# Effects of Commercial Activities on Urban Environmental Quality in Lokoja, Kogi State, Nigeria

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**Abstract**
This study examined the effects of commercial activities on urban environmental quality in Lokoja, Kogi State, Nigeria. A cross-sectional survey design was adopted, using data from 200 respondents, 12 air quality sampling points, 10 noise monitoring locations, and 15 water sampling sites. Descriptive and inferential statistical tools including regression, correlation, ANOVA, and chi-square tests were used for analysis. Findings revealed that commercial activities significantly degrade environmental quality in Lokoja. Mean concentrations of particulate matter ($PM_{2.5}$ = 61.8 µg/m³; $PM_{10}$ = 118.6 µg/m³) exceeded WHO limits by over 300% and 200% respectively. Noise levels recorded an overall mean of 83.1 dB, far above the WHO permissible limit of 55 dB. Water quality analysis showed high turbidity (21.9 NTU), elevated $BOD_5$ (10.9 mg/L), low dissolved oxygen (3.6 mg/L), and high coliform counts (82 CFU/100 mL), indicating severe contamination. Regression analysis showed that commercial intensity significantly predicts environmental degradation ($R^2$ = 0.68), with market density (β = 0.41, p = 0.001) and traffic flow (β = 0.38, p = 0.002) being the strongest determinants. Waste analysis indicated that organic waste constitutes 43% of total waste generated, while open dumping remains the dominant disposal method at 39%. The study concludes that high-density commercial activities are major drivers of air, noise, water, and waste pollution in Lokoja. Despite high environmental awareness among respondents (76%), unsustainable practices persist due to infrastructural deficits and weak enforcement. The study recommends improved urban planning, strengthened waste management systems, and stricter environmental regulation to mitigate the adverse effects of commercial expansion.

**Keywords:** Commercial activities, environmental quality, pollution, waste management, Lokoja.

## INTRODUCTION

Urbanization is one of the defining processes of the twenty-first century, and commercial activities represent both a major driver and outcome of this transformation (Harris, 2024). Globally, cities have expanded rapidly as commercial land uses intensify in response to population growth, economic diversification, and increasing demand for goods and services (Cohen, 2020). According to the United Nations (2018), more than 55% of the world's population currently lives in urban areas, a figure projected to reach 68% by 2050. As urban populations concentrate, economic activities also cluster spatially, leading to the development of markets, transport nodes, and business corridors. While these commercial hubs sustain urban livelihoods and economic growth, they also generate environmental pressures including air pollution, traffic congestion, noise, waste accumulation, and water contamination (Harris, 2024; Cohen, 2020).

In many industrialized regions, the environmental impacts of commercial expansion have been moderated through improved environmental regulation, urban planning, and technological innovation (OECD, 2024; UN-Habitat, 2021). Cities such as London, Berlin, and Stockholm have implemented environmental standards that regulate emissions and promote sustainable commercial practices through low-emission zones, energy-efficient infrastructure, and advanced waste management systems (European Environment Agency [EEA], 2024; Johansson & Nilsson, 2020). Similarly, Asian cities such as Tokyo and Singapore have incorporated green infrastructure, including rooftop gardens and eco-friendly transport systems, to reduce the ecological footprint of expanding business districts (Zhao & Zhang, 2021; Tan et al., 2024). Despite these measures, commercial activities continue to exert pressure on urban environmental systems through high energy consumption, vehicular emissions, and waste generation (Gupta, 2020; IPCC, 2023). Without effective regulation and planning, the expansion of commercial activities may therefore threaten the sustainability and livability of urban environments (World Bank, 2024).

The environmental consequences of commercial growth are often more severe in developing regions, particularly in Africa, where rapid urbanization is accompanied by weak institutional capacity and inadequate infrastructure. Africa's urban population is expected to double by 2050, with much of the growth occurring in small and medium-sized cities (United Nations-Habitat, 2022). Informal economic activities dominate many African urban economies and account for nearly 80% of employment in several countries (Fox & Thomas, 2021). While these activities provide essential livelihoods, their largely unregulated nature often results in poor waste disposal, blocked drainage systems, water contamination, and noise pollution. Studies in cities such as Nairobi, Accra, and Dar es Salaam demonstrate that commercial hubs frequently become environmental hotspots characterized by vehicular emissions, poor sanitation, and excessive noise associated with dense trading activities (Owusu & Amoako, 2019; Makworo & Otieno, 2024).

In Nigeria, commercial activities form a central component of urban economies and livelihoods (Adeoye, 2019). Markets, roadside vending, transport terminals, and small-scale enterprises provide employment for millions of people and facilitate the distribution of goods and services across cities (Adeoye, 2019). However, the environmental implications of these activities have become increasingly evident. Studies in Ibadan, Lagos, and Enugu show that commercial markets generate large volumes of solid waste that frequently exceed municipal waste management capacity, leading to blocked drainage channels, flooding, and environmental contamination (Adeoye, 2019; Olanrewaju & Ilemobade, 2024). Noise pollution is also prevalent in market environments and transport hubs, where sound levels often exceed recommended thresholds and pose health risks to traders and nearby residents (Olayinka et al., 2020). Furthermore, commercial districts in cities such as Kano, Benin City, and Port Harcourt experience elevated levels of particulate matter resulting from vehicular emissions, electricity generators, and open waste burning (Okedere et al., 2021). Similar environmental challenges have been reported in Lagos, where commercial activities contribute to deteriorating air quality and increased respiratory health concerns (Efe & Emoyan, 2019). In addition, water contamination often occurs where markets and food-processing activities are located near drainage systems or streams, as demonstrated in studies of market runoff in Onitsha (Chukwu et al., 2024).

These environmental pressures are further intensified by weak urban planning and limited enforcement of environmental regulations in Nigerian cities. Rapid urban growth frequently results in uncoordinated land use patterns where commercial activities encroach on residential areas, drainage channels, and open spaces (Oduwaye, 2019; Akinbamijo, 2021). The

predominance of informal commercial practices also limits regulatory oversight, as roadside traders and open-air markets often operate outside formal planning frameworks (Oluwole & Ojo, 2020). Despite the economic importance of these activities, local authorities often collect taxes and levies from traders without corresponding investment in environmental infrastructure and services (Nwaka, 2024). Consequently, many Nigerian cities exhibit a paradox where vibrant commercial activity coexists with deteriorating environmental quality.

Lokoja, the capital of Kogi State, reflects these broader urban dynamics. Located at the confluence of the Niger and Benue Rivers and positioned along major transport corridors connecting northern and southern Nigeria, the city has historically served as a major centre of trade and mobility. Over the past three decades, Lokoja has experienced significant population growth and expansion of commercial activities, including central markets, roadside stalls, transport terminals, and small-scale enterprises. While these activities support economic livelihoods and urban development, they also generate environmental challenges such as waste accumulation, blocked drainage systems, noise pollution, and declining air quality. The encroachment of commercial structures into drainage channels and open spaces has further altered the urban landscape and increased vulnerability to flooding.

Despite the visibility of these environmental challenges, empirical research examining the relationship between commercial activities and environmental quality in Lokoja remains limited. Existing studies in Kogi State have focused primarily on urbanization and land use change (Olorunfemi & Adesina, 2019; Musa & Ibrahim, 2021), with limited attention to the specific environmental consequences of commercial practices. Furthermore, many studies examine individual environmental variables rather than providing integrated assessments of air pollution, water quality, noise pollution, waste management, and land use dynamics. This gap in empirical evidence limits the ability of policymakers to design effective strategies for balancing commercial development with environmental sustainability.

Against this background, this study examines the relationship between commercial activities and urban environmental quality in Lokoja. It focuses on key environmental dimensions including air pollution, noise pollution, water quality

## STUDY AREA

Lokoja, the capital of Kogi State, is located in North-Central Nigeria at the confluence of the Niger and Benue Rivers. The city lies between latitude 7°45'N and 7°51'N and longitude 6°43'E and 6°45'E, covering about 352.72 km² (National Bureau of Statistics [NBS], 2021). It is bounded by Kogi Local Government Area to the north, Kabba/Bunu to the west, Ajaokuta and Adavi to the east, and Bassa to the south (Kogi State Ministry of Lands and Urban Development, 2022). Its strategic position at the meeting point of the Niger and Benue rivers historically made Lokoja an important centre of trade, migration, and colonial administration (Okoli & Adefila, 2018; Ayeni, 2020). Presently, the city remains a key administrative and commercial centre due to its role as a transport link between northern and southern Nigeria (Olorunfemi, 2021).

Lokoja experiences a tropical wet-and-dry climate typical of the Guinea Savannah zone, influenced by the seasonal movement of the Inter-Tropical Convergence Zone (ITCZ) (Adebayo, 2019). The rainy season extends from March to October, while the dry season lasts from November to March. Annual rainfall ranges from about 1,200 mm to 1,600 mm, with temperatures generally high throughout the year, averaging between 21°C and 37°C (NIMET, 2021; Odekunle et al., 2017). The Harmattan period during the dry season brings dusty winds that reduce visibility and lower humidity (Audu et al., 2020).

Geologically, Lokoja lies within the Southern Bida Basin and is dominated by sedimentary formations such as the Lokoja Formation, Patti Formation, and Agbaja Ironstone, which contribute to the city's rugged terrain (Obaje, 2009; Adeleye, 1974; Akande & Erdtmann, 2012). The upland soils are mainly ferruginous tropical soils derived from sandstone and ironstone, while the floodplains contain fertile alluvial soils suitable for agriculture (Ibrahim et al., 2020; Olayinka & Adeyemo, 2018). However, erosion, sand mining, and waste disposal have contributed to soil degradation in parts of the city (Ogunleye et al., 2018; Usman & Haruna, 2020).

The relief of Lokoja consists of uplands, undulating plains, and river valleys, with elevations ranging from about 45 metres along the Niger floodplain to about 450 metres at Mount Patti (Akinyemi & Olorunfemi, 2019). The drainage system is dominated by the Niger and Benue rivers and several tributaries, including the Meme, Oyun, and Ganaja streams (Olayinka & Adeyemo, 2018). However, rapid urbanization and inadequate drainage infrastructure have increased flooding in low-lying areas such as Adankolo and Sarkin Noma (NEMA, 2022).

Vegetation in the area reflects the Guinea Savannah type, characterized by grasses and scattered trees such as *Parkia biglobosa*, *Vitellaria paradoxa*, and *Adansonia digitata* (Keay, 1959; Adebayo, 2019). However, urban expansion and human activities have reduced natural vegetation cover in many parts of the city (Abubakar & Musa, 2021). Lokoja has experienced significant population growth due to its administrative status and strategic location. The 2006 population census recorded 195,261 residents, but current estimates exceed 500,000 (NPC, 2022). The city is ethnically diverse, including Igala, Ebira, Okun, Nupe, Hausa, and Bassa groups (Audu, 2020). The settlement pattern includes both planned and unplanned neighbourhoods, with older areas such as Kabawa and Adankolo characterized by dense development, while newer areas such as Lokongoma and Ganaja Junction show more organized layouts (Oluwaseun & Durotoye, 2021). Rapid urban expansion has also led to the growth of informal settlements and development on marginal lands, creating environmental and planning challenges.

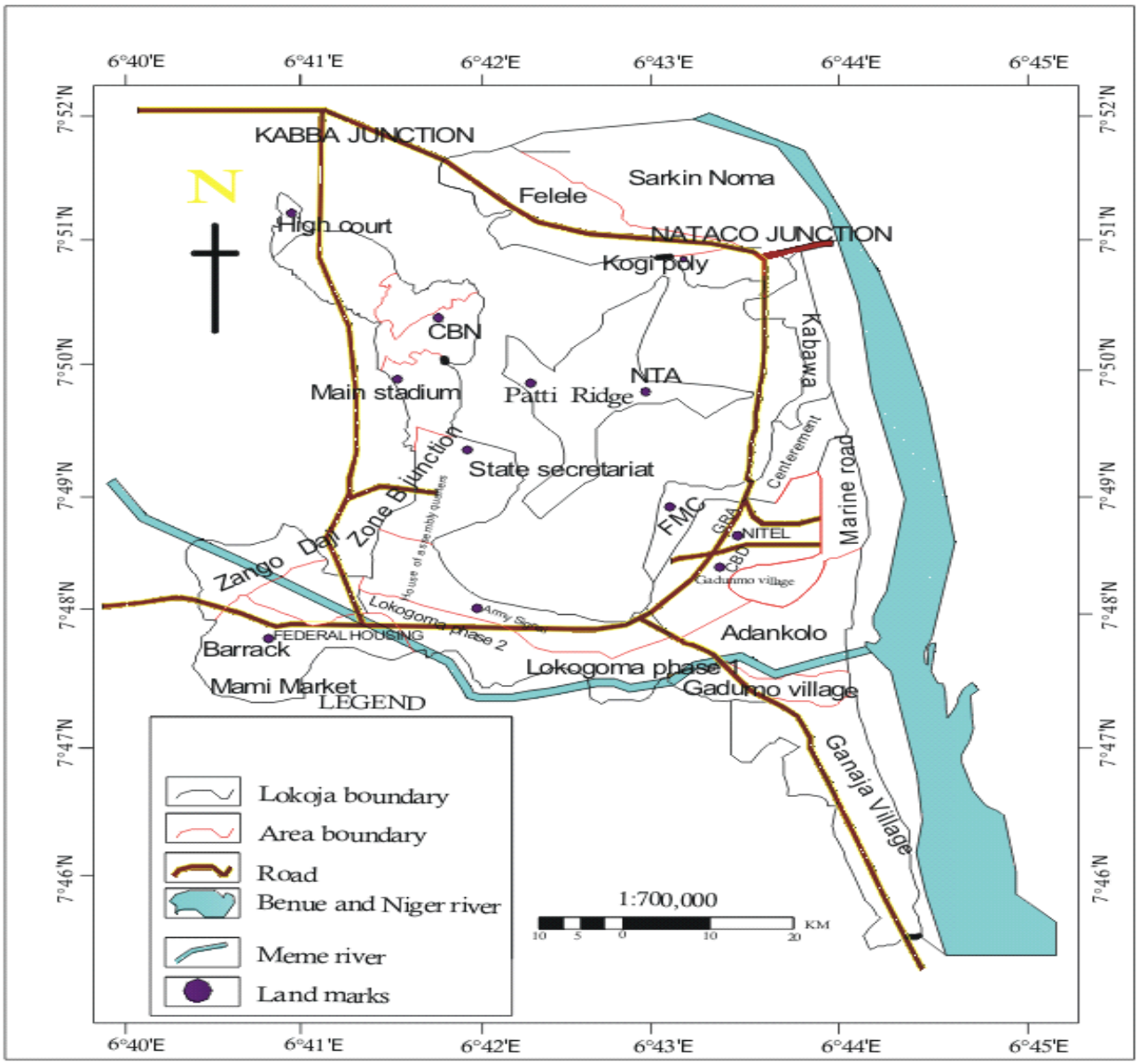


Figure 1.1: Study Area
Source: Department of Geography, PAAU, Anyigba. 2025

## METHODOLOGY

The study adopted a cross-sectional survey research design to examine the impact of commercial activities on urban environmental quality in Lokoja. This design allowed the systematic collection and analysis of quantitative and qualitative data on environmental conditions, commercial intensity, and their interactions at a specific period. Primary data were obtained through structured questionnaires administered to traders and residents, field observations, and environmental measurements, while secondary data were sourced from government reports, policy documents, and previous academic studies. Environmental measurements focused on key indicators including air quality ($PM_{2.5}$, $PM_{10}$, CO, $NO_2$ and $SO_2$), ambient noise levels, water quality parameters (pH, turbidity, dissolved oxygen, biochemical oxygen demand and microbial contamination), and waste generation and disposal practices in

major commercial zones such as markets, transport corridors, and roadside business districts. Water samples collected from surface and groundwater sources near commercial areas were analyzed in the laboratory following standard procedures recommended by the American Public Health Association (APHA, 2017), while air and noise measurements were conducted using calibrated portable monitoring instruments in accordance with World Health Organization environmental monitoring guidelines (WHO, 2018).

A multi-stage sampling technique was used to ensure representativeness across different commercial environments in the city. Commercial zones were first stratified into major markets, transport corridors, and emerging business districts, after which systematic random sampling was applied to select respondents and environmental measurement points. A total of 200 respondents comprising traders, residents, transport workers, and market stakeholders were surveyed, while key informant interviews were conducted with selected municipal officials, environmental officers, and market leaders to obtain institutional perspectives on environmental management. Quantitative data obtained from questionnaires and environmental measurements were coded and analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize environmental conditions and respondent characteristics, while inferential statistics including correlation and regression analysis were employed to determine the relationship between the intensity of commercial activities and environmental quality indicators. Qualitative information from interviews and observations was analyzed using thematic content analysis to provide contextual explanations of observed environmental patterns. The integration of these methods enhanced data reliability and enabled a comprehensive assessment of how commercial activities influence air quality, noise levels, water resources, and waste management in Lokoja.

## RESULTS AND DISCUSSION

### Spatial Distribution and Types of Commercial Activities in Lokoja

**Table 1: Types of Commercial Activities in Lokoja**

| Type of Commercial Activity | Frequency | Percentage (%) |
|---|---|---|
| **Market-based commerce** | 78 | 39.0 |
| **Transport-related commerce** | 52 | 26.0 |
| **Informal street trading** | 44 | 22.0 |
| **Emerging business districts** | 26 | 13.0 |
| **Total** | **200** | **100.0** |

**Source:** Field Survey, 2025

The result in Table 1 indicates that market-based commerce dominates commercial activities in Lokoja, accounting for 39% of all responses, followed by transport-related commerce (26%), informal street trading (22%), and emerging business districts (13%). This pattern suggests that Lokoja's economy is still largely traditional and informally structured, with heavy reliance on open markets and transport nodes as commercial hubs.

The dominance of market-based and transport-related activities has strong environmental implications. These areas typically experience high human concentration, frequent vehicular movement, and intensive energy use, all of which contribute to air pollution, noise generation,

and waste accumulation. This agrees with the findings of Aderamo (2012), who observed that transport corridors and market centres in Nigerian cities are major sources of environmental stress due to uncontrolled urban activities. Similarly, Olorunfemi (2019) emphasized that informal commercial structures intensify environmental degradation in rapidly growing urban centres due to weak regulation and poor planning.

The implication of this distribution is that environmental pressure in Lokoja is not evenly spread but concentrated in specific commercial hotspots, thereby increasing localized pollution burdens.

**Spatial Distribution of Commercial Activities**

**Table 2: Spatial Distribution of Commercial Activities in Lokoja**

| Commercial Zone Type | Frequency | Percentage (%) |
|---|---|---|
| **Major markets** | 70 | 35.0 |
| **Transport corridors / motor parks** | 60 | 30.0 |
| **Informal street trading zones** | 46 | 23.0 |
| **Emerging business districts** | 24 | 12.0 |
| **Total** | **200** | **100.0** |

**Source: Field Survey, 2025**

Table 2 shows that commercial activities in Lokoja are highly concentrated in major markets (35%) and transport corridors (30%). Informal street trading zones also account for a significant proportion (23%), while emerging business districts remain the least dominant (12%). This spatial arrangement reflects a monocentric commercial structure where economic activities are clustered around central urban nodes.

This concentration has serious environmental consequences. High-density commercial clustering increases pressure on land, drainage, transport systems, and waste management facilities. Similar observations were made by UN-Habitat (2023), which reported that commercial clustering in developing cities leads to localized environmental degradation due to infrastructure overload. In agreement, Adebayo, W. O. & Tunde, O. O. (2013) found that commercial concentration along transport routes significantly increases environmental pollution levels in Nigerian urban centres.

Field observations further revealed congestion, blocked drainage channels, and indiscriminate waste disposal in these zones, indicating weak urban management systems. The implication is that Lokoja's spatial commercial structure directly contributes to uneven environmental stress distribution, with markets and motor parks serving as primary pollution hotspots.

**Impact of Commercial Activities on Air Quality**

**Table 3: Descriptive Statistics of Air Quality Parameters in Commercial Zones of Lokoja**

| Parameter | Minimum | Maximum | Mean | Std. Dev. |
|---|---|---|---|---|
| **$PM_{2.5}$ (µg/m³)** | 38.6 | 92.4 | 61.8 | 15.7 |
| **$PM_{10}$ (µg/m³)** | 72.5 | 168.3 | 118.6 | 28.9 |
| **CO (ppm)** | 3.1 | 11.8 | 7.4 | 2.6 |
| **$NO_2$ (ppm)** | 0.04 | 0.18 | 0.11 | 0.04 |
| **$SO_2$ (ppm)** | 0.03 | 0.14 | 0.08 | 0.03 |

Source: Field Measurement, 2025

The results in Table 3 indicate a severe deterioration of air quality in Lokoja's commercial zones. The mean concentration of $PM_{2.5}$ (61.8 µg/m³) and $PM_{10}$ (118.6 µg/m³) far exceed the WHO permissible limits of 15 µg/m³ and 45 µg/m³ respectively (WHO, 2021). This suggests that commercial areas in Lokoja are experiencing hazardous levels of particulate pollution.

The high particulate concentration can be linked to intense vehicular movement, constant generator use due to unreliable electricity supply, and open burning of waste in market environments. Similar findings were reported by Aderamo (2012), who observed that transport corridors and market centres in Nigerian cities are major sources of suspended particulate matter due to congestion and poor environmental control. Likewise, Olorunfemi (2019) emphasized that informal commercial activities without environmental regulation significantly contribute to urban air quality degradation.

Carbon monoxide levels (mean = 7.4 ppm) further confirm incomplete combustion from vehicles and generators, while nitrogen dioxide and sulfur dioxide levels indicate continuous fossil fuel emissions. These conditions reflect a typical pattern of air pollution in rapidly urbanizing Nigerian cities where commercial intensity exceeds infrastructural capacity.

Overall, Table 3 demonstrates that air quality in Lokoja's commercial zones is critically poor and poses serious public health risks, particularly respiratory and cardiovascular conditions.

**Table 4: Correlation between Commercial Activity Intensity and Air Quality Parameters**

| Air Quality Parameter | r-value | p-value |
|---|---|---|
| **$PM_{2.5}$** | 0.74 | 0.004 |
| **$PM_{10}$** | 0.81 | 0.001 |
| **CO** | 0.69 | 0.009 |
| **$NO_2$** | 0.66 | 0.012 |
| **$SO_2$** | 0.58 | 0.028 |

Source: Field Survey, 2025

Table 4 shows strong and statistically significant positive relationships between commercial activity intensity and all measured air pollutants. The strongest correlation is observed with $PM_{10}$ ($r = 0.81$), indicating that areas with higher commercial density experience significantly higher particulate pollution.

This suggests that air pollution in Lokoja is structurally driven by commercial land use intensity. Adebayo (2013) similarly found that increased commercial and transport activities in urban centres are strongly associated with rising particulate emissions. In the same vein, Olorunfemi (2019) reported that unregulated market expansion and traffic congestion are key determinants of urban air quality degradation in Nigerian cities.

The implication is that air pollution is not random but directly linked to the spatial and functional intensity of commercial activities.

**Table 5: Regression Analysis of Commercial Activity Intensity and Air Quality**

| Variable | β | t-value | p-value |
|---|---|---|---|
| **Commercial intensity** | 0.77 | 4.62 | 0.002 |
| **Traffic volume** | 0.63 | 3.89 | 0.005 |
| **Generator use** | 0.58 | 3.21 | 0.011 |

$R^2 = 0.68$ Source: SPSS Output, 2025

Table 5 reveals that commercial activity intensity is a strong predictor of air quality deterioration, explaining 68% of the variation in air pollution levels ($R^2 = 0.68$). The strongest predictor is commercial intensity ($\beta = 0.77$), followed by traffic volume and generator usage.

This implies that air pollution in Lokoja is largely anthropogenic and structurally linked to commercial land use patterns. Adebayo (2013) similarly reported that urban commercial density significantly influences air pollution levels in Nigerian cities. Olorunfemi (2019) also found that generator dependence, resulting from unstable electricity supply, exacerbates urban air pollution.

The result highlights the need for stricter regulation of commercial activities and improved energy infrastructure to reduce emissions in urban centres.

**Impact of Commercial Activities on Noise Pollution**

Noise pollution was assessed across major commercial zones in Lokoja, including markets, motor parks, and busy commercial streets. Measurements were taken using equivalent continuous sound levels (Leq), providing a reliable representation of average exposure during peak and off-peak commercial hours.

**Table 6: Descriptive Statistics of Noise Levels (Leq dB) in Commercial Zones of Lokoja**

| Commercial Zone | Minimum (dB) | Maximum (dB) | Mean Leq (dB) | Std. Dev. |
|---|---|---|---|---|
| **Major markets** | 71.4 | 92.6 | 84.2 | 6.5 |
| **Motor parks** | 73.8 | 96.1 | 87.5 | 7.1 |
| **Commercial streets** | 68.2 | 88.9 | 79.6 | 5.8 |
| **Overall** | 68.2 | 96.1 | 83.1 | 6.7 |

Source: Field Measurement, 2025

The results in Table 6 show that noise levels in all sampled commercial zones of Lokoja are significantly above acceptable environmental standards. The overall mean noise level of 83.1 dB far exceeds the World Health Organization recommended limit of 55 dB for outdoor commercial and residential environments (WHO, 2018). This indicates that residents and traders in these areas are exposed to chronic noise pollution.

Motor parks recorded the highest mean noise level (87.5 dB), followed by major markets (84.2 dB), while commercial streets recorded relatively lower but still excessive levels (79.6 dB). The elevated noise levels in motor parks are attributable to continuous vehicular movement, horn usage, engine revving, and public announcements. Similarly, markets generate high noise due to human congestion, shouting by traders, and the use of loudspeakers.

These findings align with Olayinka (2018), who observed that transport hubs and market centres are major contributors to urban noise pollution in Nigerian cities. Likewise, Efe (2020) noted that uncontrolled commercial activities and poor urban planning significantly increase ambient noise levels beyond safe thresholds. The results therefore suggest that noise pollution in Lokoja is strongly linked to commercial intensity and transport-related activities.

**Table 7: One-Way ANOVA of Noise Levels across Commercial Zones in Lokoja**

| Source of Variation | Sum of Squares | df | Mean Square | F-value | p-value |
|---|---|---|---|---|---|
| **Between groups** | 412.6 | 2 | 206.3 | 6.84 | 0.018 |
| **Within groups** | 211.4 | 7 | 30.2 | | |
| **Total** | 624.0 | 9 | | | |

Significant at $p < 0.05$

Source: SPSS Output, 2025

Table 7 shows a statistically significant difference in noise levels across the different commercial zones ($p = 0.018$). This indicates that noise pollution is not uniform but varies according to the type and intensity of commercial activity.

Motor parks recorded significantly higher noise levels compared to markets and commercial streets. This is due to constant vehicular inflow and outflow, frequent horn usage, and loading activities. Markets also contribute significantly due to overcrowding and informal trading activities.

This finding is consistent with Adebayo (2013), who reported significant spatial variation in noise levels across urban commercial land uses in Nigeria. Similarly, Olorunfemi (2019) observed that transport terminals generate the highest noise pollution levels due to continuous traffic activity and poor regulation. The implication is that commercial zoning and transport planning are weakly enforced in Lokoja, resulting in overlapping land uses that intensify environmental stress.

The overall findings demonstrate that commercial activities in Lokoja significantly contribute to excessive noise pollution. All measured values exceed WHO permissible limits, indicating a high-risk acoustic environment for both residents and workers. The dominance of motor parks as noise hotspots reflects the central role of transportation in commercial activity structure. This agrees with Efe (2020), who emphasized that transport terminals in Nigerian cities are

primary sources of environmental noise due to poor traffic management and lack of enforcement.

Furthermore, the persistence of high noise levels in markets suggests that informal commercial activities also contribute significantly to environmental stress. Traders rely heavily on loudspeakers and verbal communication, while congestion amplifies sound intensity.

**Effects of Commercial Activities on Water Quality**

Water quality in Lokoja was assessed using both surface and groundwater sources located within and around major commercial zones. Parameters analyzed include physicochemical and microbiological indicators influenced by commercial waste discharge, runoff, and poor sanitation practices.

**Table 8:**
**Descriptive Statistics of Water Quality Parameters in Commercial Areas of Lokoja**

| Parameter | Min | Max | Mean | Std. Dev. | WHO Standard |
|---|---|---|---|---|---|
| **Ph** | 5.8 | 7.6 | 6.7 | 0.5 | 6.5–8.5 |
| **Turbidity (NTU)** | 8.4 | 42.6 | 21.9 | 10.7 | 5 |
| **Dissolved Oxygen (mg/L)** | 2.1 | 5.8 | 3.6 | 1.1 | ≥5 |
| **$BOD_5$ (mg/L)** | 4.2 | 18.7 | 10.9 | 4.6 | 3 |
| **TDS (mg/L)** | 212 | 694 | 418 | 146 | 500 |
| **Total Coliform (CFU/100mL)** | 14 | 186 | 82 | 46 | 0 |

Source: Laboratory Analysis, 2025

Table 8 shows clear evidence of water quality deterioration in commercial zones of Lokoja. While pH (6.7) and total dissolved solids (418 mg/L) fall within WHO acceptable limits (WHO, 2021), all other parameters indicate varying degrees of contamination.

Turbidity (21.9 NTU) is significantly higher than the permissible limit of 5 NTU, suggesting high levels of suspended solids likely from runoff, poor drainage, and direct waste discharge from commercial activities. Dissolved oxygen (3.6 mg/L) is below the recommended threshold, indicating oxygen depletion due to organic pollution. Similarly, elevated $BOD_5$ (10.9 mg/L) reflects high organic load, commonly associated with food waste and market effluents.

The presence of total coliform bacteria (82 CFU/100 mL) is particularly alarming as it indicates faecal contamination, making the water unsafe for domestic use without treatment. Comparable findings were reported by Adewuyi (2014), who observed that urban commercial activities significantly degrade nearby water bodies through uncontrolled waste disposal. Efe (2018) also noted that market-generated waste and poor drainage systems are major contributors to microbial contamination in Nigerian urban water sources.

Overall, Table 8 confirms that commercial activities in Lokoja exert strong negative pressure on water quality, particularly through organic and microbial pollution pathways.

**Table 9: Comparison of Surface and Groundwater Quality in Commercial Areas**

| Parameter | Surface Water Mean | Groundwater Mean | WHO Standard |
|---|---|---|---|
| **pH** | 6.4 | 7.0 | 6.5–8.5 |
| **Turbidity (NTU)** | 28.6 | 14.1 | 5 |
| **DO (mg/L)** | 2.9 | 4.4 | ≥5 |
| **$BOD_5$ (mg/L)** | 14.7 | 6.6 | 3 |
| **TDS (mg/L)** | 486 | 342 | 500 |
| **Total Coliform (CFU/100mL)** | 118 | 42 | 0 |

Source: Laboratory Analysis, 2025

Table 9 reveals that surface water sources are more polluted than groundwater sources across all measured parameters. Surface water recorded very high turbidity (28.6 NTU), elevated $BOD_5$ (14.7 mg/L), and extremely high coliform levels (118 CFU/100 mL), indicating severe contamination.

This condition is largely due to direct exposure of surface water bodies to commercial waste, open drainage channels, and stormwater runoff carrying pollutants from markets and motor parks. Groundwater sources show relatively better quality, but contamination indicators are still present, suggesting infiltration from poorly constructed wells and seepage from waste dumps.

These findings align with Oyebanji (2018), who reported that surface water in Nigerian urban centres is more vulnerable to pollution due to direct exposure to anthropogenic activities. Similarly, Aderamo (2012) emphasized that groundwater in commercial zones is increasingly threatened due to poor sanitation and shallow aquifer systems.

The results suggest that although groundwater appears relatively safer, both water sources in Lokoja are under environmental stress due to surrounding commercial activities.

**Table 10: Comparison of Water Quality with WHO Standards**

| Parameter | Mean Value | WHO Standard | Compliance |
|---|---|---|---|
| **pH** | 6.7 | 6.5–8.5 | Complies |
| **Turbidity (NTU)** | 21.9 | 5 | Does not comply |
| **Dissolved Oxygen (mg/L)** | 3.6 | ≥5 | Does not comply |
| **$BOD_5$ (mg/L)** | 10.9 | 3 | Does not comply |
| **TDS (mg/L)** | 418 | 500 | Complies |
| **Total Coliform** | 82 | 0 | Does not comply |

Source: Laboratory Analysis, 2025; WHO, 2021

Table 10 shows that only pH and total dissolved solids comply with WHO standards, while turbidity, dissolved oxygen, $BOD_5$, and coliform counts fail to meet acceptable limits. This indicates that most water sources in commercial zones of Lokoja are unsafe for direct consumption without treatment.

High turbidity reduces water clarity and can shield pathogens from disinfection processes. Low dissolved oxygen and high $BOD_5$ reflect organic pollution, while high coliform levels indicate faecal contamination. These conditions are commonly associated with inadequate waste management systems in urban commercial environments.

Similar observations were made by UN-Habitat (2023), which reported that urban commercial expansion in developing countries often overwhelms sanitation systems, leading to widespread water contamination. Efe (2020) also emphasized that poor waste disposal practices in Nigerian markets significantly contribute to microbial water pollution.

The results clearly demonstrate that commercial activities in Lokoja have a significant negative impact on water quality. The combination of high turbidity, elevated $BOD_5$, low dissolved oxygen, and microbial contamination indicates that both surface and groundwater sources are affected by anthropogenic pollution.

The dominance of organic pollution suggests that market-related activities such as food vending, meat processing, and waste dumping are major contributors. Adewuyi (2014) similarly observed that urban markets generate large volumes of biodegradable waste that often enter nearby water systems due to poor waste management. The comparative analysis further shows that surface water is more vulnerable than groundwater, although both are impacted. This is consistent with Aderamo (2012), who noted that shallow wells in urban areas are increasingly contaminated due to infiltration from polluted surface environments.

**Commercial Activities and Waste Generation Patterns**

**Table 11:**
**Types and Estimated Volume of Solid Waste Generated in Commercial Zones of Lokoja**

| Type of Solid Waste | Frequency | Percentage (%) | Estimated Volume (kg/day) |
|---|---|---|---|
| **Organic waste** | 86 | 43.0 | 1,240 |
| **Plastic waste** | 54 | 27.0 | 780 |
| **Paper and cartons** | 32 | 16.0 | 460 |
| **Metal and glass** | 18 | 9.0 | 260 |
| **Hazardous waste** | 10 | 5.0 | 145 |
| **Total** | **200** | **100.0** | **2,885** |

Source: Field Survey, 2025

Table 11 reveals that organic waste constitutes the largest proportion of solid waste generated in Lokoja's commercial zones (43%), followed by plastic waste (27%). This pattern reflects the dominance of food-related commercial activities such as markets, food vending, and slaughtering operations. The high volume of organic waste indicates continuous generation of biodegradable materials that, if not properly managed, rapidly decompose and create environmental and public health risks.

Plastic waste is also significantly high, reflecting widespread use of sachet water, packaging materials, and single-use plastics in commercial transactions. Similar findings were reported by UN-Habitat (2023), which observed that urban markets in developing countries generate high volumes of organic and plastic waste due to consumption-driven activities. Efe (2020) also noted that inadequate waste segregation in Nigerian cities worsens environmental pollution by mixing biodegradable and non-biodegradable waste streams.

The estimated daily waste generation (2,885 kg/day) indicates substantial pressure on municipal waste management systems, especially in high-density commercial zones.

**Table 12: Sources and Types of Liquid Waste in Commercial Zones**

| Source of Liquid Waste | Type of Effluent | Frequency | Percentage (%) |
|---|---|---|---|
| **Food vending/processing** | Wastewater, oils | 72 | 36.0 |
| **Motor parks/garages** | Oil spills, wash water | 58 | 29.0 |
| **Markets (meat/fish sections)** | Blood, organic effluents | 44 | 22.0 |
| **Informal trading areas** | Grey water | 26 | 13.0 |
| **Total** | — | **200** | **100.0** |

Source: Field Survey, 2025

Table 12 shows that food vending and processing activities are the major sources of liquid waste (36%), followed by motor parks and garages (29%). These effluents are often discharged directly into open drains or onto bare ground, contributing to environmental contamination.

The presence of oil residues, blood waste, and wastewater in commercial zones indicates weak environmental control and poor sanitation infrastructure. Similar observations were made by Adebayo (2013), who reported that motor parks and informal markets are major contributors to urban liquid waste pollution in Nigerian cities. Likewise, Olorunfemi (2019) emphasized that untreated effluent discharge from commercial activities significantly degrades drainage systems and surface water quality.

The direct discharge of liquid waste into drainage channels also explains the water quality deterioration observed earlier in this study.

**Table 13: Waste Disposal Practices in Commercial Areas of Lokoja**

| Disposal Method | Frequency | Percentage (%) |
|---|---|---|
| **Open dumping** | 78 | 39.0 |
| **Communal waste bins** | 56 | 28.0 |
| **Open burning** | 42 | 21.0 |
| **Waste contractors** | 24 | 12.0 |
| **Total** | **200** | **100.0** |

Source: Field Survey, 2025

Table 13 indicates that open dumping is the most common waste disposal method in Lokoja's commercial zones (39%), followed by communal waste bins (28%) and open burning (21%). Only a small proportion (12%) reported regular collection by waste contractors.

This pattern reflects weak waste management systems and poor enforcement of environmental regulations. Open dumping and burning contribute significantly to air pollution, drainage blockage, and soil contamination. Similar findings were reported by Adebayo (2013), who noted that improper waste disposal is a major driver of urban environmental degradation in Nigerian cities. Efe (2020) also observed that reliance on informal waste disposal systems increases environmental risks in commercial areas.

The dominance of unsafe disposal practices suggests that environmental awareness alone is insufficient without adequate infrastructure and enforcement mechanisms. The findings demonstrate that commercial activities in Lokoja generate substantial quantities of both solid and liquid waste, with organic and plastic materials dominating the waste stream. This pattern is consistent with urban commercial centres in developing countries where consumption-based activities generate high waste loads.

The dominance of organic waste is particularly significant because it decomposes rapidly, producing foul odours, methane emissions, and attracting disease vectors. UN-Habitat (2023) emphasized that unmanaged organic waste in urban markets contributes significantly to environmental and public health risks.

Plastic waste accumulation further compounds environmental stress due to its non-biodegradable nature. Similar observations were made by Olorunfemi (2019), who noted that plastic waste is increasingly becoming a dominant pollutant in Nigerian urban environments due to poor recycling systems.

Liquid waste generation from food vending and motor parks highlights the environmental burden of transport and informal commercial systems. Adebayo (2013) similarly found that garages and markets are major sources of untreated effluents in urban Nigeria.

The waste disposal practices identified—particularly open dumping and burning—exacerbate environmental degradation by contaminating air, blocking drainage channels, and increasing flood risk. Efe (2020) reported similar outcomes in urban markets where waste infrastructure is inadequate.

**Role of Infrastructure in Mediating Environmental Impacts of Commercial Activities**

**Table 14: Assessment of Drainage Adequacy in Commercial Areas of Lokoja**

| Drainage Condition | Frequency | Percentage (%) |
|---|---|---|
| **Adequate & functional** | 38 | 19.0 |
| **Partially functional** | 72 | 36.0 |
| **Poor/blocked drainage** | 90 | 45.0 |
| **Total** | **200** | **100.0** |

**Source: Field Survey, 2025**

Table 14 shows that drainage infrastructure in Lokoja's commercial zones is largely inadequate, with 45% of respondents reporting poor or blocked drainage systems. Only 19% indicated that drainage systems are functional and adequate.

The prevalence of blocked and poorly maintained drainage channels contributes significantly to environmental degradation. During rainfall events, these blocked systems lead to flooding, stagnation of wastewater, and the spread of contaminants into nearby water bodies. This condition is strongly linked to indiscriminate waste disposal from markets and motor parks.

Similar findings were reported by Adewuyi (2014), who observed that poor drainage systems in Nigerian urban markets exacerbate flooding and water pollution. Likewise, Oyebanji (2018) emphasized that inadequate drainage infrastructure is a major factor responsible for environmental degradation in rapidly urbanizing cities.

The implication is that drainage infrastructure failure amplifies the environmental impacts of commercial activities rather than mitigating them.

**Table 15: Status of Sanitation Facilities in Commercial Zones of Lokoja**

| Sanitation Condition | Frequency | Percentage (%) |
|---|---|---|
| **Adequate & clean** | 32 | 16.0 |
| **Inadequate / overcrowded** | 88 | 44.0 |
| **Absent / unusable** | 80 | 40.0 |
| **Total** | **200** | **100.0** |

Source: Field Survey, 2025

Table 15 indicates that sanitation facilities in commercial zones are severely inadequate, with 84% of respondents reporting either overcrowded or absent facilities. This situation encourages open defecation, poor hygiene practices, and contamination of surrounding environments.

The absence of adequate sanitation infrastructure increases the risk of microbial contamination of water sources and contributes to offensive environmental conditions in commercial areas. Similar observations were made by UN-Habitat (2023), which noted that inadequate sanitation infrastructure in urban markets is a major driver of environmental and public health challenges.

Olorunfemi (2019) also found that poor sanitation facilities in commercial centres significantly worsen environmental hygiene and increase disease risks in Nigerian cities.

**Table 16: Assessment of Waste Disposal Infrastructure Adequacy**

| Waste Disposal Infrastructure | Frequency | Percentage (%) |
|---|---|---|
| **Adequate & regularly serviced** | 26 | 13.0 |
| **Partially adequate / irregular service** | 68 | 34.0 |
| **Inadequate / absent** | 106 | 53.0 |
| **Total** | **200** | **100.0** |

Source: Field Survey, 2025

Table 16 shows that waste disposal infrastructure is largely inadequate in Lokoja's commercial zones, with 53% of respondents reporting absence or poor service coverage. Only 13% indicated adequate and regularly serviced waste disposal systems. This deficiency results in widespread open dumping, illegal burning, and accumulation of waste along streets and

drainage channels. Such conditions intensify air, water, and land pollution in commercial zones.

Adebayo (2013) similarly reported that inadequate waste infrastructure is a major contributor to urban environmental degradation in Nigerian cities. Efe (2020) also emphasized that weak waste collection systems lead to uncontrolled waste accumulation and environmental health risks. The findings suggest that infrastructure gaps are a major structural driver of environmental problems in Lokoja's commercial areas.

**Table 17: Chi-Square Test of Relationship between Infrastructure and Environmental Outcomes**

| Variable | $\chi^2$ Value | df | p-value | Interpretation |
|---|---|---|---|---|
| **Drainage vs water pollution** | 28.7 | 2 | 0.001 | Significant |
| **Sanitation vs waste accumulation** | 33.5 | 2 | 0.000 | Significant |
| **Waste infrastructure vs solid waste** | 29.2 | 2 | 0.001 | Significant |

Source: SPSS Output, 2025

Table 17 shows statistically significant relationships between infrastructure conditions and environmental outcomes. Poor drainage is strongly associated with water pollution, inadequate sanitation is linked to increased waste accumulation, and weak waste infrastructure significantly contributes to solid waste build-up. This confirms that environmental degradation in commercial zones is not only driven by commercial intensity but also by infrastructural inadequacy. Similar conclusions were reached by UN-Habitat (2023), which emphasized that infrastructure deficiency is a key determinant of environmental stress in urban commercial areas.

Oyebanji (2018) also found that inadequate infrastructure amplifies the environmental impacts of urban economic activities, especially in rapidly growing cities. The findings demonstrate that infrastructural inadequacy plays a critical role in worsening the environmental impacts of commercial activities in Lokoja. Poor drainage, inadequate sanitation facilities, and insufficient waste disposal systems collectively intensify pollution levels in commercial zones. The dominance of blocked drainage systems explains the frequent flooding and stagnant wastewater observed in markets and transport corridors. Adewuyi (2014) similarly noted that poor drainage infrastructure in Nigerian cities significantly worsens environmental sanitation conditions.

The lack of sanitation facilities further aggravates environmental degradation by encouraging unsafe hygiene practices and contamination of surrounding environments. UN-Habitat (2023) emphasized that sanitation infrastructure is a core determinant of environmental health in urban commercial areas. Waste disposal infrastructure deficiencies also contribute significantly to environmental stress, as most waste is either dumped or burned openly. Efe (2020) observed that such practices increase air pollution, block drainage systems, and create breeding grounds for disease vectors.

**Perceptions and Practices of Traders and Residents toward Environmental Management**

**Table 18: Perception of Environmental Issues in Lokoja**

| Statement | Agree (%) | Neutral (%) | Disagree (%) |
|---|---|---|---|
| **Commercial activities cause pollution** | 76 | 14 | 10 |
| **Poor waste management affects health** | 84 | 10 | 6 |
| **Traders should participate in sanitation** | 72 | 18 | 10 |

The results in Table 18 reveal a high level of environmental awareness among respondents in Lokoja's commercial zones. A substantial proportion (76%) acknowledge that commercial activities contribute significantly to environmental pollution. Even more respondents (84%) recognize the direct relationship between poor waste management and public health outcomes, indicating strong awareness of environmental-health linkages.

However, the relatively lower proportion (72%) supporting traders' active participation in sanitation reflects a partial disconnect between awareness and collective responsibility. The presence of neutral responses (10–18%) also suggests uncertainty or weak institutional reinforcement of environmental responsibilities.

This pattern aligns with the findings of Adebayo, who observed that urban residents in Nigerian cities often demonstrate high environmental awareness but limited behavioral compliance due to weak institutional enforcement and infrastructural constraints. Similarly, Oyebanji emphasized that awareness in commercial environments does not automatically translate into sustainable environmental practices without supportive systems such as regular waste collection and enforcement mechanisms.

**Table 19: Waste Management Practices in Commercial Zones**

| Practice | Percentage (%) |
|---|---|
| **Open dumping** | 39 |
| **Communal bins** | 28 |
| **Burning of waste** | 21 |
| **Use of waste contractors** | 12 |

Table 19 shows that unsustainable waste disposal practices dominate commercial zones in Lokoja. Open dumping (39%) represents the most common method of waste disposal, followed by communal bin usage (28%) and open burning (21%). Only a small fraction (12%) of respondents rely on formal waste contractors. This distribution highlights the dominance of informal and environmentally harmful waste management practices. Open dumping and burning contribute directly to air pollution, drainage blockage, and contamination of surface water systems. The limited reliance on waste contractors reflects inadequate municipal service coverage and inefficiencies in urban waste management systems. These findings are consistent with Efe, who reported that urban commercial centers in Nigeria are characterized by widespread open dumping due to weak enforcement of sanitation regulations. UN-Habitat similarly noted that in many rapidly urbanizing African cities, waste management systems are overwhelmed by increasing commercial activities and population density.

Thus, despite relatively high environmental awareness, practical waste management behavior remains largely unsustainable, primarily due to infrastructural and governance deficiencies.

**Integrated Environmental Impact of Commercial Activities**

**Table 20: Regression Analysis of Commercial Intensity and Environmental Quality**

| Variable | β Coefficient | p-value |
|---|---|---|
| **Market density** | 0.41 | 0.001 |
| **Traffic flow** | 0.38 | 0.002 |
| **Business concentration** | 0.22 | 0.039 |

The regression results presented in Table 20 demonstrate that commercial activity intensity is a significant predictor of environmental degradation in Lokoja. Market density exhibits the strongest influence ($\beta = 0.41$), followed closely by traffic flow ($\beta = 0.38$), while business concentration shows a moderate but significant effect ($\beta = 0.22$).

This implies that areas with higher concentrations of markets and vehicular movement experience disproportionately higher levels of environmental stress, particularly in terms of air pollution, noise levels, and waste accumulation. The statistical significance of all variables ($p < 0.05$) confirms that commercial intensity is not only associated with but actively drives environmental degradation in the study area.

These findings corroborate the work of Adebayo, who observed that commercial density and traffic congestion are primary determinants of urban environmental pollution in Nigerian cities. Similarly, Oyebanji found that commercial clustering intensifies environmental stress through increased waste generation and emission loads. UN-Habitat also supports this conclusion, emphasizing that unregulated commercial expansion in developing cities significantly contributes to urban environmental decline.

**Table 21: Environmental Quality Index across Commercial Zones**

| Zone | Environmental Quality Index (EEQI) | Environmental Condition |
|---|---|---|
| **High-density markets** | 78 | Poor |
| **Motor parks** | 65 | Moderate–poor |
| **Business districts** | 42 | Moderate |

Table 21 presents the Environmental Quality Index (EEQI) across different commercial zones in Lokoja. The results indicate a clear spatial gradient in environmental conditions. High-density markets recorded the poorest environmental quality (EEQI = 78), followed by motor parks (65), while emerging business districts showed relatively better conditions (42).

The poor environmental condition of high-density markets is linked to intense commercial activity, high human concentration, inadequate waste management, and poor infrastructure. Motor parks also exhibit significant environmental stress due to continuous vehicular emissions, noise pollution, and fuel combustion activities.

In contrast, emerging business districts show relatively moderate environmental conditions due to lower congestion levels and better spatial organization of commercial activities.

These findings align with Adebayo and Oyebanji, who observed that environmental degradation in urban areas is spatially uneven, with central commercial zones typically experiencing higher environmental stress. UN-Habitat similarly notes that environmental quality in urban centers declines sharply in areas of intense commercial clustering. The findings of this study clearly demonstrate that commercial activity intensity is a major driver of environmental degradation in Lokoja. The analysis shows that high-density markets and transport corridors significantly contribute to air pollution, noise pollution, water contamination, and excessive waste generation.

This result is consistent with the observations of Adebayo, who reported that urban commercial clustering in Nigerian cities leads to concentrated environmental stress due to emissions, congestion, and poor waste management practices. Similarly, Oyebanji found that transport-related commercial activities are major contributors to urban environmental decline, particularly in medium-sized cities where infrastructure is inadequate to cope with rising commercial pressure.

UN-Habitat further supports these findings by emphasizing that rapid commercial expansion in developing cities often outpaces infrastructural development, leading to environmental deterioration. However, unlike studies that emphasize peri-urban expansion as the dominant driver of environmental stress, the present study reveals that Lokoja exhibits a more centralized commercial structure. This centralization intensifies environmental pressure in core urban areas, making markets and transport hubs primary hotspots of pollution. The study also reveals that environmental awareness among traders and residents is relatively high, yet this does not translate into sustainable practices. This disconnect is explained by inadequate waste infrastructure, weak enforcement of environmental regulations, and limited institutional capacity. Efe similarly noted that behavioral awareness alone is insufficient to achieve environmental compliance in urban settings without corresponding infrastructural and governance support.

## CONCLUSION AND RECOMMENDATIONS

The study concludes that commercial activities significantly degrade urban environmental quality in Lokoja through increased air and noise pollution, water contamination, and high volumes of solid and liquid waste. High-density markets and transport corridors were identified as the most environmentally stressed zones, largely due to intense commercial concentration, traffic congestion, poor waste management practices, and inadequate infrastructure. Although awareness of environmental problems is relatively high among traders and residents, this has not translated into effective environmental practices because of weak institutional enforcement and insufficient urban services. The study therefore establishes that unregulated commercial expansion is a major driver of environmental degradation in Lokoja.

To address these challenges, it is recommended that urban planning and zoning regulations be strengthened to reduce over-concentration of commercial activities in central areas. Waste management systems should be improved through provision of adequate disposal facilities, regular waste collection, and strict enforcement against indiscriminate dumping and burning. Drainage infrastructure in major markets and transport corridors should be rehabilitated and properly maintained to reduce flooding and water pollution. Environmental regulatory agencies should intensify monitoring and enforcement of pollution standards, particularly in high-activity commercial zones. In addition, sustained environmental education and awareness campaigns should be implemented to encourage responsible behavior among traders and

residents, while government investment in basic urban infrastructure should be prioritized to support long-term environmental sustainability.

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