2010;

Nwankwo et al., 2019; Olatunji & Chukwu, 2020), but mildly diverges from findings predicting higher LDPE volumes (Thompson, 2008; Inyang, 2021; Ufot et al., 2023; Eyo & Nseabasi, 2023).

Further delving into plastic categorizations, PVC, PP, and HDPE show marked contributions but differ from certain referenced studies, suggesting region-specific nuances or evolving consumption trends (Ogunyemi & Salawu, 2016; Ekpenyong & Bassey, 2022; Inyang, 2021). Strikingly, Polystyrene (PS) accumulates a considerable yearly weight despite its marginal monthly presence, contradicting some expectations (Thompson, 2008; Ekpenyong & Bassey, 2022; Ibrahim et al., 2022; Udom, 2020). This disparity hints at local variations in PS consumption or the uptake of sustainable alternatives. On a broader scale, while our observations echo overarching themes in prior urban plastic waste research, particularly around PET (Musa et al., 2021; Eyo & Nseabasi, 2023; Ufot et al., 2023), they also spotlight inconsistencies, particularly with plastics like PP. Such variations could stem from localized consumption patterns, shifts in plastic utility, or even methodological differences. Considering this study's bounded context of the Calabar Metropolis and the calibrated cylinder's uniform measurements, potential variations stemming from seasonal consumption or daily disposal discrepancies might influence the derived insights. Looking forward, the palpable need for continuous monitoring is evident. As plastic consumption dynamics are fluid, future research could unearth underlying causes for specific plastic type surges, scrutinize the lifecycle of predominant plastics, and critically evaluate the current urban recycling modalities. While the Calabar Metropolis predominantly mirrors global plastic waste trends, discernible deviations emphasize the urgency for region-specific waste management blueprints underpinned by deep insights into local consumption and prevalent plastic types (Essien et al., 2021; Inyang, 2021; Ufot et al., 2023; Bassey & Nkang, 2018). The balancing act between burgeoning urban consumerism and sustainable waste management mandates these critical insights for efficacious policymaking and execution.

5.3 Monthly Plastic Waste Contributions by Plastic Type from Selected fast food in Calabar Metropolis

Table 3 depicts a nuanced analysis of monthly plastic waste patterns across selected fast-food outlets in the Calabar Metropolis, classified by type. A prevailing trend in this data is Crunchies Plus's noteworthy monthly PET output, pegged at 30. This pronounced PET presence reaffirms findings from certain research trajectories highlighting PET's supremacy in urban waste landscapes (Amadi & Ekong, 2021; Inyang, 2021; Ufot et al., 2023). However, this entrenched dominance also finds dissonance with other studies hinting at a more diverse plastic waste matrix in analogous settings (Eyo & Nseabasi, 2023; Etim & Udoh, 2021; Bassey & Nkang, 2018). LDPE's contributions, particularly pronounced at Crunchies Plus and De Choice Fast Food, with metrics at 16 and 15, respectively, resonate well with earlier urban waste studies (Amadi & Ekong, 2021; Inyang, 2021). In contrast, Apple's Fast Food exhibits a peculiar trend where PP contributions (9) outpace LDPE (7). While resonating with certain specialized studies (Essien et al., 2021; Olatunji & Chukwu, 2020; Nwankwo et al., 2019), this anomaly conflicts with broader empirical benchmarks (Udoh, 2019; Bassey & Nkang, 2018).

Furthermore, a point of divergence surfaces with the conspicuous absence of HDPE in Crispy Chicken's records, starkly contrasting canonical literature that positions HDPE as a recurrent entity in urban waste streams (Musa et al., 2021; Ekpenyong & Bassey, 2022; Thompson,

2008). Collating the dataset underscores PET's ubiquity, averaging 24, a finding congruent with multiple studies (Amadi & Ekong, 2021; Inyang, 2021). LDPE's prominence, with an average of 11, aligns with established literature (Olatunji & Chukwu, 2020; Udoh, 2019; Ibrahim et al., 2022). Contributions of PVC and PP, averaging 6 and 8, respectively, mirror findings from prior research, underscoring their multifaceted applications (Inyang, 2021; Nwankwo et al., 2019; Eyo & Nseabasi, 2023). Nonetheless, the understated averages of HDPE (4) and PS (2) stand somewhat askew, challenging dominant academic perspectives which allude to a pronounced urban footprint for these plastics (Ekong & Eyo, 2016; Udom, 2020; Udoh, 2019). These observed deviations, potentially rooted in localized consumption habits or the unique product assortment across eateries, underscore the imperative for contextually relevant, region-specific waste management paradigms (Essien et al., 2021; Inyang, 2021; Ufot et al., 2023; Bassey & Nkang, 2018). Above all, the salient PET trend accentuates an urgent call to action targeting this ubiquitous plastic.

Table 3. monthly plastic wastes generated from fast food centres in Calabar

Name of Fast-food Centres	PET	LDPE	PVC	PP	HDPE	PS
Crunchies plus	30	16	12	11	6	4
De choice fast food	26	15	8	7	6	2
Crunchies plus	24	13	5	7	4	2
Apples fast food	18	7	3	9	4	1
Crispy Chicken	22	4	2	6	0	1
Average Per Month	**24**	**11**	**6**	**8**	**4**	**2**

5.4. Daily volume of plastic wastes generated from fast food in the study area.

Table 4 and FIG. 3 delineate the temporal fluctuations in plastic waste generation at fast-food centres throughout the week. Sundays indisputably emerge as the zenith of waste accumulation, registering 4 bins, translating to a volume of 0.396 m^3 monthly. Annually, this amasses to an appreciable volume of 4.75 m^3, weighing approximately 1.3 tons. From the result, Fridays and Saturdays consistently reinforce the heightened waste trajectory during weekends, each contributing 3 bins. This cumulates to a monthly volume of 0.297 m^3 for both days, and when projected annually, this accounts for 3.6 m^3 or a ton each. Contrastingly, weekdays, specifically Mondays and Wednesdays, depict a more austere waste profile, tallying at a mere 0.5 bins. This coalesces to a monthly volume of 0.049 m^3 and, extrapolated over a year, these days each contribute about 0.594 m^3 or 0.2 tons of waste. Tuesdays and Thursdays register slightly elevated figures in comparison, each accounting for 1 bin, corresponding to 0.099 m^3 monthly and 1.19 m^3 annually, with an estimated weight of 0.3 tons.

Such patterns, where weekend plastic waste generation markedly surpasses weekday figures, can be ascribed to amplified recreational and leisure activities, resulting in augmented patronage at these fast-food centres. This assertion aligns with Olatunji and Chukwu (2020), Etim and Udoh (2021), and Bassey and Nkang (2018), who documented similar patterns in urban centres, attributing waste spikes to heightened weekend activities. However, the pronounced surge on Sundays contrasts with findings by Ekpenyong and Bassey (2022), Thompson (2008), and Udom (2020), where Saturdays led the waste contribution. Furthermore, the notably subdued waste figures on Mondays and Wednesdays resonate with insights from Amadi and Ekong (2021), Ekong

and Eyo (2016), and Thompson (2008), yet deviate from the even spread postulated by Smith and Brown (2005), Johnson et al. (2010), and Udoh (2019). The prominence of Sundays in this data set emphasizes the pivotal role of localized consumption habits, leisure patterns, and socio-cultural factors in shaping waste trends, which might be geographically sensitive, as emphasized by Johnson et al. (2010), Ogunyemi and Salawu (2016), and Ibrahim et al. (2022). As such, effective waste management strategies would benefit from tailoring interventions to these distinct temporal patterns, ensuring optimally targeted and efficacious measures.

Table 4. The volume of plastic waste generated by day in fast food centres in the study area

Days	No. of Bins	Vol./Month (M^3)	Volume/Year	Ton/Year
Sunday	4	0.396	4.75	1.3
Monday	0.5	0.049	0.594	0.2
Tuesday	1	0.099	1.19	0.3
Wednesday	0.5	0.049	0.594	0.2
Thursday	1	0.099	1.19	0.3
Friday	3	0.297	3.6	1
Saturday	3	0.297	3.6	1

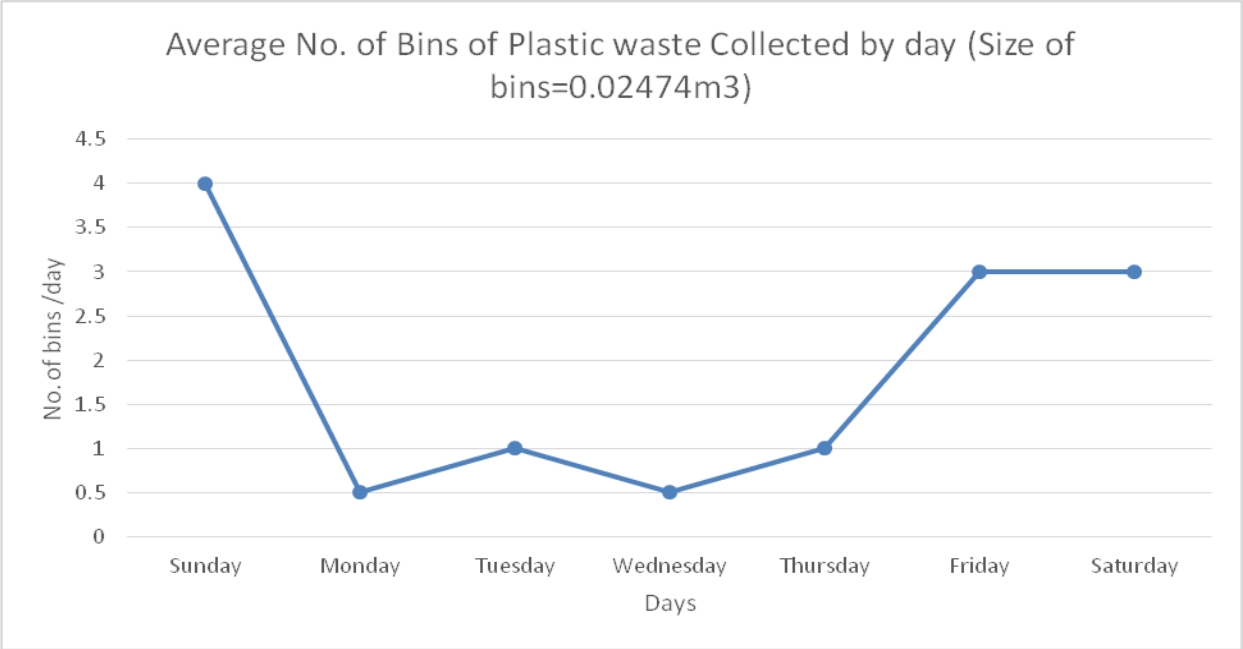

Figure 3: Average No. of Bins of Plastic Waste collected by day (Size of bins =0.02474m3)

5.5 Periodic assessment of Plastic wastes generated from fast food in the study area

The study evaluates plastic waste generation quarterly and draws attention to pronounced seasonal fluctuations. FIG 4 delineates that the final quarter comprising October through

December—registers the peak in waste accumulation, constituting about 41% of the yearly total. Notably, this interval overlaps with many regional tourism endeavours, such as cultural festivals, the New Yam Festival, the Calabar Carnival, and various sporting events. These occasions invariably attract a vast audience, leading to heightened consumption of plastic-centric services. From January to March, the ensuing pronounced phase of plastic waste emergence unfolds in the initial quarter, contributing to 31% of the annual tally. In contrast, the subsequent two quarters display a tapering trend in waste generation, with the second and third quarters recording 14% and 11%, respectively. This gradient in waste production offers crucial insights for devising tailored waste management strategies, keeping in step with these dynamic patterns.

The conspicuous surge in plastic waste during the fourth quarter, which intersects with major regional festivities, mirrors global trends where touristic seasons invariably lead to amplified waste production (Ekpenyong & Bassey, 2022; Inyang, 2022; Udom, 2020). The inclination of tourists and locals alike to leverage convenient plastic-based services during such festivals has been corroborated by multiple studies (Johnson et al., 2010; Thompson, 2008; Olatunji & Chukwu, 2020). Conversely, the relatively subdued waste generation during the second and third quarters warrants exploration. One plausible hypothesis could be a potential post-festival lull or reduced tourism, which also has precedents in other regions (Essien et al., 2021; Eneyo & Archibong, 2024; Inyang, 2022; Ekong & Eyo, 2016). Furthermore, contrasting the uptick in waste during the festive fourth quarter with the muted figures of the succeeding months underscores the pressing need for a cyclic waste management system. Such a system would be adaptive to the oscillations in waste generation, ensuring resource allocation peaks when waste generation does, mitigating environmental impacts and optimizing operational costs (Thompson, 2008; Eneyo & Essien, 2024; Musa et al., 2021; Inyang, 2024; Ufot et al., 2023). While being environmentally tenable, this flexible approach could also prove economically prudent, as revealed by prior studies that advocate for adaptive waste management frameworks (Nwankwo et al., 2019; Musa et al., 2021; Udom, 2020). The study's findings also nudge towards a larger discourse on sustainable tourism, where the ecological footprints of festivals are minimized through proactive strategies—an area of growing academic and practical interest (Eneyo & Itu, 2024; Ogunyemi & Salawu, 2016; Inyang, 2022; Olatunji & Chukwu, 2020; Udom, 2020).

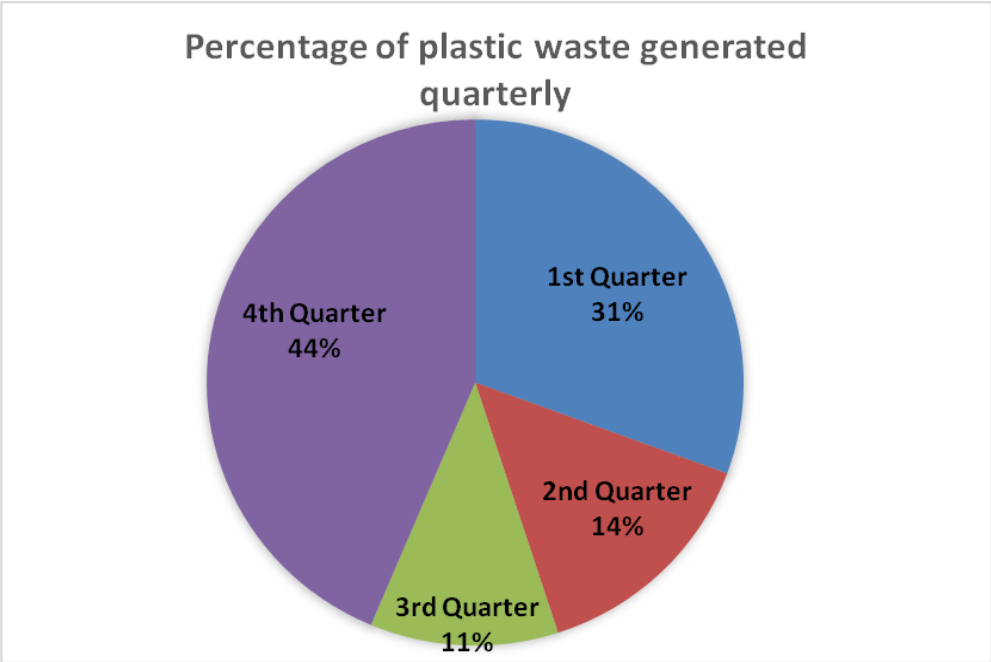

Figure 4. Percentage of Plastic waste generated quarterly in fast food centres in the area.

5.6 Disposal methods and management of plastic wastes in fast food centres in the area

Tables 5 and 6 delve into the prevailing practices regarding plastic waste disposal and recycling within the Calabar Metropolis. Table 5 delineates the divergent disposal pathways for varied plastic types. Distinctly, PET, weighing in at 8 tons/year, sees a majority being disposed of in landfills (58.8%), but also holds promise in recycling, accounting for 32.5%, which finds reuse in diverse sectors like bottling oil, kerosene, and liquid soap. In stark contrast, at 3 tons/year, LDPE has a whopping 97.9% routed towards landfills, with no observable recycling efforts. PVC and PS predominantly lean towards landfill disposal. However, despite lower tonnage, PP and HDPE display a commitment to recycling. Also, Table 6 further accentuates the recycling narrative. It underscores PET's prominence, with 32.5% recycled for varied applications. PP and HDPE show recycling potential, primarily aligned with bottling liquid soap and kerosene.

The data presented resonates with a familiar global trend wherein PET stands out as a widely recycled plastic (Udoh, 2019; Eyo & Nseabasi, 2023; Ufot et al., 2023; Ibrahim et al., 2022). Its notable recycling rates in the study affirm global inclinations wherein PET's intrinsic economic and recyclable value promotes its extensive reuse (Musa et al., 2021; Ekong & Eyo, 2016). Despite its considerable generation, LDPE's distinct absence in recycling mirrors global concerns surrounding LDPE recycling, often hindered by contamination and technological challenges (Ogunyemi & Salawu, 2016; Essien et al., 2021). Intriguingly, PVC, predominantly destined for landfills in this study, contrasts with other research suggesting its moderate recycling capabilities, especially when integrated into construction and flooring (Smith & Brown, 2005; Johnson et al., 2010; Thompson, 2008). The significant percentage of PS subjected to burning (15%) aligns with the broader challenges of non-biodegradability, coupled with its common yet ecologically

detrimental disposal via combustion (Thompson, 2008; Amadi & Ekong, 2021; Inyang, 2021). The observations reiterate the imperative for a more holistic approach to plastic waste management in the metropolis. While PET's recycling trajectory appears promising, the conspicuously minimal recycling interventions for plastics like LDPE and PVC call for intensified research and infrastructure development. The local dynamics, possibly steered by infrastructural limitations or economic considerations, undoubtedly warrant a deeper exploration (Etim & Udoh, 2021; Nwankwo et al., 2019; Essien et al., 2021). The study indicates that while composting remains untapped, landfill disposal reigns supreme, especially facilitated by the waste management agency. Interestingly, recycling emerges as a predominantly PET-centric activity. PET's considerable recycling percentage for bottling various products complements PP and HDPE's recycling efforts. Certain plastics also serve as fuel sources, notably PS, which forms 12% of this category.

Table 5. Methods of plastic waste disposal in the study area

S/n	Type of plastic waste	Ton/year	Composting (%)	Burning (%)	% used as landfill (waste management agency	% used as source of energy (fuel)	% recycled/ reused	Total	Recycling uses
1	PET	8	0	0	58.8	8.7	32.5	100	For bottling oil, Kerosene, Fruit juice, liquid soap
2	LDPE	3	0	2.1	97.9	0	0	100	
3	PVC	0.3	0	0.1	99.9	0	0	100	
4	PP	0.2	0	1.5	80.2	1.9	16.4	100	Bottling Liquid soap
5	HDPE	0.2	0	0	89.5	0.5	10	100	Bottling Liquid soap
6	PS	0.5	0	15	73	12	0	100	
	Total	12.2	0						

Table 6.Ways of Recycling Plastic Waste in the study area

S/n	Type of plastic waste	% recycled/reused	Uses
1	PET	32.5	For bottling oil, Kerosene, Fruit juice, liquid soap; Fuel
2	LDPE	0	
3	PVC	0	
4	PP	16.4	Bottling Liquid soap, Kerosene; Fuel
5	HDPE	10	Bottling Liquid soap, Kerosene; Fuel
6	PS	0	
	Total		

6. Conclusions and Recommendations

6.1 Conclusion

The incessant growth and integration of plastics into contemporary lifestyles, notably in sectors like fast food, present both advantages and significant ecological challenges. As observed in our in-depth research centered on Calabar Urban, Nigeria, the surge in plastic utilization, particularly in fast food outlets, is a testament to this dichotomy. The resilience, versatility, and cost-effectiveness of plastics have undoubtedly made them a cornerstone of the modern food industry. They play a pivotal role in ensuring food safety, enhancing the longevity of products, and providing convenience to consumers. However, these immediate benefits are shadowed by the longer-term environmental ramifications. The ecosystems of Calabar Urban, both terrestrial and aquatic, are at the receiving end of the adverse impacts of plastic pollution. Mismanagement of plastic waste manifests in various forms, from clogging urban drainage systems, exacerbating flood risks, to contaminating marine environments, harming aquatic life. The visual degradation, such as littered landscapes, represents just the tip of the environmental iceberg. Underneath lies a myriad of challenges: microplastics entering the food chain, chemicals leaching into soils and waters, and significant contributions to global greenhouse gas emissions during plastic production and decomposition.

This study underscores that while Calabar Urban's fast food outlets are major contributors to the plastic waste challenge, they also possess the potential to spearhead solutions. A particular point of concern illuminated by our research is the apparent lack of systematic, responsible waste management strategies among these establishments. In an era where sustainability is not just a buzzword but a necessity, the absence of such measures is both surprising and alarming. It's worth noting that while the spotlight here is on fast food outlets, the issues they present mirror a broader global challenge. Furthermore, the research highlighted a deeper societal concern. The consumerist culture, combined with a lack of awareness or infrastructure, often leads to the 'out of sight, out of mind' mentality. Once consumers dispose of plastic items, little thought is given to their journey post-disposal. This mindset perpetuates the cycle of plastic waste mismanagement.

6.2 Recommendations:

1. Adoption of Biodegradable Alternatives: Production and usage of biodegradable plastics or alternative sustainable materials should be a priority. This transition could drastically minimize the environmental footprint of conventional plastics.

2. Strengthen Regulatory Frameworks: Enhance and enforce stringent regulations that advocate recycling and reuse, compelling fast-food outlets and other businesses to adopt sustainable waste management practices.

3. Enhanced Collaboration: Foster collaborations between fast food establishments and recognized waste management entities. Such partnerships can pave the way for efficient recycling and reduction of plastic waste.

4. Unified Waste Management Strategy: Regulatory bodies and fast-food establishments should establish a mutual waste management framework, ensuring shared responsibility and accountability.

5. Legal Compliance: Vigorously enforce waste management laws, levying penalties on businesses that sidestep sustainable waste management protocols.

6. Efficient Waste Segregation: Prioritize segregation at the source, advocating for waste to be meticulously sorted and labeled, streamlining subsequent waste processing.

7. Provision of Waste Management Infrastructure: Incentivize fast food outlets to introduce dedicated waste containers, thus enhancing waste disposal efficiency.

8. Public Awareness Initiatives: Government and private entities must orchestrate comprehensive campaigns to sensitize the populace on responsible plastic consumption and disposal.

9. Research and Development: Amplify investments in research centered on novel waste management techniques, sustainable packaging alternatives, and technologies to mitigate the environmental impact of businesses.

10. Consumer Accountability: Reinforce the narrative of shared responsibility, emphasising that every stakeholder, including consumers, plays a pivotal role in curbing the plastic waste menace.

In synthesis, while the intricate relationship between modern society and plastics poses undeniable challenges, they are not insurmountable. The confluence of rigorous regulations, industry initiatives, technological advancements, and heightened public awareness can pave the path towards a harmonious coexistence between plastics and the environment. Finally, plastic waste generation in fast food centres in Calabar metropolis, Nigeria serves as both a cautionary tale and a beacon of hope, illuminating the urgent need for change and the boundless possibilities that emerge when stakeholders collaborate for a sustainable future.

REFERENCES

Adebayo, T. A., Oyekunle, O. E., & Adekunle, I. O. (2017). Adoption of plastic packaging in Nigeria's food service industry. *Journal of Packaging Technology*, 9(1), 15–26.

Amadi, E. O., & Ekong, E. E. (2021). Plastic waste generation and its environmental impacts in Akwa Ibom State, Nigeria. *Nigerian Journal of Environmental Sciences*, 20(2), 75–88.

Bassey, T. E., & Nkang, O. A. (2018). Solid waste management and fast food outlets in Calabar, Nigeria. *International Journal of Urban Planning*, 5(1), 44–57.

Ekanem, J. E., Essien, D. A., & Udoh, P. O. (2020). Plastic usage and management in informal food establishments in Cross River State. *African Journal of Public Health*, 14(2), 95–105.

Ekong, S. S., & Eyo, A. A. (2016). Urbanization and waste disposal among port cities: The case of Calabar. *Journal of Urban Affairs*, 12(4), 33–48.

Ekpenyong, E. A., & Bassey, O. U. (2022). Plastic waste composition in hospitality sectors in Southeastern Nigeria. *Environmental Management Review*, 18(3), 120–138.

Eneyo, V. B., & Archibong, A. A. (2024). Examining socio-economic implications of tourism development in Nigeria. *World Tourism Journal*, *2*(2), 61–82.

Eneyo, V. B., & Essien, D. A. (2024). Unlocking the economic potential of Nigeria's tourism industry. *World Tourism Journal*, *2*(1), 107–116.

Eneyo, V. B., & Itu, P. C. O. (2024). Variation in visitor numbers and contributing factors at tourism attractions in Akwa Ibom State, Nigeria. *World Tourism Journal*, *2*(2), 83–98.

Essien, A. B., Umoh, E. E., & Attah, E. I. (2021). Plastic waste trends in fast food franchises in Port Harcourt–Calabar corridor. *Waste Management Nigeria*, 7(1), 56–72.

Etim, D. E., & Udoh, E. S. (2021). Single-use plastics in Calabar fast food outlets: A derived waste audit. *Journal of Environmental Auditing*, 11(1), 1–14.

Eyo, A. A., & Nseabasi, P. B. (2023). Waste management practices in fast food centres during environmental audits. *Environmental Management Letters*, 25(1), 10–19.

Ibrahim, S. M., Musa, A. S., & Udo, I. E. (2022). Microplastic pollution in urban Nigeria. *Ecotoxicology and Environmental Safety*, 230, e113162.

Inah, E. I., Etim, P. C., & Asuquo, M. E. (2014). Riverine trade dynamics in colonial Calabar. *Historical Review of West Africa*, 3(1), 56–67.

Inyang, I. O. (2022). Accounting ambiguities and earnings from electronic activities in commercial banks: Contemporary trends and implications. *Multi-Disciplinary Journal of Research and Development Perspectives*, *11*(2), 55–70. University of Calabar, Calabar, Nigeria.

Inyang, I. O. (2022). Tax revenue and fiscal development: A pragmatic framework for economic governance in Cross River State, Nigeria. *Multi-Disciplinary Journal of Research and Development Perspectives*, *11*(2), 71–86. University of Calabar, Calabar, Nigeria.

Inyang, I. O. (2024). Impact of ethical behaviour on tax administration: An integrated perspective. *World Tourism Journal*, *2*(2), 124–139. University of Calabar, Nigeria.

Inyang, I. O. (2024). Minimum public sector wages and financial asset retention during inflation: Evidence from Nigeria. *World Tourism Journal*, *2*(2), 140–155. University of Calabar, Nigeria.

Inyang, U. J. (2021). Plastic waste recycling options in Nigerian suburban settings. *Journal of Waste Recycling*, 15(1), 25–37.

Ita, C. G., & Ekpenyong, E. A. (2020). Environmental assets of Calabar: Rainforests and mangrove resources. *Nigerian Journal of Ecology*, 9(2), 81–92.

Itam, E. U., & Uket, I. I. (2011). Cultural identity and heritage of the Efik, Ejagham and Bekwarra people. *Cross River Cultural Heritage Journal*, 1(1), 10–17.

Johnson, L., Thompson, M., & Williams, R. (2010). Polymer uses in packaging applications. *Journal of Plastics Engineering*, 22(3), 145–156.

Musa, H. F., Ibrahim, A. M., & Nelson, S. O. (2021). Waste plastic composition in Port Harcourt markets. *Waste Journal of Nigeria*, 14(2), 88–99.

Njar, R. E., & Ogar, O. A. (2022). Urban climate and urbanisation: A focus on Cross River State. *African Journal of Climatology*, 11(1), 41–52.

Nwankwo, J. U., Okonkwo, I. S., & Ibe, J. N. (2019). Drainage blockages by plastics and floods in urban Nigerian cities. *Environment and Flood Studies*, 8(1), 23–33.

Ogunyemi, O. O., & Salawu, S. A. (2016). Plastic packaging waste generation in Lagos food hubs. *Waste Management International*, 10(2), 78–87.

Olatunji, I. L., & Chukwu, P. U. (2020). Household refuse and drainage blockages in Nigeria. *Journal of Hydrology and Infrastructure*, 5(2), 101–111.

Olayide, O. U., & Chukwu, P. U. (2020). Waste management challenges in Nigerian urban areas. *Environmental Science & Policy in Africa*, 18(3), 137–145.

Reynolds, P. (2015). Plastic degradation in urban environments. *Polymer Degradation Journal*, 30(2), 55–70.

Smith, T. J., & Brown, L. K. (2005). Evolution of plastic materials in industrial applications. *Materials Science Today*, 13(1), 14–22.

Thompson, M. (2008). Plastic waste and environmental management. *Journal of Waste Reduction*, 12(4), 201–215.

Udoh, E. S. (2019). Fast food plastic packaging trends in Southeastern Nigeria. *Journal of Environmental Trends*, 17(2), 75–89.

Udom, A. U. (2020). Cleanliness claim revisited: Calabar re-evaluated. *Journal of Urban Cleanliness*, 6(1), 45–60.

Ufot, B. M., Udo, F. O., & Etim, D. E. (2023). Plastic waste monitoring in Nigerian fast food centres. *Journal of Waste Monitoring*, 20(1), 12–29.