

Assessment of Environmental Noise Pollution in Warri and Effurun Metropolitan Cities

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Abstract

Environmental noise pollution affects not only the quality of life, but it poses a serious health and social problem. The Cirrus integrating averaging sound level instrument: model CR262A was employed to determine the noise levels at the twenty-two (22) selected sampling stations. The measurement of the noise was carried out during the morning, afternoon, and evening periods, to evaluate noise pollution within the twin city. Results indicated that there is no much difference ($p > 0.05$) in the mean noise values within the different periods of the day at each sampling station, but there is significant variation ($p < 0.05$) in the mean noise values at each period of the day over all the sampling stations. The results of the noise measurement showed that Enerhen Junction and NNPC Complex recorded the highest and lowest overall noise values of 84.84 ± 5.39 dB(A) and 70.90 ± 2.98 dB(A) respectively. The results of this survey showed that the noise values at all the measurements points within Warri and Effurun metropolitan cities and at all the periods of the day is more than the Nigeria Federal Ministry of Environment (NFME) and World Health Organization (WHO) permissible limit of 55dB daily noise level criteria for residential areas. The survey requires the need to enact and enforce permissible noise levels/standards for residential neighbourhoods of 55dB by relevant environmental authorities both at Federal and state levels instead of applying 90dB standard meant for regulations in industrial settings.



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Introduction

Noise pollution, majorly a by-product of high human population density and developed industrial state, is now globally recognized as a major challenge for the quality of life in urban areas. It is becoming

progressively perpetual, yet unnoticed form of air pollution even in developed nations.

The growth in noise pollution is unsustainable because it involves direct, as well as cumulative,

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adverse health effects. It also adversely affects future generations and has sociocultural, aesthetic, and economic effects.^{1,2} The most important factors raising noise pollution in urban areas include interalia appliances, vehicular traffic, neighborhood electrical appliances, TV and music systems. Others include public address systems, railway and air traffic, garbage trucks, construction equipment, manufacturing processes, and lawnmowers and generating sets. The noise created does not affect only people, but even oneself, fall prey to the cumulative noise generated by the household equipments used daily.³ Agarwal and Swami, confirmed that the transportation sector was one of the major contributors to noise in urban areas. Hence, as a first step towards assessment of noise pollution, measurement was taken up with emphasis on traffic noise.⁴

The hike in the population and in the number of vehicles movement has led to an increase in noise pollution, but noise pollution has been considered to be no effect than other contaminants in the environment.⁵ In comparison to many other environmental issues, noise pollution continues to increase and is accompanied by an growing number of complaints from people vulnerable to the noise.

The health significance of noise pollution are: noise-induced hearing impairment; interference with speech communication; disturbance of rest and sleep; psycho-physiological as well as mental-health. Other effects are decrease of children's ability to comprehend, concentration, assimilation and performance effects; effects on residential behavior and annoyance as well as interference with proposed activities.^{6,7}

The air medium through which noise is released and moves is common to all human. Therefore People, businesses, and organizations, do not have unrestricted rights to emits noise at will, as if the resultant effects of noise were uncommon only to their private property. On the contrary, people should have obligation to use the host medium in ways that are compatible with or do not hamper other uses⁸ According to Maduemezia⁹, noise pollution is one aspect of environmental pollution that is taken rather lightly in Nigeria. He asserted that greater part of the sources of noise in the society is of a social

origin. However, noise, as a polluting agent in the environment, has been recognized in recent years as a serious threat to the quality of life enjoyed by people in most industrialized nations. In developing nations, however, noise pollution has not been seen as dangerous and having adverse effect on the life of the people.^{10,11}

World Health Organisation also state that there is evidence, that disturbed sleep causes fatigue, accidents and reduced performance (Naish *et al.*, 2012).

The effects of noise are seldom catastrophic, and are often only transitory, but adverse effects can be cumulative with prolonged or repeated exposure. Sleep disruption, the masking of speech and television, and the inability to enjoy one's property or leisure time, impair the quality of life. This is probably the reason why not much research into environmental noise pollution has been carried out within Nigeria cities. Consequently, the need for monitoring environmental noise pollution has become necessary in Warri-Effurun and environs, so that the citizens can have a better understanding of the level of noise they are daily exposed to and the health implication.

Materials and Methods

Description of the Study Area

The study was carried out in the twin city of Effurun-Warri metropolis in Delta State of the Niger Delta Region, Nigeria and is situated on lat. 5°52'0"E and Long. 5°35'0"N- (Figure 1).

The metropolis is a multicultural landscape (consisting of Urhobo, Itsekiris and Ijaws among others) with a population of 500,698.¹² The coastal city is a tourist centre with a wide range of existing potential attraction Sites and Monuments, Hospitality Centres, Festivals and Dances, in addition to its known religious tolerance.¹³ The study area is among the largest oil-producing sites in the African continent and has a sea port strategically located in the city, making it an industrialized and highly commercial city characterized with high traffic volume all year round with frequent traffic jams at market and road junction vicinities located along the major roads in the city.¹⁴

Twenty-two noise monitoring stations were carefully

selected to represent all the quarters of the study area with high noise pollution sources. The monitoring sites consist of road junctions and

markets situated along the major roads and are opened on a daily basis from morning to evening. The monitoring stations were geo-referenced using

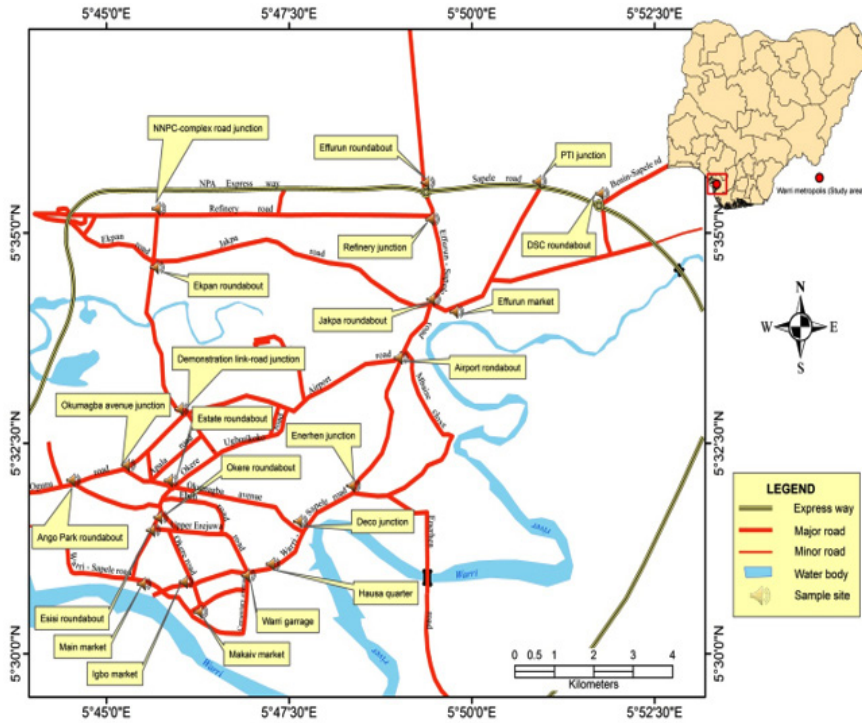


Fig. 1: A Map of Nigeria and map of Effurun-Warri showing the Sampling stations

Global Positioning System (GPS).^{15,16} Table 1 shows the monitoring stations and their respective coordinates.

Calibrator is a small, battery driven device and has a standard sound level of 94 dB with an accuracy of ± 0.5 dB.¹⁷

Cirrus Integrating Averaging Sound Level Meter: Model CR262A

Cirrus Sound Level Meter

Model CR262A is a type II, portable direct noise measuring device according to IEC 60651 specifications. It is an integrating averaging sound level hand-held meter with 35–130 dB(A) as a measuring range. The instrument is fitted with microphone interface that responds to sound pressure from the acoustic source and transforms it into an electric signal which can be interpreted by the measuring instrument.

Noise Measurement Procedure

The measurements were made at street level (at market centres' road junctions and passenger loading parks). It was a typical walk-through surveys with the Sound Level Meter (SLM) held comfortably well away from the body at a distance of about 2.0 m above the ground level with the microphone pointed horizontally to the surrounding noise sources.¹⁸

The sound meter was calibrated by a calibrator as defined by IEC 60942 for checking the accuracy of the hand-held indicating instruments. The

A-weighted instantaneous sound pressure level (L_{Ai}) measurements were taken for a period of 10 minutes per station per day for one week, (bringing the total period of reading to 70 minutes per sampling station). This procedure was carried out for morning (6:00–8:30 a.m.), afternoon (12:00–2:30 p.m.) and evening (5:00–7:30 p.m.) measurements.¹⁹

Table 1: Sampling stations and their coordinates and descriptions

| S/ N | Name of Station | Elevation | Coordinate | Description of the measurement station |
|---------|-------------------------|-----------|----------------------------------|---|
| 1 | DSC Roundabout | 12 | N 05° 34'15.8" E 05° 48'33.0" | One of the major gateway roundabouts to the study area. Surrounded by filling stations and other businesses |
| 2 | PTI junction | 11 | N 05° 34'23.6" E 05° 47'59.5" | PTI junction is surrounded by PTI school on the south and has road side shops including shops for musicals. |
| 3 | Effurun market | 6 | N 05° 33'22.3" E 05° 47'18.3" | Market Site along PTI road, Effurun. It has high density and traffic jam. It hosts a lot of shops for musicals. |
| 4 | Jakpa round about | 8 | N 05° 33'21.9" E 05° 47'06.0" | Jakpa roundabout is a major traffic junction. It has high traffic jam, many musical shops and high pedestrian. |
| 5 | Effurun roundabout | 11 | N 05° 34'10.3" E 05° 47'04.6" | The major gateway roundabout to the study area. It has a high traffic and some businesses. |
| 6 | Refinery junction | 11 | N 05° 34'10.5" E 05° 47'04.6" | Traffic junction near Navy yard Effurun. It is a link to refiner road from Effurun-Sapele Road. |
| 7 | Airport junction | 12 | N 05° 32'51.7" E 05° 46'48.0" | The site is a major traffic junction. It has high traffic jam, many musical shops. It is near mother of redeemer catholic church. |
| 8 | Enerhen junction | 9 | N 05° 31'42.9" E 05° 46'25.7" | It is a major traffic junction along Effurun-Sapele. It has high traffic jam, many musical shops and high pedestrian daily. |
| 9 | Deco junction | 10 | N 05° 31'31.0" E 05° 45'59.1" | The station is a traffic junction. It has lot of musical shops and high pedestrian. Is located along Warri-Sapele |
| 10 | Hausa Quarters | 11 | N 05° 31'03.7" E 05° 45'46.2" | Most busy market in the study area along warri-Sapele road. It is an activity area with high daily traffic jam. |
| 11 | Warri Garage | 16 | N 05° 30'57.4" E 05° 45'27.8" | Warri garage site is along Warri-Sapele road. It has a motor park and many road side businesses. |
| 12 | Makaiva Market | 11 | N 05° 30'38.8" E 05° 45'62.4" | Relatively busy market in the study area behind warri stadium. It is an activity area with high traffic. |
| 13 | Igbo market | 11 | N 05° 30'50.9" E 05° 44'59.5" | Relatively busy market in the study area along warri-Sapele road. It is an activity area with high traffic. |
| 14 | Main market | 11 | N 05° 30'49.4" E 05° 44'44.7" | Relatively busy market in the study area along warri-Sapele road. It is an activity area with high daily traffic jam. |
| 15 | Esisiroundabout | 12 | N 05° 31'29.3" E 05° 44'40.2" | This site is created along E sisi road at E sisi GRA. It has scanty shops. |
| 16 | Okere roundabout | 14 | N 05° 31'34.0" E 05° 44'40.9" | The station is a traffic junction. It has high traffic jam, musical shops and high pedestrian. Is located near Okere prison. |
| 17 | Estate roundabout | 10 | N 05° 31'45.6" E 05° 44'46.6" | The station is a major traffic junction. It has high traffic jam, musical shops and high pedestrian. Is located along Avenue Rd. |
| 18 | OkumagbaAv. Junction | 9 | N 05° 31'53.4" E 05° 44'24.2" | The site is created along Airport road close Total Filling Station. The site is relatively free of traffic jam. |
| 19 | Ango park roundabout | 10 | N 05° 31'46.4" E 05° 43'55.1" | The site is a traffic junction that is relatively free along Airport road. There are a lot of business shops around it |
| 20 | Demonstration link Road | 11 | N 05° 32'22.2" E 05° 44'51.3" | The site is a traffic junction along Airport road surrounded by delta career college and college of education, Edjeba. |
| 21 | Ekpan roundabout | 10 | N 05° 33'43.1" E 05° 44'37.0" | This site near shrine and primary school at Ekpan. It is surrounded by business operators including musical shops. |
| 22 | NNPC Complex Road | 13 | N 05° 34'08.5" E 05° 44'39.3" | The site is a traffic junction that is relatively free, but busy sometimes especially at resumption an closure of NNPC workers |

Analysis of Variance (ANOVA) was used as a statistical tool to analyse the data obtained from the noise measurement at 95% confidence level.

for residential environment and the mean noise level value for the control station (Oha Community) of 54.66 dB(A).²⁰

Result and Discussion

The results of the noise level measured in decibel {dB(A)} at 22 strategic locations at different periods of the day (morning, afternoon and evening) in Effurun and Warri metropolitan cities, Delta State, Nigeria, shows that even the lowest noise level value recorded at NNPC Complex Road (72.12 dB(A)) is more than the WHO limit of 55 dB(A)

Morning Period

The result of the noise level for the morning period in Warri-Effurun metropolis (Table 2 and Figure 2) below shows that, Delta Steel Company (DSC) roundabout had an average noise level of 75.04±6.59 dB(A). The summary of noise level measurements for the morning period, shows that Hausa Quarters

Table 2: The values for average, minimum and maximum noise level in dB(A) during morning period

| S/N | Sampling Sites | Morning | | |
|--------------------|-------------------------|------------|------------|-------------|
| | | Average | Min. | Max. |
| Noise level, dB(A) | | | | |
| 1 | DSC Roundabout | 75.04±6.59 | 63.07±4.47 | 91.09±7.44 |
| 2 | PTI Junction | 76.60±6.82 | 63.74±3.75 | 93.40±5.14 |
| 3 | Effurun Market | 78.10±6.92 | 68.56±2.70 | 93.14±5.17 |
| 4 | Jakpa Roundabout | 78.94±5.28 | 69.43±3.49 | 93.91±7.75 |
| 5 | Effurun Roundabout | 77.77±5.83 | 67.54±3.12 | 94.97±6.41 |
| 6 | Refinery Junction | 77.40±4.15 | 64.87±5.00 | 88.93±4.93 |
| 7 | Airport Junction | 80.86±6.91 | 69.11±6.49 | 96.47±6.79 |
| 8 | Enerhen Junction | 82.14±5.26 | 71.77±6.59 | 100.16±6.52 |
| 9 | Deco Junction | 76.29±6.83 | 66.24±5.62 | 91.16±4.72 |
| 10 | Hausa Quarter | 84.60±3.33 | 71.47±7.83 | 97.20±5.26 |
| 11 | Igbo Market | 74.97±4.23 | 64.89±3.50 | 92.41±5.62 |
| 12 | Warri Garage | 76.73±6.98 | 65.39±4.83 | 90.67±6.07 |
| 13 | Makaiva Market | 74.29±6.78 | 63.84±5.38 | 90.21±6.49 |
| 14 | Main Market | 75.99±5.15 | 64.66±1.77 | 91.37±3.90 |
| 15 | Esis Roundabout | 74.90±5.25 | 64.36±4.22 | 88.77±3.97 |
| 16 | Okere Roundabout | 76.30±3.71 | 63.91±2.85 | 88.49±1.74 |
| 17 | Estate Roundabout | 78.24±3.27 | 65.74±5.89 | 95.31±4.37 |
| 18 | Okumagba Av. Junction | 75.04±4.44 | 62.54±2.43 | 92.16±7.41 |
| 19 | Ango park Roundabout | 72.16±1.83 | 61.73±1.85 | 87.81±3.56 |
| 20 | Demonstration Link Road | 72.84±4.81 | 59.03±3.40 | 87.36±3.05 |
| 21 | Ekpan Roundabout | 74.34±4.13 | 61.59±4.58 | 88.40±2.03 |
| 22 | NNPC Complex Junction | 72.70±3.23 | 59.17±2.05 | 90.39±2.82 |

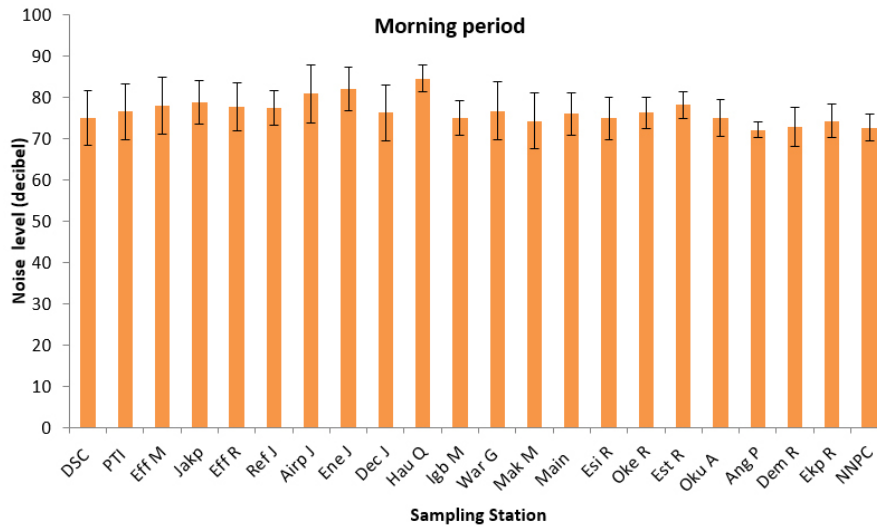


Fig. 2: The average noise level values for the morning period of the 22 sampling stations

recorded the highest value of 84.60±3.33 dB(A), while Ango park roundabout had the lowest value of 72.16±1.83 dB(A).

Afternoon Period

The result of the noise measurement during the

afternoon period (Table 3 and Figure 3) shows that the mean noise level values of 75.01±4.90 dB(A), 79.76±4.36 dB(A) and 73.03±4.49 dB(A) were recorded for Okere roundabout, Estate roundabout and Okumagba Avenue junction respectively. On the overall, the afternoon measurement shows that Enerhen Junction recorded the highest value

Table 3: The values for average, minimum and maximum noise level in dB(A) during Afternoon period

| S/N | Sampling Sites | Afternoon | | |
|--------------------|--------------------|------------|------------|-------------|
| | | Average | Min. | Max. |
| Noise level, dB(A) | | | | |
| 1 | DSC Roundabout | 73.71±4.99 | 63.20±5.87 | 91.09±7.44 |
| 2 | PTI Junction | 77.76±5.91 | 67.13±7.54 | 93.40±5.14 |
| 3 | Effurun Market | 80.31±4.07 | 67.14±4.79 | 93.14±5.17 |
| 4 | Jakpa Roundabout | 79.96±4.98 | 67.96±3.75 | 93.91±7.75 |
| 5 | Effurun Roundabout | 78.26±6.07 | 68.00±7.91 | 94.97±6.41 |
| 6 | Refinery Junction | 75.80±5.48 | 63.34±3.33 | 88.93±4.93 |
| 7 | Airport Junction | 79.81±6.02 | 65.90±2.94 | 96.47±6.79 |
| 8 | Enerhen Junction | 83.70±4.89 | 72.14±6.22 | 100.16±6.52 |
| 9 | Deco Junction | 76.97±4.53 | 64.64±6.01 | 91.16±4.72 |
| 10 | Hausa Quarter | 83.27±4.87 | 70.96±4.23 | 97.20±5.26 |
| 11 | Igbo Market | 77.14±5.25 | 65.51±5.98 | 92.41±5.62 |
| 12 | Warri Garage | 78.31±6.13 | 65.87±5.25 | 90.67±6.07 |
| 13 | Makaiva Market | 73.44±5.44 | 62.04±5.46 | 90.21±6.49 |
| 14 | Main Market | 76.34±3.45 | 64.56±2.58 | 91.37±3.90 |

| | | | | |
|----|-------------------------|------------|------------|------------|
| 15 | Esi Roundabout | 75.03±5.05 | 62.90±5.11 | 88.77±3.97 |
| 16 | Okere Roundabout | 75.01±4.90 | 62.23±5.24 | 88.49±1.74 |
| 17 | Estate Roundabout | 79.76±4.36 | 65.59±3.85 | 95.31±4.37 |
| 18 | Okumagba Av. Junction | 73.03±4.49 | 62.20±4.78 | 92.16±7.41 |
| 19 | Ango park Roundabout | 73.74±3.85 | 60.11±4.35 | 87.81±3.56 |
| 20 | Demonstration Link Road | 71.97±2.45 | 59.04±0.33 | 87.36±3.05 |
| 21 | Ekpan Roundabout | 76.66±4.81 | 63.64±5.83 | 88.40±2.03 |
| 22 | NNPC Complex Junction | 70.90±2.98 | 60.20±3.99 | 90.39±2.82 |

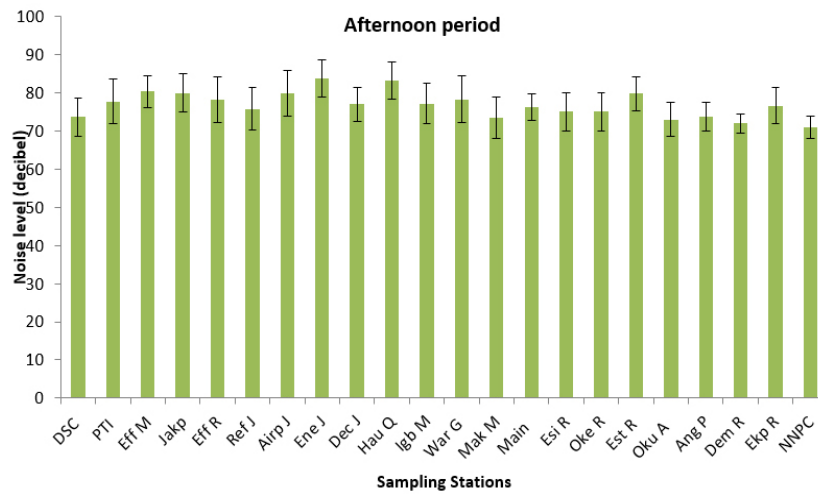


Fig. 3: The average noise level values for the afternoon period of the 22 sampling stations

of noise level [83.70±4.89 dB(A)], while NNPC Complex Junction had the lowest value of noise level [70.90±2.98 dB(A)] during the period under review

Evening Period

The result of the environmental noise assessment within the study area during the evening period (Table 4 and Figure 4) showed that DSC roundabout

had an average noise level of 76.80±7.37 dB(A), while 78.97±5.92 dB(A) was recorded for PTI junction station. The Enerhen junction and Hausa Quarters sampling stations recorded the highest and second to the highest mean noise level during the evening measurement with values of 84.84±5.39 dB (A) and 83.90 ±5.36 dB (A) respectively. The least and second lowest average noise level were

Table 4: The average, minimum and maximum noise values in dB(A) during the evening period

| S/N | Sampling Sites | Evening | | |
|--------------------|--------------------|------------|------------|------------|
| | | Average | Min. | Max. |
| Noise level, dB(A) | | | | |
| 1 | DSC Roundabout | 76.80±7.37 | 67.84±5.78 | 93.79±9.48 |
| 2 | PTI Junction | 78.97±5.92 | 65.99±8.39 | 95.24±4.69 |
| 3 | Effurun Market | 82.84±5.01 | 71.10±5.23 | 96.69±4.71 |
| 4 | Jakpa Roundabout | 81.39±5.36 | 70.36±3.42 | 96.16±7.26 |
| 5 | Effurun Roundabout | 78.04±4.83 | 68.53±3.68 | 93.23±5.85 |

| | | | | |
|----|-------------------------|------------|------------|-------------|
| 6 | Refinery Junction | 78.33±4.97 | 70.63±6.10 | 91.26±7.83 |
| 7 | Airport Junction | 81.69±5.26 | 69.33±5.38 | 93.16±5.31 |
| 8 | Enerhen Junction | 84.84±5.39 | 72.47±7.25 | 98.41±6.99 |
| 9 | Deco Junction | 78.90±4.90 | 69.46±6.79 | 93.77±6.87 |
| 10 | Hausa Quarter | 83.90±5.36 | 72.39±3.64 | 101.27±5.28 |
| 11 | Igbo Market | 77.54±4.25 | 69.01±3.22 | 95.57±4.45 |
| 12 | Warri Garage | 78.67±5.49 | 67.80±3.85 | 96.01±5.05 |
| 13 | Makaiva Market | 74.30±4.05 | 67.83±5.95 | 88.09±2.61 |
| 14 | Main Market | 77.30±4.37 | 65.81±5.73 | 91.46±3.04 |
| 15 | Esis Roundabout | 75.64±4.41 | 64.80±7.27 | 90.54±6.38 |
| 16 | Okere Roundabout | 77.29±3.07 | 66.54±5.98 | 93.09±6.55 |
| 17 | Estate Roundabout | 80.19±4.27 | 68.49±3.21 | 96.00±4.89 |
| 18 | Okumagba Av. Junction | 74.71±4.97 | 63.69±4.43 | 87.93±4.60 |
| 19 | Ango park Roundabout | 73.63±4.09 | 66.76±5.35 | 87.89±4.57 |
| 20 | Demonstration Link Road | 72.74±3.97 | 63.79±4.49 | 88.07±1.66 |
| 21 | Ekpan Roundabout | 76.50±4.95 | 64.09±3.56 | 90.11±3.54 |
| 22 | NNPC Complex Junction | 72.77±4.29 | 63.86±6.16 | 95.41±6.12 |

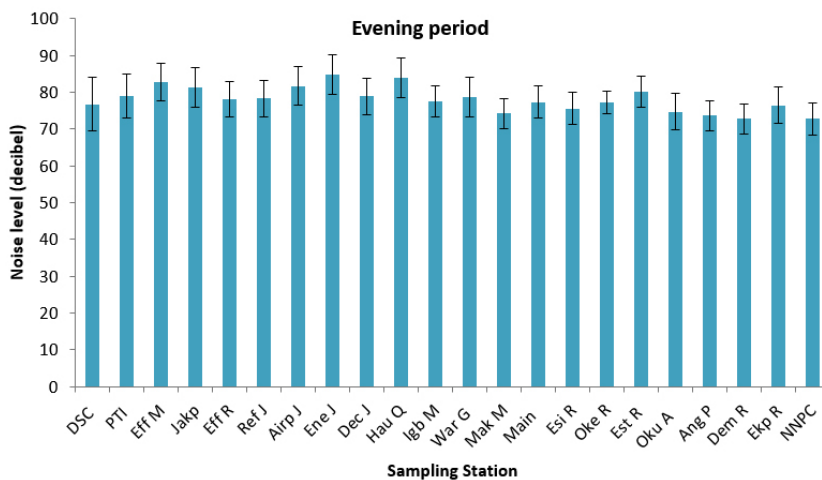


Fig. 4: The average noise level values for the evening period of the 22 sampling stations

recorded at Demonstration Link Road and NNPC Complex Junction with values of 72.74±3.97 dB(A) and 72.77±4.29 dB(A) accordingly.

Diurnal Comparison at Each Station

When the average noise levels per station are examined across different periods of the day, one could say that the values are not the same. However, the statistical analysis (ANOVA) of the result (Table 5, and Figure 5) affirms that there is no much differences ($p > 0.05$) between the average noise levels at varied periods (morning, afternoon and evening periods) of the day, when all the stations are considered individually.

Diurnal Comparison at all the Stations

The result of the statistical test using ANOVA also indicated that there is a significant difference at ($p < 0.05$) of average noise level for different stations at a particular period of time.

Morning Period

The post hoc statistical analysis using Duncan multiple range shows that the morning period has four (4) different groups of stations that have no considerable difference ($p > 0.05$) in their average noise values. The Group I, II, III and IV have an average noise level values ranges of 72.16dB(A) to 78.94dB(A), 74.29dB(A) to 80.86dB(A), 75.99dB(A)

to 82.14 dB(A) and 78.94dB(A) to 84.60 dB(A) respectively. The groups also have 19, 17, 12 and 4 numbers of stations respectively.

multiple range shows that the afternoon period has six (6) different groups of stations that have no much difference ($p>0.05$) in their average noise values.

Afternoon Period

The post hoc statistical analysis using Duncan

Evening Period

The post hoc statistical analysis using Duncan multiple range shows that the evening period has

Table 5: The combined mean noise level values for the morning, afternoon and evening periods

| S/N | Sampling Sites | Morning | Afternoon | Evening | P-Value |
|-----|-------------------------|------------------|------------------|------------------|---------|
| | | $\bar{x} \pm SD$ | $\bar{x} \pm SD$ | $\bar{x} \pm SD$ | |
| 1 | DSC Roundabout | 75.04±6.59 | 73.71±4.99 | 76.80±7.37 | P>0.05 |
| 2 | PTI Junction | 76.60±6.82 | 77.76±5.91 | 78.97±5.92 | P>0.05 |
| 3 | Effurun Market | 78.10±6.92 | 80.31±4.07 | 82.84±5.01 | P>0.05 |
| 4 | Jakpa Roundabout | 78.94±5.28 | 79.96±4.98 | 81.39±5.36 | P>0.05 |
| 5 | Effurun Roundabout | 77.77±5.83 | 78.26±6.07 | 78.04±4.83 | P>0.05 |
| 6 | Refinery Junction | 77.40±4.15 | 75.80±5.48 | 78.33±4.97 | P>0.05 |
| 7 | Airport Junction | 80.86±6.91 | 79.81±6.02 | 81.69±5.26 | P>0.05 |
| 8 | Enerhen Junction | 82.14±5.26 | 83.70±4.89 | 84.84±5.39 | P>0.05 |
| 9 | Deco Junction | 76.29±6.83 | 76.97±4.53 | 78.90±4.90 | P>0.05 |
| 10 | Hausa Quarter | 84.60±3.33 | 83.27±4.87 | 83.90±5.36 | P>0.05 |
| 11 | Igbo Market | 74.97±4.23 | 77.14±5.25 | 77.54±4.25 | P>0.05 |
| 12 | Warri Garage | 76.73±6.98 | 78.31±6.13 | 78.67±5.49 | P>0.05 |
| 13 | Makaiva Market | 74.29±6.78 | 73.44±5.44 | 74.30±4.05 | P>0.05 |
| 14 | Main Market | 75.99±5.15 | 76.34±3.45 | 77.30±4.37 | P>0.05 |
| 15 | Esisi Roundabout | 74.90±5.25 | 75.03±5.05 | 75.64±4.41 | P>0.05 |
| 16 | Okere Roundabout | 76.30±3.71 | 75.01±4.90 | 77.29±3.07 | P>0.05 |
| 17 | Estate Roundabout | 78.24±3.27 | 79.76±4.36 | 80.19±4.27 | P>0.05 |
| 18 | Okumagba Av. Junction | 75.04±4.44 | 73.03±4.49 | 74.71±4.97 | P>0.05 |
| 19 | Ango park Roundabout | 72.16±1.83 | 73.74±3.85 | 73.63±4.09 | P>0.05 |
| 20 | Demonstration Link Road | 72.84±4.81 | 71.97±2.45 | 72.74±3.97 | P>0.05 |
| 21 | Ekpan Roundabout | 74.34±4.13 | 76.66±4.81 | 76.50±4.95 | P>0.05 |
| 22 | NNPC Complex Junction | 72.70±3.23 | 70.90±2.98 | 72.77±4.29 | P>0.05 |

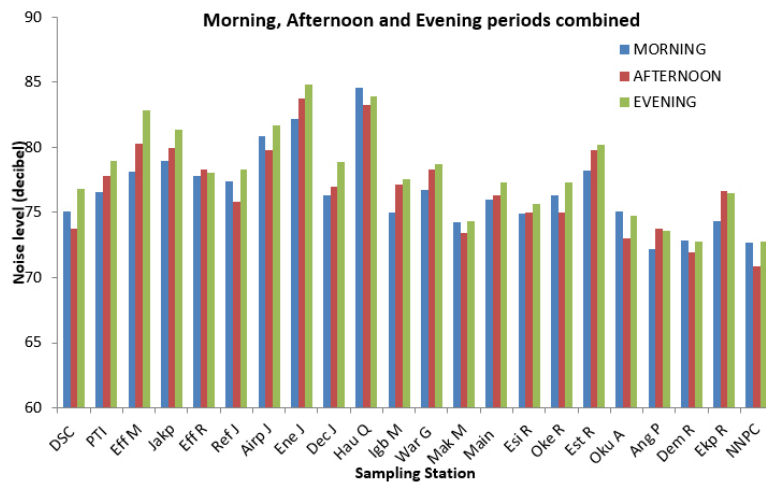


Fig. 5: The average noise level values for the morning, afternoon and evening period of the 22 sampling stations

Key: Abbreviations for Figure 1-4

| | | | | | |
|--------------|--------------------|--------------|-----------------------|--------------|-------------------------|
| DSC | DSC Roundabout | Ref J | Refinery Junction | Igb M | Igbo Market |
| PTI | PTI Junction | AirpJ | Airport Junction | War G | Warri Garage |
| Eff M | Effurun Market | Ene J | Enerhen Junction | Mak M | Makaiva Market |
| Jakp | Jakpa Roundabout | Dec J | Deco Junction | Main | Main Market |
| Eff R | Effurun Roundabout | Hau Q | Hausa Quarter | Esi R | Esi Roundabout |
| Ekp R | Ekpan Roundabout | Est R | Estate Roundabout | Dem R | Demonstration Link Road |
| Oke R | Okere Roundabout | Oku A | Okumagba Av. Junction | NNPC | NNPC Complex Junction |
| Ang P | Angoark Roundabout | | | | |

six (6) different groups of stations that have no significant difference exist ($p>0.05$) in their average noise values.

The research work also revealed that there was general decrease in noise pollution levels in Warri and Effurun in 2012 from the previous available data. For example, average noise level values of 107 dB(A) and 95 dB(A) as recorded for Enerhen and Estate junction by Rim-Rukeh 21 are far higher than the current average values of 84.84 dB(A) and 80.19 dB(A) in 2012, for the same sampling stations respectively. The noise reduction is attributed to a new policy promulgated by Delta State Government that stopped the operation of commercial motor bikes (Okada) in some selected cities in the state including the study area (Warri and Effurun) around November, 2012. This is in line with a study conducted in Sweden which showed that Road traffic noise constituted by far the largest (accounts for about 78 per cent) portion of Urban environmental noise pollution.^{22,23}

Findings

The findings of the study are as follows:

- Significant difference ($p<0.05$) in the average noise values at each period (morning or afternoon or evening) of the day over all the sampling stations.
- Morning period: Hausa quarters have the highest noise level of 84.60+3.33 dB(A), while Ango park Roundabout records lowest of 72.16+1.83 dB(A).
- Afternoon period: Enerhen Junction recorded highest noise level of 83.70+4.89 dB(A) and lowest of 70 .90+2.98 dB(A) obtained for

NNPC Complex Junction.

- Evening period: Enerhen Junction and Demonstration Link Road recorded 84.84+5.39 dB(A) and 72.74+3.97 dB(A) for highest and lowest respectively.
- The noise level values in Warri and Effurun metropolitan cities exceeded World Health Organisation (WHO) limit of 55dB daily noise level criteria for residential areas at all the measurement points and far above the average value of the control of 54.66 dB.
- No significant difference exist ($p>0.05$) in the average noise level values at a particular sampling station over the periods (morning, afternoon and evening) of the day.

Conclusion

The high noise level recorded at the 22 strategic locations within the study area (Effurun and Warri) pose a significant health hazard to the residents. Therefore Government Authorities at various level should put legislative framework in place to protect the growing population of the residents in Effurun and Warri against the high health risk and other effects of environmental noise pollution.

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