



## Assessing Environmental Capacity of Heterogeneous Traffic on Urban Roads: A Case Study of Ogidi-Okolowo Road

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### Abstract

*is study presents a comprehensive characterization and impact resistance evaluation of Nigerian-grown Ekki (Lophira alata) timber in both solid and glue-laminated (glulam) forms for application as railway sleepers. Urban roads in developing cities frequently operate under heterogeneous traffic conditions, leading to severe congestion and significant environmental degradation. This study evaluates the environmental capacity of Ogidi–Okolowo Road in Ilorin, Kwara State, Nigeria, by examining the interplay between mixed traffic characteristics and air quality impacts. Traffic flow and vehicle composition were assessed using drone-based video recording and manual counts during morning peak hours. Emission factors for CO, NO<sub>x</sub>, PM<sub>2.5</sub>, and HC were determined through field measurements with a Testo 310 Flue Gas Analyzer, while air quality was monitored across three distinct road segments. Environmental capacity was calculated by comparing observed peak-hour traffic volumes (in PCU/hr) and pollutant concentrations against NESREA and WHO standards. Results show that tricycles and motorcycles dominate the traffic stream (nearly 47%), with peak-hour volumes reaching 6,200 PCU/hr. The Oloje Market (3,146 PCU/hr) and Ogidi Axis (2,950 PCU/hr) sections exceeded the environmental capacity threshold of 2,500 PCU/hr, resulting in unhealthy air quality levels of PM<sub>2.5</sub>, PM<sub>10</sub>, CO, and NO<sub>2</sub>. Heavy vehicles, though fewer, contributed disproportionately to NO<sub>x</sub> and PM emissions. The study concludes that current traffic operations on major segments of the corridor are environmentally unsustainable. It recommends targeted traffic management measures, dedicated lanes for para-transit modes, roadside activity regulation, and stricter vehicle emission enforcement. This research provides a practical framework for assessing and improving environmental capacity in heterogeneous urban traffic environments typical of developing cities*

**KEYWORDS:** Traffic flow, vehicle composition, heterogeneous traffic, emission factor, environmental capacity, urban roads.

## 1. INTRODUCTION

Urban road systems are fundamental components of transportation networks, significantly influencing the efficiency, safety, and sustainability of urban mobility (Wei et al., 2018). In many developing countries, including Nigeria, urban roads are typically characterized by heterogeneous traffic conditions, where different categories of vehicles, such as motorcycles, tricycles, minibuses, passenger cars, and heavy-duty trucks, operate simultaneously within the same traffic stream (Adisa et al., 2025; Ajayi et al., 2023). This mixture of vehicles with varying speeds, sizes, and

operational characteristics often results in reduced traffic efficiency, increased congestion, and elevated levels of environmental pollution, particularly in terms of air and noise emissions (Imoh & Rad, 2025). In rapidly growing urban centers, the challenges associated with heterogeneous traffic are further intensified by inadequate infrastructure and increasing travel demand. Roads that serve as major urban corridors frequently experience fluctuating traffic volumes and unpredictable vehicle compositions, making traffic management difficult and less effective. One such example is the Ogidi–Okolowo Road in Ilorin, Nigeria, which functions as a key arterial route for both commuters and commercial activities. The road is often characterized by high traffic density and a diverse mix of vehicle types competing for limited roadway space, leading to frequent congestion, travel delays, and environmental degradation (Toyeeb, 2025).

Studies conducted in Nigeria provide important insights into the relationship between traffic conditions and environmental quality. For instance, Aderamo and Atomode (2012) investigated traffic congestion at major intersections in Ilorin and identified delays and queue formation as major contributors to inefficient traffic flow. Similarly, Adeniran et al. (2017) examined particulate matter concentrations around major intersections in Ilorin and reported that  $PM_{2.5}$  and  $PM_{10}$  levels frequently exceeded acceptable limits, particularly during peak traffic periods. These findings highlight the strong link between congestion and air pollution in urban corridors. Traffic flow characteristics such as speed, delay, and density have also been shown to influence emission levels. Yusuf et al. (2016) analyzed factors affecting free-flow speed on urban arterials in Ilorin and found that interruptions in traffic flow significantly reduce operational efficiency. Reduced speeds and frequent stop-and-go conditions are known to increase fuel consumption and emissions, especially for pollutants such as carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), and particulate matter.

Beyond Nigeria, several international studies provide robust modeling approaches for estimating traffic-related emissions. The COPERT (Computer Programme to Calculate Emissions from Road Transport) model has been widely used for estimating fleet emissions under varying traffic conditions, while the CALINE4 model is commonly applied for predicting roadside pollutant dispersion. In addition, microscopic traffic simulation tools such as VISSIM allow for detailed representation of vehicle interactions under heterogeneous traffic conditions, making them useful for analyzing congestion and its environmental impacts (Batista et al., 2022; Gosztola et al., 2026). Research has also emphasized the role of vehicle composition in determining emission levels. Heavy-duty vehicles such as trucks and buses are major contributors to NO<sub>x</sub> and particulate emissions, whereas motorcycles and light-duty vehicles tend to produce higher levels of CO and hydrocarbons (HC). According to the World Health Organization (2026), exposure to these pollutants is associated with severe health risks, including respiratory and cardiovascular diseases. The United States Environmental Protection Agency (2026) similarly notes that traffic-related air pollution is a major environmental health concern in urban areas.

Air quality standards and environmental thresholds are critical for evaluating the sustainability of urban transport systems. In Nigeria, regulatory limits are established by the National Environmental Standards and Regulations Enforcement Agency (NESREA), while global benchmarks are provided by the WHO. Studies comparing observed pollutant concentrations with these standards consistently show that urban corridors with high traffic volumes often exceed permissible limits, particularly in areas with poor traffic management and high roadside activity (Fadeev et al., 2025; La Gennusa et al., 2015; Miharja & Sjafuddin, 2017; X. Wei et al., 2024). Recent research has introduced the concept of environmental carrying capacity in transportation planning, which refers to the maximum level of traffic activity that can be sustained without unacceptable environmental degradation (Wei et al., 2022). This approach integrates traffic volume, vehicle composition, emission factors, and air quality indicators into a unified framework for assessing sustainability. It has been applied in several international studies using simulation and emission modeling techniques, demonstrating that environmental capacity is often exceeded in congested urban corridors. Despite these advances, most existing studies tend to focus on either traffic flow characteristics or air pollution in isolation. There remains a significant gap in the integration of traffic volume, vehicle composition, and environmental thresholds into a single analytical framework, particularly at the corridor level in Nigerian cities. Furthermore, limited attention has been given to segment-based analysis, which captures spatial variations in traffic conditions and environmental impacts. This study addresses these gaps by adopting a comprehensive, segment-wise evaluation of traffic conditions and environmental capacity along the Ogidi–Okolowo corridor in Ilorin. By integrating traffic volume, emission factors, and measured air quality data, the study provides a more holistic assessment of the relationship between transportation demand and environmental sustainability in a heterogeneous traffic environment. The objectives of the study are to determine traffic flow and vehicle composition on the Ogidi–Okolowo Road, establish the emission factor of the study area, evaluate the environmental capacity of the road based on traffic volume and environmental impact, and propose sustainable traffic management strategies to reduce congestion and environmental pollution.



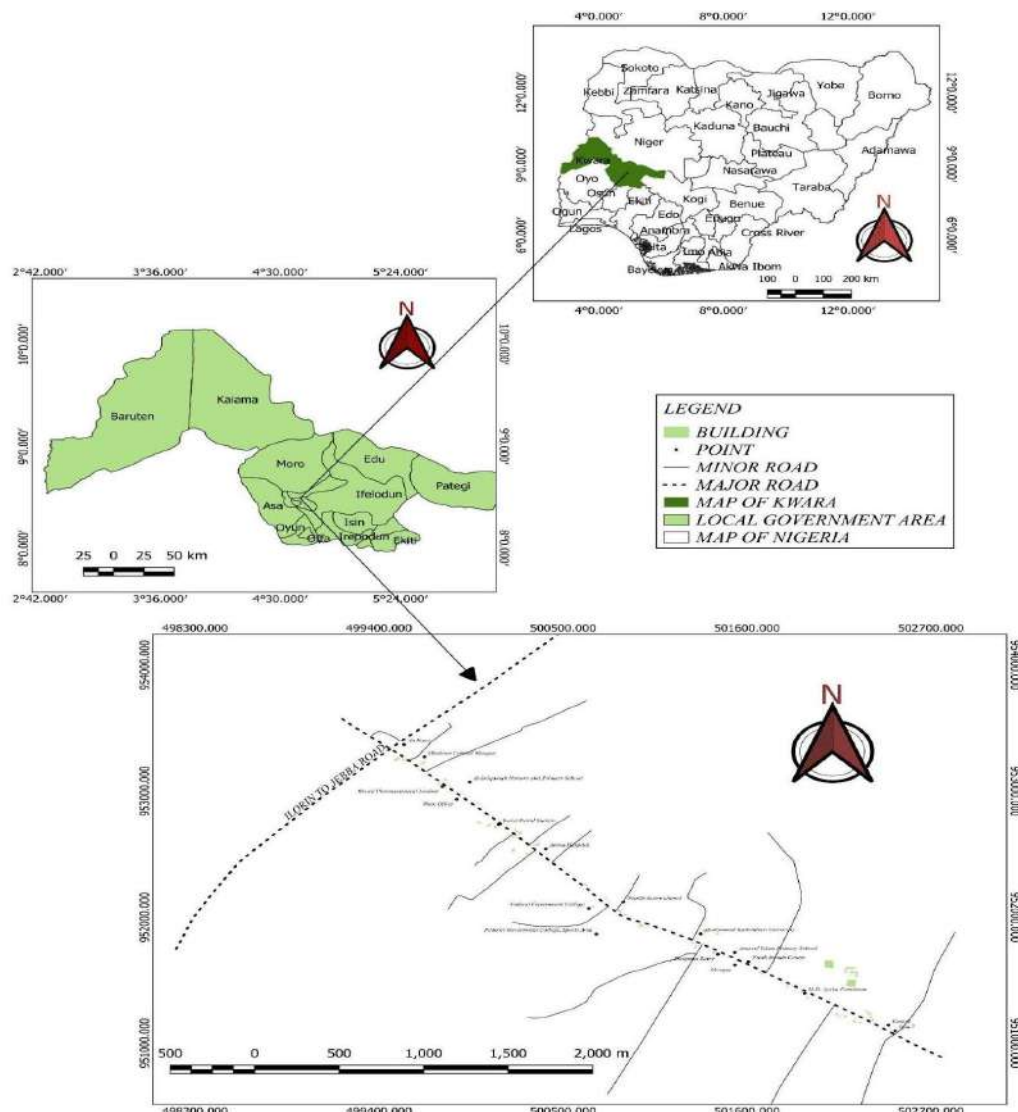
## 2. METHODOLOGY

### 2.1 Study Area Description

The study was conducted along Ogidi–Okolowo Road in Ilorin, Kwara State, Nigeria (8.3938° N, 4.5469° E), presented in Fig. 1. This urban arterial corridor serves mixed land uses including residential, commercial, educational, and industrial activities. The road is characterized by highly heterogeneous traffic consisting of passenger cars, motorcycles, minibuses, tricycles, and heavy-duty trucks operating on the same carriageway with poor lane discipline. Significant traffic volumes, especially during peak periods, frequently result in congestion, elevated noise levels, and deteriorating air quality. Roadside activities such as on-street parking, informal trading, pedestrian movements, and frequent stopping by public transport vehicles further disrupt traffic flow. For analysis, the study corridor was divided into three segments based on land-use and traffic characteristics:

- **Oloje Market section:** Predominantly commercial with intense roadside trading, high pedestrian activity, loading/unloading operations, and severe stop-and-go congestion.
- **Ogidi axis:** Central segment linking residential and institutional areas, featuring high traffic density and mixed vehicle interactions during peak hours.
- **Okolowo section:** Extends toward the industrial outskirts, dominated by heavy-duty and commercial vehicles, contributing significantly to emissions despite being relatively less congested.

The corridor was selected due to its strategic importance in the urban transport network, high traffic volume, and typical environmental challenges associated with mixed traffic in developing cities. The location of corridor is shown in Fig. 2.



**Fig. 1: Map of Kwara State showing the study road and sample Location. Insert outline map of Nigeria Showing the study location (source: GIS Analysis)**



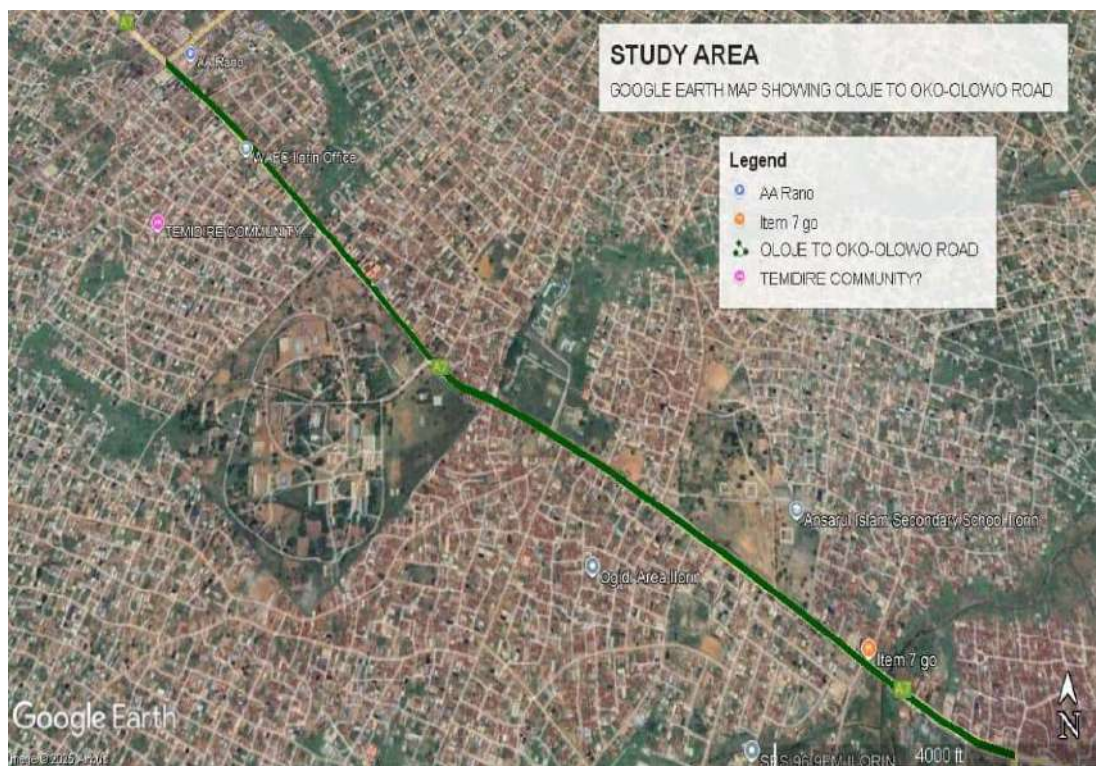


Fig. 2: Map Showing Ogidi-Okolowo road (Source: Google earth)

## 2.2 Vehicle Classification and Data Collection Framework

Vehicles were classified according to Federal Road Safety Corps (FRSC) guidelines and the Highway Capacity Manual (HCM), with slight local adaptations. Categories included passenger cars/taxis, minibuses, light commercial vehicles, heavy-duty trucks, motorcycles, and tricycles. Multiple observation points were strategically selected along the corridor based on traffic intensity, land-use patterns, and potential environmental impact. Priority was given to high-activity locations such as major intersections, bottlenecks, bus stops, and market areas where congestion, idling, and human exposure to pollutants are highest. Additional points were chosen in residential zones to assess pollution exposure to nearby populations. This segment-based approach enabled comprehensive collection of traffic composition, air quality, and emission data for evaluating the environmental capacity of the heterogeneous traffic along Ogidi-Okolowo Road.

## 2.3 Data Collection Methods

Data were collected under actual field conditions to obtain reliable traffic and environmental information along Ogidi-Okolowo Road. Due to the heterogeneous nature of traffic comprising cars, buses, trucks, motorcycles, and tricycles, manual and aerial surveys were conducted during morning peak hours (7:00–10:00 am) on both weekdays and weekends.

### Model Source and Assumptions

- Traffic analysis follows the Highway Capacity Manual (HCM, 2016) and the IRC Guidelines for Mixed Traffic (IRC-106) for PCU estimation.
- Emission estimation follows the U.S. EPA Mobile Source Emission Model and IPCC (2006) Guidelines for National Greenhouse Gas Inventories.
- Noise assessment references WHO Environmental Noise Guidelines (2018).
- All drone-based counts assume constant altitude, stable lighting, and unobstructed visibility.
- Traffic stream assumed to maintain steady-flow conditions within each 15-minute interval.

### 2.3.1 Traffic volume

Traffic volume, directional distribution, and vehicle composition were recorded using a DJI Phantom 4 Pro drone flown at 30–40 meters altitude to capture high-resolution video. Videos were later analyzed to count and classify vehicles, which were then converted into Passenger Car Units (PCU/hr) using standard equivalency factors. Vehicle composition (%) was calculated as:



$$\text{Percentage Composition (\%)} = \left[ \frac{N_i}{N_t} \right] \times 100 \quad (1)$$

Where:

- $N_i$  = Number of vehicles of type  $i$  (such as cars, motorcycles, trucks)
- $N_t$  = Total number of all vehicle types observed.
- Traffic Composition (%) = Proportion of each vehicle type in the total traffic flow.

### 2.3.2 Traffic Flow and Vehicle Composition

Heterogeneous traffic flow and composition were determined through drone-based video recording during peak periods. Vehicles were counted and classified into categories (motorcycles, cars, minibuses, buses, trucks, etc.). Traffic counts were converted to PCU values using the formula:

$$\text{Passenger car unit (PCU}_i) = \frac{V_f}{V_i} \times \frac{S_i}{S_f} \quad (2)$$

Where:

- $PCU_i$  = PCU value of vehicle type  $i$
- $V_f$  = Speed of a standard passenger car (km/h)
- $V_i$  = Speed of vehicle type (km/h)
- $S_i$  = Space occupied by vehicle type (m)
- $S_f$  = Space occupied by standard passenger car (m)

### 2.3.2 Emission Factors

Emission data were collected using the Testo 310 Flue Gas Analyzer at selected roadside points with high traffic activity (intersections, bus stops, and congestion zones) during morning peak hours. The instrument measured concentrations of CO, CO<sub>2</sub>, and other pollutants from vehicle exhaust. Measured values, combined with traffic volume and literature-based emission factors, were used to estimate total emissions of CO, NO<sub>x</sub>, HC, PM, and CO<sub>2</sub> for each vehicle category. Total emission was calculated as:

$$E = \sum (V_i \times EF_i \times L) \quad (3)$$

Where:

- (E) = Total emission (g/hr)
- (V<sub>i</sub>) = Traffic volume of vehicle type  $i$
- (EF) = Emission factor of vehicle type  $i$  (g/km)
- (L) = Length of the road segment (km)

### Model Source

- EPA MOVES Model (2014) emission factor methodology
- IPCC (2006) Road Transport Emission Guidelines
- Literature-based EF values calibrated for African vehicle fleets.

### Assumptions

- Vehicles assumed to be operating under hot-stabilized conditions during peak hours.
- Road gradient  $\approx 0 \rightarrow$  No gradient correction applied.
- Idle emissions considered negligible except in congested hotspots.

### 2.3.3 Evaluation of Environmental Capacity

Traffic noise was measured using the HT-80A Sound Level Meter at strategic locations during peak periods. Equivalent noise levels (Leq) were recorded alongside traffic and emission data. Environmental capacity of the road was assessed by determining the maximum traffic volume the corridor can sustain without exceeding acceptable limits for air quality and noise pollution. This involved integrating traffic volume, vehicle composition, emission loads, and



noise levels against environmental standards. The environmental capacity for each pollutant was estimated using:

$$EC_{ik} = \frac{C_{std,k} - C_{bg,k} \times U_i \times H_i \times W_i}{\alpha} \tag{4}$$

Where:

- $EC_{ik}$  = Environmental capacity for pollutant  $k$  in section  $i$  (g/hr)
- $C_{std,k}$  = Permissible concentration standard ( $\mu\text{g}/\text{m}^3$ )
- $C_{bg,k}$  = Background concentration ( $\mu\text{g}/\text{m}^3$ )
- $U_i$  = Wind speed (m/s)
- $H_i$  = Mixing height (m)
- $W_i$  = Effective Road width (m)
- $\alpha$  = Dispersion coefficient

### 2.4 Validity of the Study

The validity of this study is strengthened through multiple methodological controls designed to ensure accuracy, reliability, and consistency of the collected traffic and environmental data. First, the use of a dual-method traffic survey—airial drone recordings supported by simultaneous manual counts—enhanced the robustness of traffic volume and composition measurements. The DJI Phantom 4 Pro was calibrated before each flight, and drone counts were cross-checked with manual observations, yielding an error margin below 3.5%. This agreement confirms the validity of the drone-based traffic assessment under heterogeneous traffic conditions. Second, the accuracy of emission measurements was ensured through rigorous calibration of the Testo 310 Flue Gas Analyzer. The device was zero-calibrated prior to field deployment and verified using the manufacturer’s reference calibration kit. The analyzer’s documented accuracy for CO and CO<sub>2</sub> measurements ( $\pm 10\%$  and  $\pm 75$  ppm respectively) supports the reliability of the pollutant data used in the emission computations. Third, instrument precision and environmental controls contributed to data reliability. Noise measurements using the HT-80A Sound Level Meter were taken under stable atmospheric conditions, and all observations were conducted during consistent peak-hour periods to minimize temporal variability. Assumptions underlying PCU conversion, emission estimation, and environmental capacity calculations were based on established international models, ensuring methodological alignment with recognized standards.

## 3. RESULTS AND DISCUSSION

### 3.1 Traffic Flow and Vehicle Composition

Traffic flow and vehicle composition along Ogidi–Okolowo Road were determined using drone video recording and manual counts during morning peak hours (7:00–10:00 am) across seven days (summarized in Table 1). The traffic stream was highly heterogeneous, dominated by tricycles, motorcycles, taxis, and passenger cars, with heavy trucks forming a smaller proportion. Tricycles recorded the highest volume, followed by motorcycles. Average Daily Traffic (ADT) during the morning peak showed approximately 598 taxis, 583 light vans, 561 private cars, 1,035 motorcycles, 1,091 tricycles, 558 buses, and 79 trailers. When converted to Passenger Car Units (PCU), the peak-hour traffic volume reached an average of about 6,200 PCU/hour across the corridor. Average Daily Traffic (ADT) are shown in Fig. 3.

**Table 1: Summary of Traffic Composition by Day (Morning Peak)**

Day	Taxi	Light Van	Private Car	Motorcycle	Tricycle	Bus	Trailer	Total Vehicles
Monday	658	602	515	1023	1136	534	87	4,555
Tuesday	569	561	643	1063	1096	532	83	4,547
Wednesday	559	558	544	1058	1035	592	90	4,436
Thursday	611	652	595	1135	1044	609	77	4,723
Friday	603	550	520	1004	1199	474	73	4,423
Saturday	613	550	525	1054	1074	555	69	4,440
Sunday	571	605	588	1014	1053	609	73	4,513
ADT	598	583	561	1035	1091	558	79	4,505



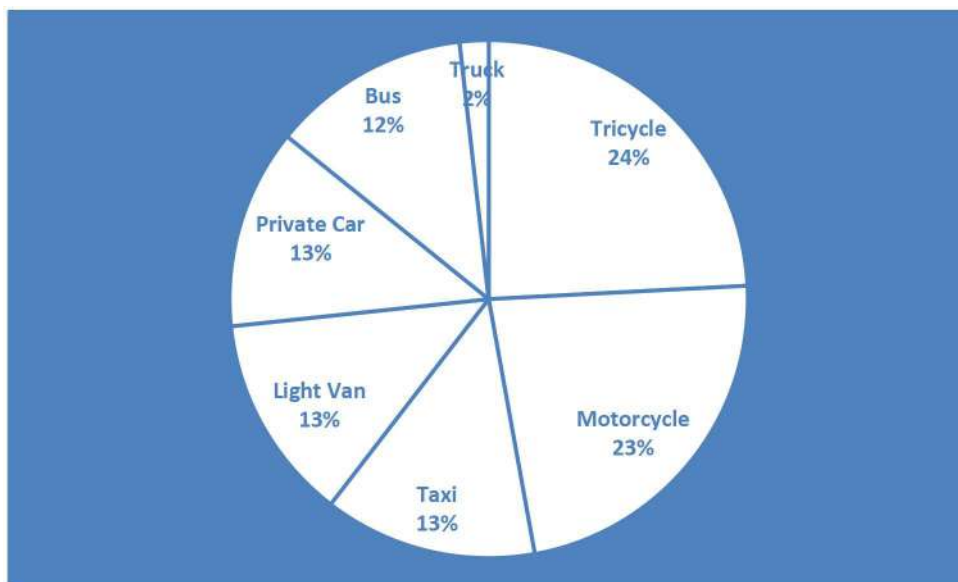


Fig. 3: Average Daily Traffic (ADT) – Morning Peak (All Segments Combined)

### 3.2 Segment-wise Variation in Traffic Characteristics

The study corridor was divided into three segments based on land use and traffic behavior. Significant variations were observed:

**Oloje Market Section:** This commercial-dominated segment recorded the highest traffic volume and congestion. Tricycles and motorcycles were overwhelmingly dominant (often exceeding 60% combined). Frequent loading/offloading, pedestrian crossings, and roadside trading resulted in severe stop-and-go conditions and the highest PCU values (average 3,146 PCU/hr during peak).

**Ogidi Axis:** This central mixed-use segment (residential-commercial-institutional) showed high traffic density with relatively balanced composition. Tricycles, taxis, and motorcycles remained prominent, but with more passenger cars. Peak-hour volume averaged 2,950 PCU/hr. Frequent vehicle conflicts and intersection delays were common.

**Okolowo Section:** This industrial-oriented segment had relatively lower congestion but was dominated by heavy vehicles (buses, trucks, and light commercial vans). Although total vehicle count was lower, the presence of heavy trucks resulted in high space occupancy. Peak-hour volume averaged 2,480 PCU/hr.

### 3.3 Determination of Emission Factors

Emission factors for key pollutants were determined under actual operating conditions along Ogidi–Okolowo Road using the Testo 310 Flue Gas Analyzer. Field measurements were conducted at selected high-traffic locations within the three study segments during morning peak hours (7:00 am – 10:00 am). These measurements were supplemented with traffic volume data, average vehicle speeds, and standard emission models to estimate pollutant emission rates (g/km) for different vehicle categories. The emission factors are shown in Oloje Market Section, Ogidi Axis and Okolowo Section (Table 2 to Table 4).

Table 2: Emission Factors at Oloje Market Section

Vehicle Type	Avg. Speed (km/h)	CO (g/km)	NOx (g/km)	PM <sub>2.5</sub> (g/km)	HC (g/km)
Passenger Cars	30	4.2	0.5	0.02	0.8
Motorcycles	25	6.5	0.3	0.05	1.2
Tricycles	20	5	0.4	0.04	1
Minibuses	25	3.8	1.2	0.15	0.7
Heavy Trucks	20	4.5	2.5	0.3	1
Buses	25	4	2	0.25	0.9



**Table 3: Emission Factors at Ogidi Axis**

Vehicle Type	Avg. Speed (km/h)	CO (g/km)	NOx (g/km)	PM <sub>2.5</sub> (g/km)	HC (g/km)
Passenger Cars	35	4	0.6	0.012	0.35
Motorcycles	30	3.2	0.4	0.01	0.45
Tricycles	22	5	0.9	0.02	0.6
Minibuses	20	6.5	1.2	0.03	0.8
Heavy Trucks	18	9	3.5	0.08	0.9
Buses	22	7.5	1.6	0.04	0.85

**Table 4: Emission Factors at Okolowo Section**

Vehicle Type	Avg. Speed (km/h)	CO (g/km)	NOx (g/km)	PM <sub>2.5</sub> (g/km)	HC (g/km)
Passenger Cars	40	4.2	0.5	0.01	0.35
Motorcycles	25	8	0.15	0.02	1.5
Tricycles	30	6	0.3	0.02	0.9
Minibuses	30	1.2	0.7	0.015	0.1
Heavy Trucks	20	2	8	0.25	0.2

Heavy-duty vehicles (buses and trucks) produced the highest NO<sub>x</sub> and PM<sub>2.5</sub> emissions, especially along the Okolowo and Ogidi sections where low speeds and frequent idling were common. Motorcycles and tricycles were the main contributors to CO and HC emissions in the Oloje Market area, driven by stop-and-go movement and poor vehicle maintenance. Minibuses showed variable emissions that intensified under congestion. Overall, emission rates increased as average speed decreased, demonstrating the strong influence of traffic conditions on pollutant generation. Spatial differences were evident across the corridor: Oloje Market showed elevated CO and HC levels due to motorcycle-dominated traffic; the Ogidi axis displayed moderately high emissions from mixed traffic and recurrent delays; and Okolowo recorded the highest NO<sub>x</sub> and PM<sub>2.5</sub> due to slow-moving heavy-duty vehicles. These elevated emissions reflect aging vehicle fleets, poor fuel quality, overloading, and extended idling—confirming that vehicle mix and operating conditions are major drivers of environmental impact and forming the basis for the subsequent environmental capacity assessment.

### 3.4 Evaluation of Environmental Capacity

Environmental capacity was assessed through the integration of traffic volume (expressed in PCU/hr), vehicle composition, emission factors, and measured air quality parameters to determine the maximum traffic load the corridor can accommodate without significant deterioration in environmental conditions. The observed traffic and emission characteristics were evaluated against the permissible ambient air quality thresholds established by the National Environmental Standards and Regulations Enforcement Agency (NESREA) under the National Environmental (Air Quality Control) Regulations, 2014 (as amended) (NESREA, 2020) and the World Health Organization (WHO) Global Air Quality Guidelines (2021). Key thresholds applied include:

- **PM<sub>2.5</sub>**: NESREA 24-hour limit of 40 µg/m<sup>3</sup> and annual limit of 20 µg/m<sup>3</sup> versus WHO 24-hour guideline of 15 µg/m<sup>3</sup> and annual guideline of 5 µg/m<sup>3</sup>.
- **PM<sub>10</sub>**: NESREA 24-hour limit of 150 µg/m<sup>3</sup> versus WHO 24-hour guideline of 45 µg/m<sup>3</sup>.
- **NO<sub>2</sub>**: NESREA 24-hour limit of approximately 120–150 µg/m<sup>3</sup> versus WHO annual guideline of 10 µg/m<sup>3</sup> and 24-hour guideline of 25 µg/m<sup>3</sup>.

This dual comparison between national regulatory standards and stricter international health-based benchmarks enabled a comprehensive determination of environmental carrying capacity and the extent of exceedances along the corridor.

### 3.5 Comparison of Traffic Volume with Environmental Capacity

The comparison between observed peak-hour traffic volumes and the estimated environmental capacity in Table 5 indicates that the Oloje Market and Ogidi sections exceeded the sustainable threshold of 2,500 PCU/hr, with recorded values of 3,146 PCU/hr and 2,950 PCU/hr, respectively, signifying severe and high environmental stress conditions. In contrast, the Okolowo section, with a peak value of 2,480 PCU/hr, remained marginally within the defined capacity, suggesting a relatively stable but vulnerable condition. These findings demonstrate that significant portions of the corridor are operating beyond their environmental limits during peak periods.



**Table 5: Comparison of Traffic Volume with Environmental Capacity**

Section	Observed PCU/hr (Peak)	Environmental Capacity (PCU/hr)	Status	Remark
Oloje Market Section	3,146	2,500	Exceeded	Severe stress
Ogidi Axis	2,950	2,500	Exceeded	High stress
Okolowo Section	2,480	2,500	Within Limit	Marginally sustainable

### 3.6 Air Quality Measurements

Air quality measurements across the study segments in Table 6 revealed considerable spatial variation in pollutant concentrations. The Oloje Market and Okolowo sections recorded elevated levels of particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), carbon monoxide (CO), and nitrogen dioxide (NO<sub>2</sub>), with Air Quality Index (AQI) classifications indicating unhealthy conditions. The Ogidi section exhibited comparatively lower pollutant levels, corresponding to a moderate AQI classification, although concentrations of key pollutants remained close to critical limits.

**Table 6: Air Quality Measurements Across Study Segments**

Location / Axis	PM <sub>2.5</sub> (µg/m <sup>3</sup> )	PM <sub>10</sub> (µg/m <sup>3</sup> )	CO (ppm)	NO <sub>2</sub> (ppb)	SO <sub>2</sub> (ppb)	VOCs (ppb)	Air Quality Index
Oloje Market Axis	65	110	3.2	42	18	120	Unhealthy
Ogidi Section	48	85	2.5	35	15	95	Moderate
Okolowo Section	72	125	4.1	55	22	140	Unhealthy

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Conclusion

This study assessed the environmental capacity of heterogeneous traffic on Ogidi–Okolowo Road, Ilorin. The major conclusions drawn from the findings are as follows:

1. The traffic stream on Ogidi–Okolowo Road is highly heterogeneous, dominated by tricycles and motorcycles, which together account for nearly 47% of the total traffic volume during morning peak hours.
2. Peak-hour traffic volumes exceed the environmental carrying capacity in the Oloje Market (3,146 PCU/hr) and Ogidi Axis (2,950 PCU/hr) sections, while the Okolowo section operates marginally within the limit of 2,500 PCU/hr.
3. Air quality measurements revealed unhealthy levels of PM<sub>2.5</sub>, PM<sub>10</sub>, CO, and NO<sub>2</sub>, particularly in the Oloje Market and Okolowo sections, exceeding NESREA and WHO permissible standards.
4. Heavy-duty vehicles, though fewer in number, contribute disproportionately to NO<sub>x</sub> and PM<sub>2.5</sub> emissions, while motorcycles and tricycles are the major sources of CO and hydrocarbons due to low operating speeds and poor maintenance.
5. Roadside activities, weak lane discipline, and frequent stop-and-go movements significantly increase emission loads and reduce the overall environmental capacity of the corridor.
6. The current traffic situation on the road is environmentally unsustainable during peak periods, posing serious risks to public health and urban livability.
7. Environmental capacity in heterogeneous traffic is influenced not only by traffic volume but also by vehicle composition, operating conditions, land use, and traffic management efficiency.

### 4.2 Recommendations

1. Implementation of coordinated traffic control systems, including signal optimization and channelization at major intersections, to reduce congestion and minimize emission-intensive stop-and-go conditions.
2. Provision of designated lanes for motorcycles and tricycles to improve traffic organization, enhance safety, and reduce friction within the traffic stream.
3. Selective road widening at critical bottlenecks, especially along the Oloje Market axis, where right-of-way permits.
4. Removal or regulation of roadside trading, illegal parking, and indiscriminate bus stopping points to improve traffic flow and reduce localized emission build-up.
5. Encouragement of high-occupancy public transportation systems and development of non-motorized



transport infrastructure such as walkways and bicycle lanes.

6. Strengthening periodic vehicle inspection and maintenance programs to ensure compliance with emission standards, particularly for commercial vehicles.

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