Assessment of Road Traffic Noise in Minna Metropolis

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Abstract:- This study focuses on the assessment of road traffic noise in Minna metropolis, recognizing transportation's pivotal role in economic growth while highlighting its negative impacts on the environment and human health, particularly noise pollution. Traffic noise, constituting a significant portion of urban noise, has become a key research area for engineers and scientists due to the escalating number of vehicles on the roads, including older vehicles emitting excessive noise. The investigation encompassed three areas in Minna city: Kpakungu, Mobil roundabout, and Kure market. Noise levels were measured using calibrated sound level meters, positioned 1.2 meters above ground level and 1 meter away from the roadside to minimize potential errors. Traffic counts encompassed various vehicle types, from 2-wheelers to buses and trucks. The study employed the Calixto model, which considers total vehicle count and the percentage of heavy vehicles, to predict noise levels. The observed noise levels were then compared with calculated/predicted noise levels (Leq). Regression analysis was conducted in all areas, resulting in correlation coefficients (R2) that demonstrated strong correlations. Kpakungu displayed the highest R2 of 0.9738, followed by Mobil with 0.911, and Kure Market with the lowest but still significant R2 of 0.8931. These findings suggest that the Calixto model is applicable to Nigeria's road conditions and can serve as a valuable tool for noise level prediction in transportation planning and environmental management.

Keywords:- *Traffic Noise, Leq, Heterogeneous, Traffic Flow, Noise Level, Distance.*

I. INTRODUCTION

Transportation is a fundamental component of a nation's economic growth and societal development, facilitating the movement of people, goods, and services across various modes, including land, air, and water transport. However, while transportation plays a pivotal role in progress, it also brings about adverse consequences, notably noise pollution. Noise pollution, characterized as "undesirable sound," poses significant environmental and health challenges, impacting human well-being and quality of life.

Among the sources of noise pollution, transportation, encompassing motorcycles, vehicles, aircraft, and rail transport, stands out as a major contributor. The escalating number of vehicles on the road, driven by population growth and increasing standards of living, has made road traffic noise a prominent concern in urban and rural environments. This study delves into the assessment of road traffic noise in Minna metropolis, Nigeria, shedding light on its diverse repercussions.

Exposure to high noise levels, both in the short and long term, presents grave concerns. Long-term exposure to noise can result in severe health issues, such as hearing impairment, circulatory system damage, and cardiovascular problems. The association between high ambient noise levels and hearing loss is well-established, particularly among daily commuters exposed to noisy highway medians for extended periods. Furthermore, hypertension and an elevated risk of ischemic heart disease have been linked to long-term noise exposure.

In the short term, excessive noise in transit stations creates an unpleasant environment for passengers, hindering communication, concentration, and comfort. Additionally, it affects the effectiveness of public announcements, potentially jeopardizing passenger safety. The adverse station environment may deter potential riders from using these stations, undermining the substantial investment made in constructing these transportation lines.

Given the prevalence of noise exposure in Minna, this study holds significant importance. Traffic noise is a dominant noise source in both urban and rural settings, posing a growing public concern. Noise's adverse impacts on health, including hearing disabilities, sleep disturbances, and cardiovascular effects, necessitate thorough examination. This research addresses the need to assess and mitigate traffic noise, aligning with international and national standards.

The primary aim of this study is to assess road traffic noise in Minna metropolis. The specific objectives of the study are to measure the hourly traffic volume of different axle loads (2-axle, 3-axle, and 4-axle, both light and heavy), determine the noise levels at transit stations and relevant noise parameters, including Traffic Noise Index (TNI), Noise Climate (NC), and Noise Pollution Level (Lnp) for all study locations. develop a road traffic noise prediction model based on the percentage of heavy vehicles and regression analysis to predict noise equivalent levels (Leq) using the Calixto model.

This research focuses on evaluating the extent of noise exposure experienced by people and commuters in

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Kpakungu, Kure Market, and Mobile areas of Minna. The study also assesses how this exposure aligns with international and national noise standards, contributing to our understanding of and strategies to mitigate traffic noise in the region.

II. METHODOLOGY

The study, titled "Assessment of Road Traffic Noise in Minna Metropolis," took place in Minna, the capital of Niger State, Nigeria. It aimed to evaluate equivalent noise levels (Le) and noise indices, including L10, L50, and L90, at various locations in Minna, including Kpakungu, Mobil, and Kure Market. The study involved assessing the noise generated by mixed traffic while categorizing the types of vehicles. The materials use for this research Work are Sound level meter(Extech SDL600), Stopwatch and Reflective jacket

➢ *Research Methods*

To achieve the study's objectives, the following methods were employed:

- *Study Area Indication:*

Minna, located 162 km from Abuja, experiences a climate between the Sahel and Guinea Savanna regions, characterized by distinct dry and rainy seasons. The town's population has steadily increased, with a notable rise in vehicle numbers.

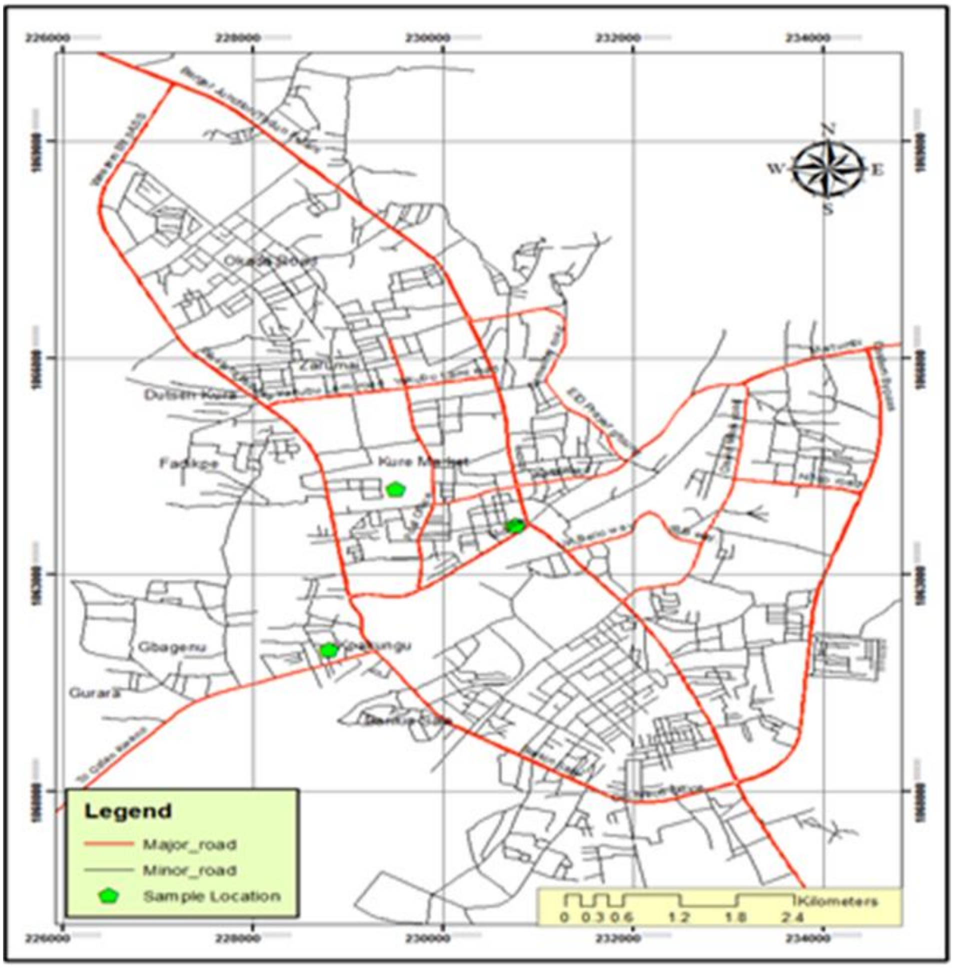

Fig 1 Map

➢ *Study Area*

- *Traffic Count:*

Traffic volume at Kpakungu, Mobil, and Kure Market locations was assessed from 7:30 AM to 7:30 PM over three weeks at each site. Vehicle counts included scooters, motorcycles, kekenapep (3-wheller, light vehicles (4-axle), and heavy vehicles such as buses and trucks.

- *Road Traffic Noise Monitoring:*

Noise levels were measured within the same time frame as traffic counts using a calibrated sound level meter. The instrument was placed on a tripod at a height of 1.2 meters and positioned 1 meter from the roadside.

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Fig 2 Road Traffic Noise Monitoring Sound Level Meter (SLM)

➢ *Data Processing*

- *Noise Descriptors*

Various noise descriptors were calculated, including Leq, L10, L50, L90, TNI (Traffic Noise Index), Lnp (Noise Pollution Level), NC (Noise Climate), Q (Traffic volume), and P (Percentage of heavy vehicles). These descriptors helped assess the extent of noise pollution resulting from heavy traffic in the study locations.

Noise Index Levels: L10, L50, and L90 represent percentiles of noise levels exceeded during measurement periods. Leq values were calculated for each hour using a sound level meter.

Noise Level Parameters: TNI, Lnp, and NC were derived from observed noise indices and played a role in quantifying noise pollution levels.

- *Development of Model for the Prediction of Noise*

A noise prediction model was developed to estimate noise levels, aiding in planning and designing a noise-free environment. The Calixto model was used, considering the percentage of heavy vehicles and a weighting factor (n) to predict equivalent noise levels (Leq). The model's validation was done using regression analysis and correlation coefficient (R2) values.

Calixto Model: The Calixto model was adapted for Nigeria road conditions by adjusting the weighting factor (n) to 10. The relationship between observed and calculated Leq values was expressed through a regression equation:

$$Leq = 14\log[Q(1 + 0.1 \times VP)] + 12.5976$$

III. RESULTS AND DISCUSSION

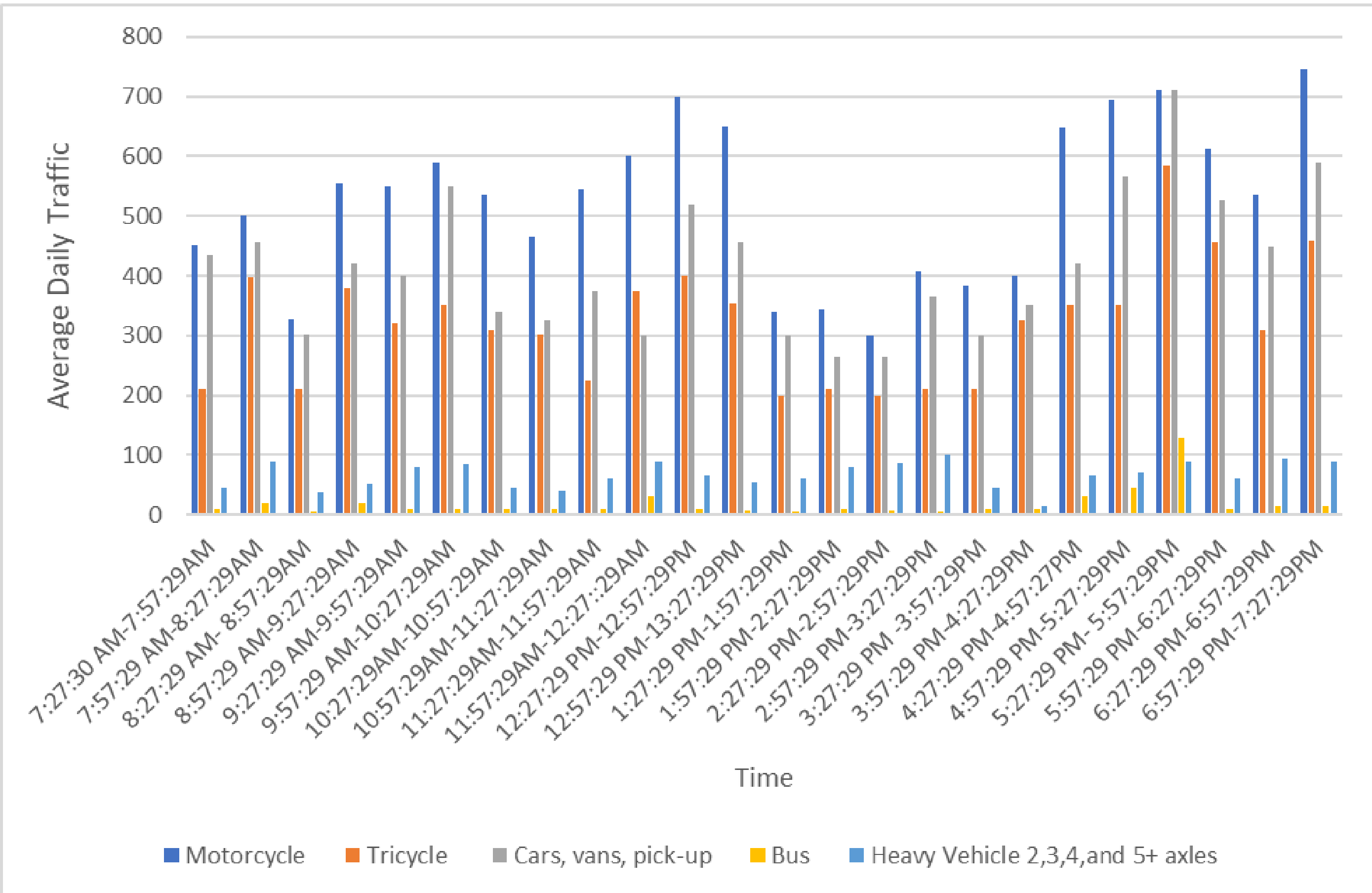


Fig 3 Average Daily Traffic for Kpakungu

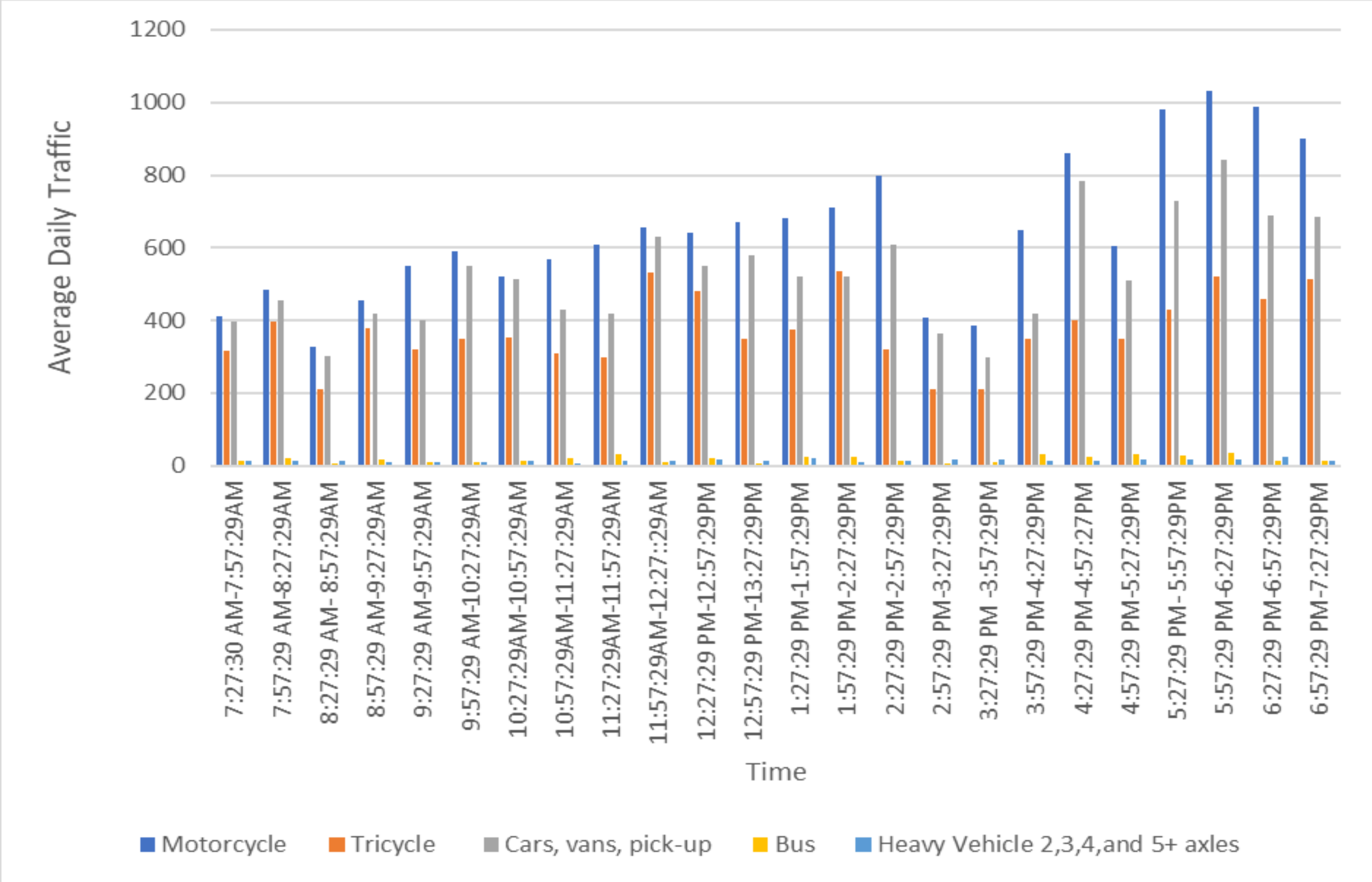


Fig 4 Average Daily Traffic for Kure Market

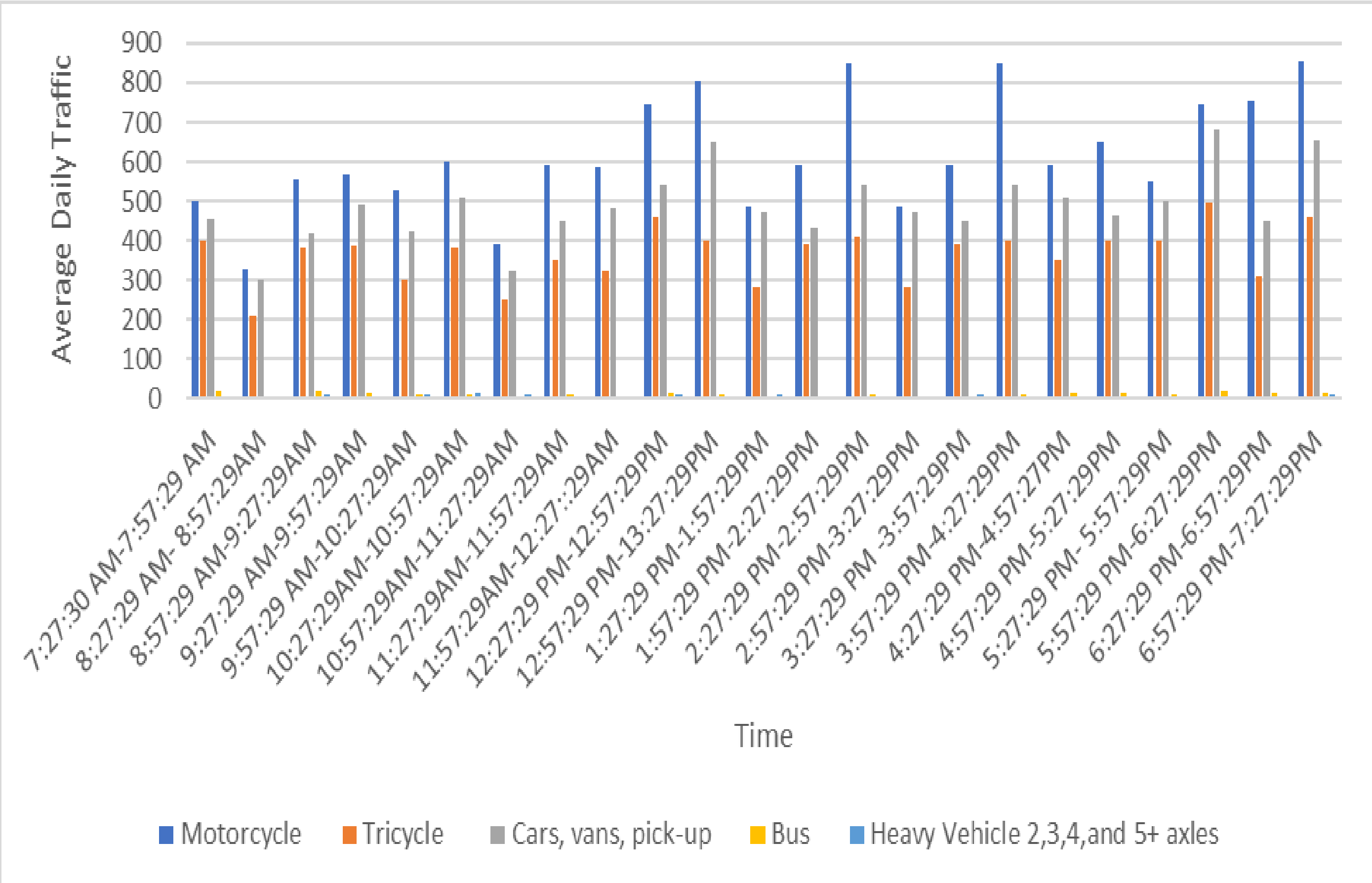


Fig 5 Average Daily Traffic for Mobil

➢ *Traffic Count:*

The traffic count data reveals significant congestion on the studied roads in Minna. Motorcycles have the highest volume at 12,589veh/day, followed closely by cars, vans, and pickups at 9,984veh/day. Tricycles, heavy vehicles, and buses also contribute, with 7,696veh/day, 1,603veh/day, and 445veh/hr, respectively for kpakungu. This congestion persists throughout the day, exceeding the recommended limits for township roads, which specify an average traffic volume between 8,000-10,000veh/day when truck traffic exceeds 15 percent (Highway Manual, 2013). Similar trends are observed at Kure Market, with motorcycles leading at 15,479veh/day, followed by cars, vans, and pickups at 12,624veh/day. Tricycles, buses, and heavy vehicles contribute 8,967veh/day, 4,361veh/day, and 339veh/day, respectively. Congestion occurs in the afternoons and evenings, surpassing recommended township road limits. At Mobil, motorcycles top the count at 14,184veh/day, trailed by cars, vans, and pickups at 11,220veh/day. Tricycles, buses, and heavy vehicles account for 8,400veh/day, 258veh/day, and 140veh/day, respectively. Similar congestion patterns emerge in the mornings and evenings, exceeding township road traffic volume limits.

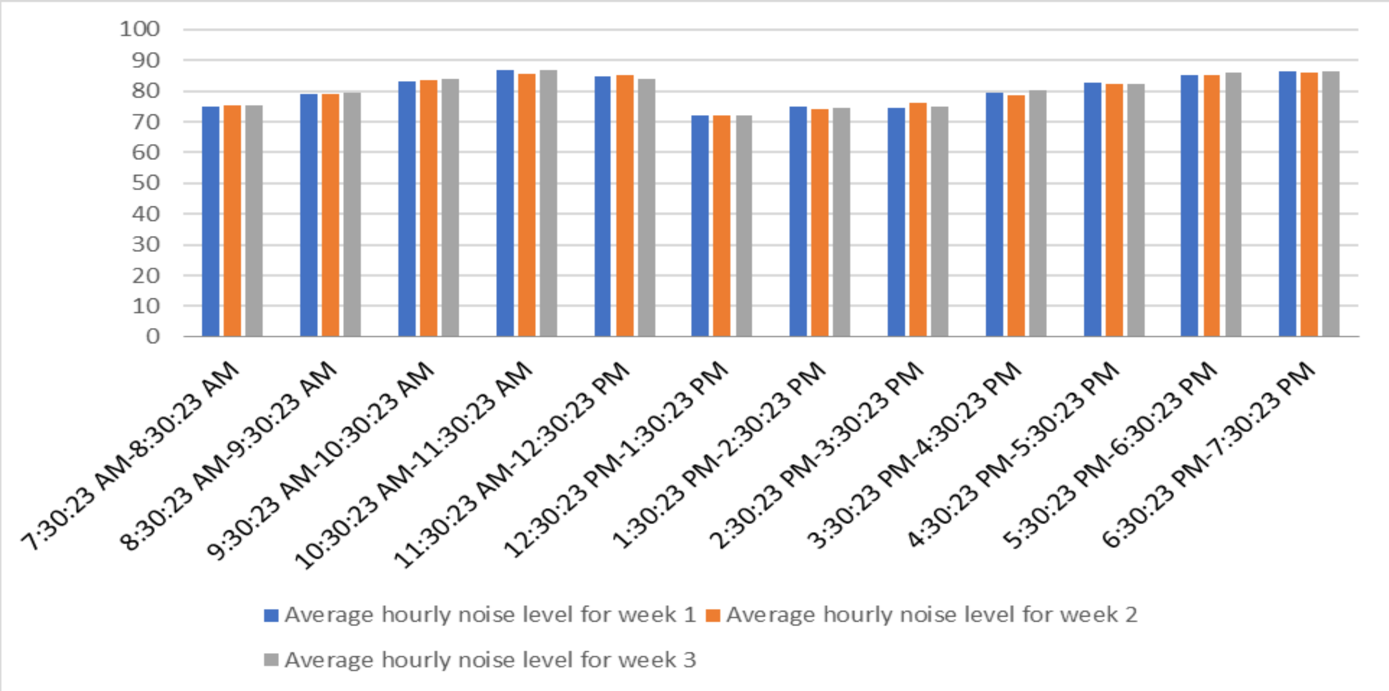


Fig 6 Average Hourly Weekly Noise Level at Mobil

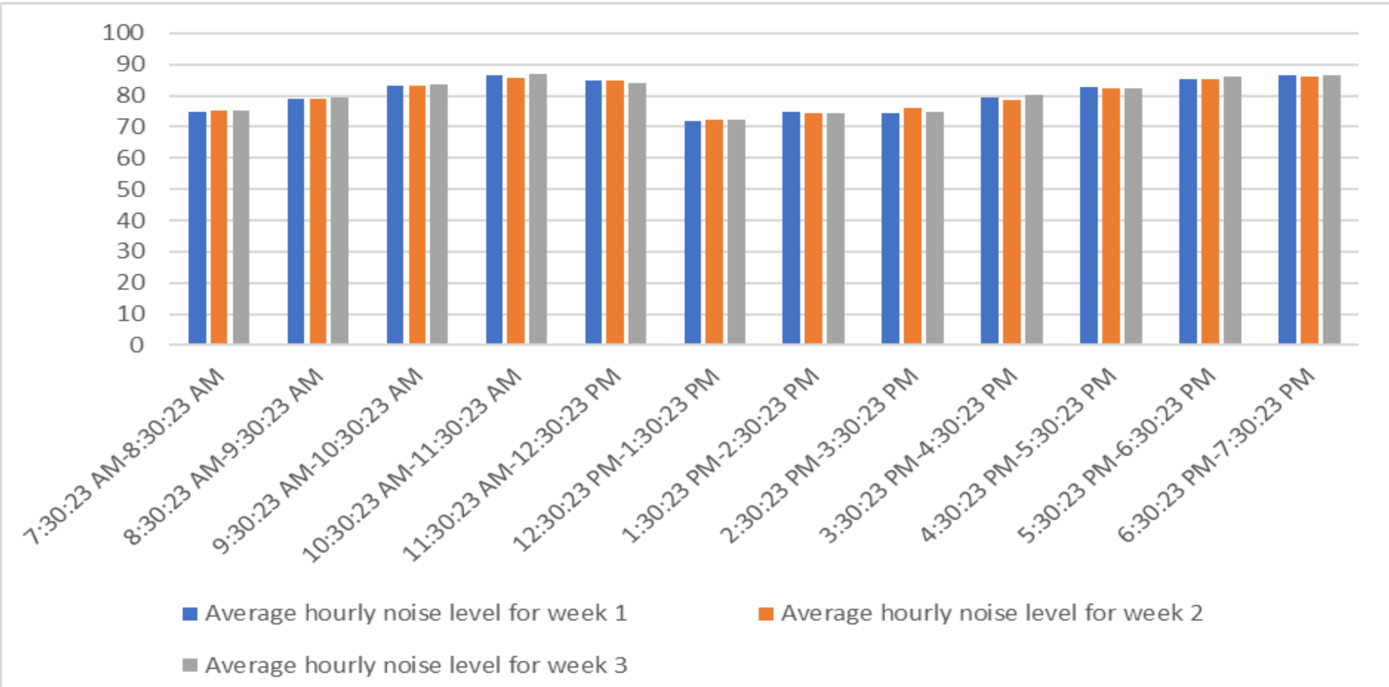


Fig 7 Average Hourly Weekly Noise Level at Kpakungu

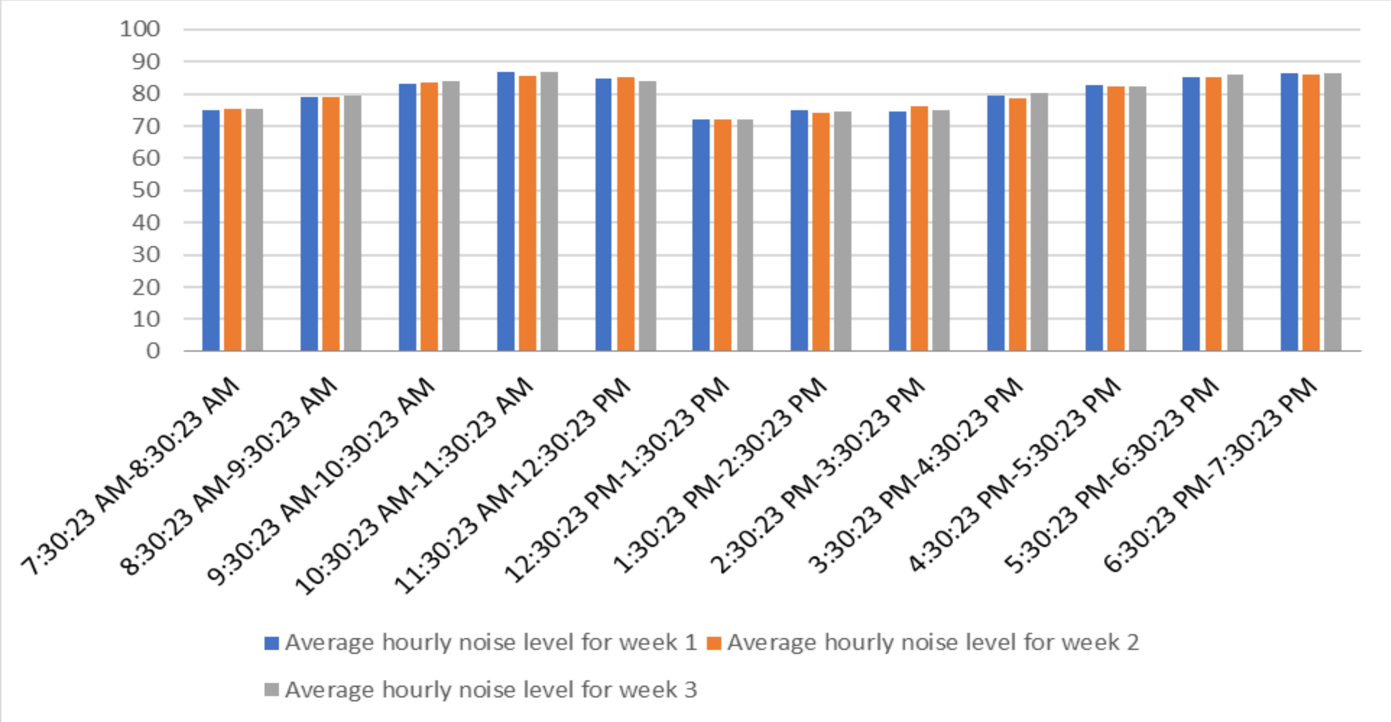


Fig 8 Average Hourly Weekly Noise Level at Kure Market

The average hourly noise levels at Kpakungu, Kure Market, and Mobil were observed over three weeks. In kpakungu, it's evident that noise levels increase from 8:30 AM to 12:30 PM due to heightened activities, including higher vehicle movements, increased horn usage, and louder music from vendors. A slight dip occurs between 12:30 PM and 4:30 PM as vehicle activity decreases, followed by another rise in the evening, attributed to commuters returning from work, school, and the market. Kure Market displays a similar pattern, with noise levels rising from 8:30 AM to 12:30 PM due to increased vehicular activity and vendor music. There's a minor drop between 12:30 PM and 3:30 PM, followed by an evening peak as commuters return.

In Mobil, noise levels follow the same trend, with an increase from 8:30 AM to 12:30 PM, a decrease between 12:30 PM and 3:30 PM, and a subsequent rise in the evening due to returning commuters. These patterns reflect daily variations in noise levels influenced by local activities and vehicular movements.

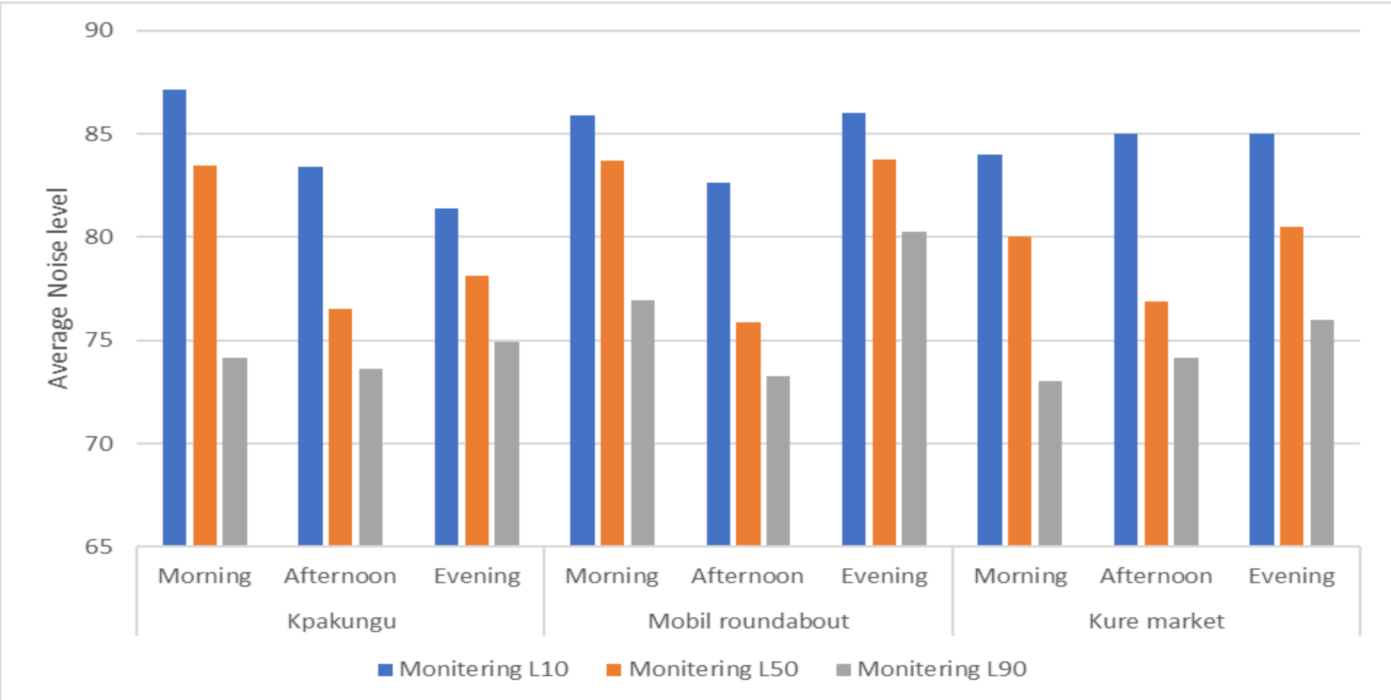


Fig 9 Noise Indices L_{10}, L_{50} and L_{90} at Study Location(S)

The noise indices, L10, L50, and L90, were examined over 12 hours at Kpakungu, Kure Market, and Mobil Roundabout. At Kpakungu (Figure 9), L10 exhibited its highest value of 87.13 in the morning, followed by 83.4 in the afternoon, and a minimum of 81.93 in the evening. L50 showed a similar pattern, with the minimum during the afternoon and maximum values in the morning and evening. L90 for 12 hours demonstrated peak values of 74.16 in the morning and 74.9 in the afternoon, with a minimum of 73.6 during the afternoon. In the case of Kure Market (Figure 9), L10 displayed its highest value of 85 during the afternoon, followed by 85 in the evening, and a minimum of 84 in the morning. L50 showed a minimum of 76.89 in the afternoon and maximum values of 80 and 80.5 in the morning and evening, respectively. L90 exhibited peak values of 74.16 in the afternoon and 76 in the evening, with a minimum of 73 during the morning. At Mobil Roundabout, L10 reached its maximum value of 85.92 in the morning, followed by 85.4 in the evening, and a minimum of 82.66 in the afternoon. L50 showed a similar trend, with a minimum in the afternoon and maximum values in the morning and evening. L90 indicated peak values of 76.92 in the morning and 80.25 in the evening, with a minimum of 73.26 during the afternoon. These indices reflect variations in noise levels throughout the day in these areas.

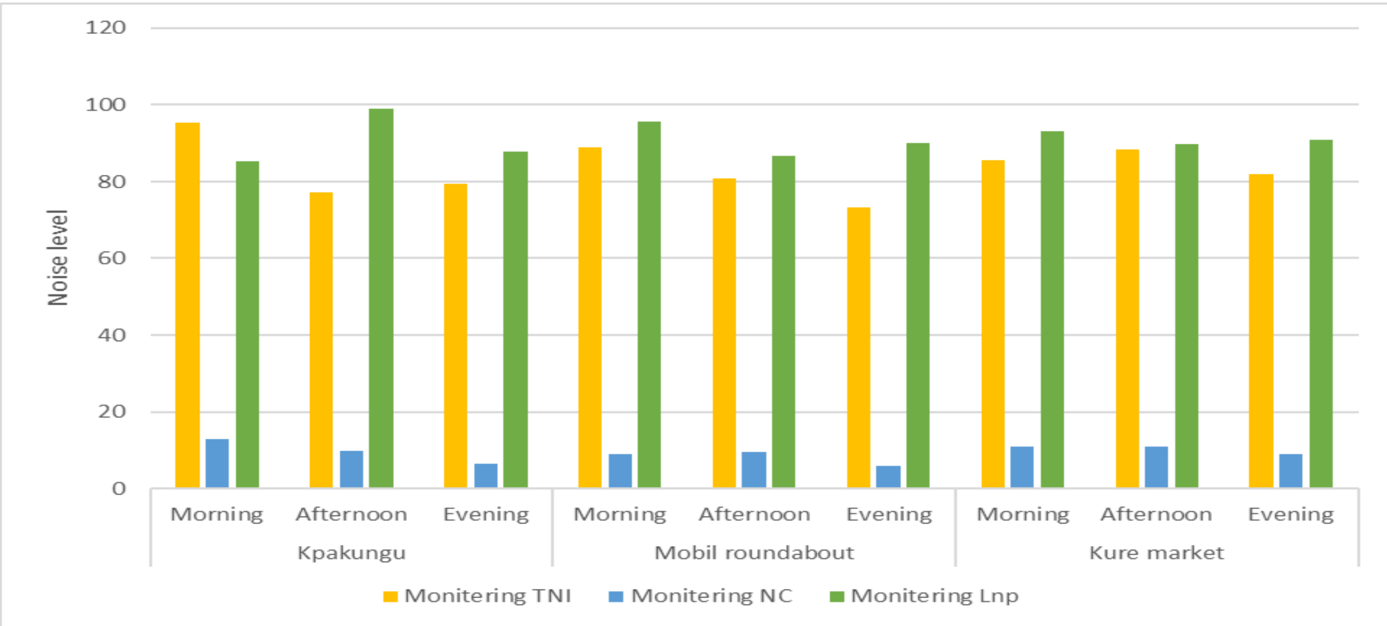
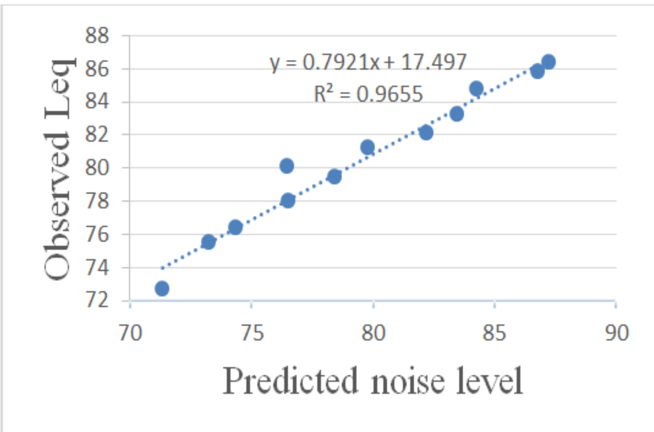


Fig 10 Noise Parameters TNI, NC and LNP Variation for all the Study Area

At the Kpakungu study location, various noise parameters were analyzed (Figure 10). The Traffic Noise Index (TNI) ranged from a minimum of 77.3 dB(A) during the afternoon to a maximum of 95.5 dB(A) and 79.3 during the morning and evening, indicating fluctuations in traffic noise. The Noise Climate (NC) showed variations between 8.35 dB and 12.84 dB, reflecting the range of sound level fluctuations over time. The Noise Pollution Level (Lnp), with a threshold value of 72 dB(A), exhibited a minimum of 85.4 dB(A) during the morning and a maximum of 99.1 dB(A) and 87.83 dB(A) during the morning and afternoon, respectively. Both TNI and Lnp exceeded the threshold values. In the Kure market area, TNI fluctuated between a minimum of 82.0 dB(A) in the evening and a maximum of 85.5 dB(A) and 88.3 during the morning and afternoon, indicating traffic flow variations (Figure 10). The NC ranged from 9.00 dB to 11 dB, showcasing sound level fluctuations over time. Lnp, with a threshold value of 72 dB(A), reached a minimum of 89.9 dB(A) during the afternoon and a maximum of 93.1 dB(A) and 90.83 dB(A) during the morning and evening, respectively. Both TNI and Lnp exceeded the threshold values.

In the Mobil area (Figure 10), TNI exhibited a minimum of 73.2 dB(A) during the evening and a maximum of 88.92 dB(A) and 80.86 during the morning and afternoon, indicating variations in traffic noise. The NC ranged from 5.8 dB to 10.0 dB, reflecting sound level fluctuations. Lnp, with a threshold of 72 dB(A), displayed a minimum of 86.77 dB(A) during the afternoon and a maximum of 95.05 dB(A) and 90.11 dB(A) during the morning and evening, respectively. Both TNI and Lnp exceeded the threshold values in this location as well.



Graph 1 Noise Level Versus Predicted Noise Level for Kpakungu Area

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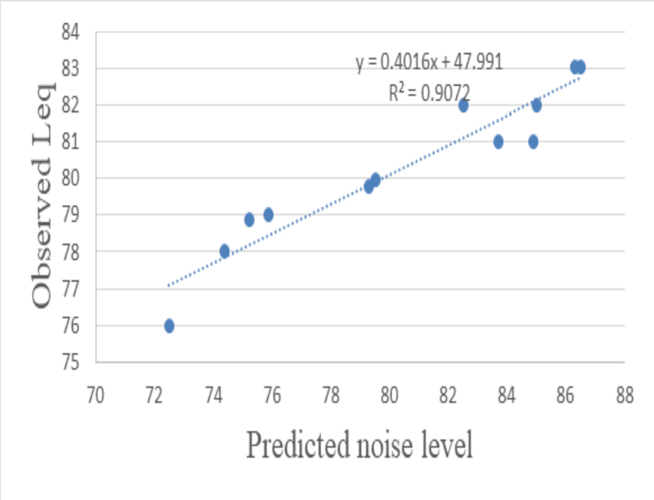
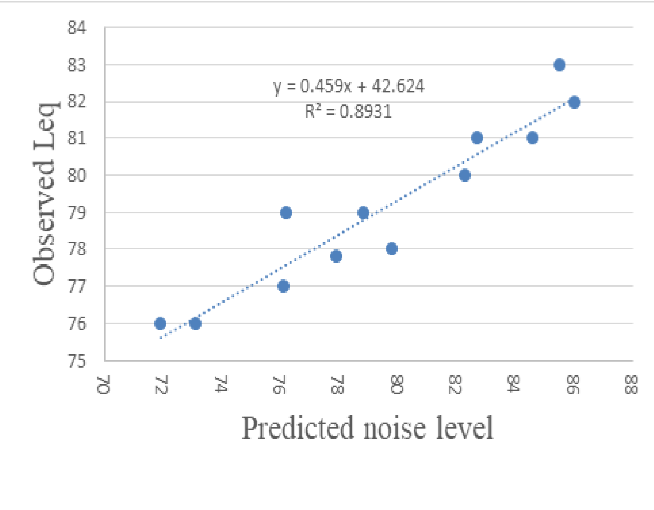


Graph 2 Noise Level Versuspredicted Noise Level for Mobil Area



Graph 3 Noise Level Versus Predicted Noise Level for Kure Market

Figures 8, 9, and 10 illustrate the validation of the urban road traffic noise prediction model using the Calixto equation for Kpakungu, Mobil, and Kure market, respectively. Strong correlation coefficients (R^2 = 0.9655, 0.9072, and 0.8931) between observed and calculated noise levels confirm the model's accuracy and reliability.

IV. CONCLUSION

This study uncovered severe traffic congestion problems along Kpakungu, Mobil, and Kure Market roads in Minna Metropolis, particularly during peak hours. Contributing factors include limited parking, narrow roadways, poor road conditions, and traffic mismanagement. Noise levels near these transit hubs exceeded recommended limits, primarily due to heavy vehicle presence, vehicle speed, and engine types. The research developed and validated the Calixto model, a predictive tool that uses total vehicle counts and the percentage of heavy vehicles to estimate noise levels (Leq). This study underscores the urgency of improving traffic management and implementing noise pollution control measures in Minna Metropolis.

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