Original Research Article

Spatio-Temporal Analysis of Noise Levels across Hotspot Areas in Port Harcourt Metropolis, Rivers State, Nigeria

Abstract

This study examinedspatial and temporal variations of noise levels across hot spot areasin Port Harcourt metropolis, Rivers State Nigeria.It employed a quasi-experimental design. The noise level was captured using Mobile Application known as decibel (dB) X in infinix note 3 android smart phone, which was calibrated with a digital noise meter SET 1350, with a measuring level range of 20–120 decibel while the sampling points were captured with the use of handheld Global Positioning System (GPS) Garmin 78sc which was calibrated to UTM zone 32N. The Geographic Information System (GIS) was the main tool inmanipulatingsurface prediction modeling Inverse Distance Weighting (IDW)in the morning and evening noise levelsusing Environmental Science Research Institute's (ESRI) software ArcGIS 10.4 version. In the twelve areas investigated, two sample points were captured in each, making a total of twenty four points. Analyses was done using ANOVA and t-test for the hypotheses and the finding of the results in mean noise levels in the morning and evening indicate that there were no statistical significant difference in the noise level as P =.89 and$P$ =.124 respectively while the t-test indicates statistical significant difference in the majority of the hotspot areas. Therefore,hypotheses of significant mean noise levels were accepted. The finding of the IDW reveals that noise pollution occurs in the morning than in the evening periods in most areas, as they exceed the allowable noise limit of WHO standardis 85 dB (A).Based on the findings, the studyrecommended among others: that noise pollution planning controls should not be compromised but operates at higher dimension through planting of trees and monitoring in order to ensure strict compliance.

Key words: Noise level, Spatio-temporal and Hotspot, IDW.

1. INTRODUCTION

There are several concepts about noise, depending on individual perception,though, what may be regarded as noise may differ from individual to individual,while pollution is generally regarded as disturbance of an element to the individual health,noise is one of the environmental pollution ofthe urban areas when it exceeds a particular limit standard which can cause numerous damages to human physiological and psychological wellbeing such as:irritability, stress, anxiety and finally interference with verbal communication and reduction in working efficiency (Ahamad, Abbas, and Reem [1]; Ugwuanyi, Ahemen and Agbendeh [11]. However, as an area grows and develops, it becomes environmentally vulnerable to factors such as:noise pollution, air pollution and water pollution. According to Ebeniro and Abumere [4],environmental noise is an unwanted acoustic signal or sound dumped into the environment without regard of its adverse effect on both man and the environment and it is mostly associated with unplanned cities of the world where structures such as: buildings, roads and industries among others are sited without proper

consideration or design. In the same vein, Khaki and Forouhid [5] affirmed that environmental noise is also caused by uncontrolled pollution growth together with industrial and technological development mostly for the urban population in the large cities.

Again, noise is an unavoidable element within and around our environment, but when it becomes excessive to our ears as a result of human activities it becomes hazardous to our health.It is on the basis of this, that several laws or standards are adopted by different agencies in countries in order to maintain relative peace or calmness in the environment. When noise generation in an environment exceeds allowable limit, it is then regarded as noise pollution. The level or rate at which sound or noise is produced is determined by the loudness, frequencies and periods among others and it is dependent on thephysical sound pressure measured in decibels (dB). It is pertinent to ascertain various spatial point levels of noise sources so that the inhabitants of a given environment and the public in general will be able to realize the levels at which noise is produced so as to provide adequate mechanisms for reduction of noise to permissible limits.

The problems associated to noise pollution are numerous, as it is theoutcome of several factors,especially emanating from anthropogenic activities within and around the urban environment such as traffic and public address system mostly. The health implication of noise pollution cannot be over emphasized as it is considered as an element that affects the quality of life (Mansouri, and Ghasenkhani [6].

In Port Harcourt metropolis, the case is not different as thequality of lives isaffectedowingto the nature of the environment which is one of the most highly industrialized metropolises in Nigeria. Perhaps, it may be the reason for such undesirable nuisance (noise pollution) occurrence.This is evidenced in some parts of Port Harcourt metropolis, especially around major commercial hubs such as:Rumuokoro, Oil Mill, as well as Mile 3, Waterlines, Trans-Amadi Industrial Layout among others.The reason could probably be due to inadequate information on the consequences of noise pollution on humans as well as inappropriate planning, especially in Nigeria as well asother third world countries. Therefore, necessary steps should be adopted to restrain this element so that people can have a better living environment.

This paperaddressed the following questions: Does noise level vary across points or areas in Port Harcourt metropolis?Does noise level vary with time in the study area?Thispaper aims at assessing various noiselevelsacross hotspot areas in Port Harcourt metropolis,Rivers State, with the followingobjectives:to examine spatial variation of noise level, to analyze noise distribution and generate noise pollution map in the study area.

1.1 Study Area

Historically, Port Harcourt is the capital of Rivers State in Nigeria. It is a Port town lying along the Bonny River which was named after "Lewis Harcourt" a former colonial secretary's surname as a way of immortalizing him. It is a metropolis covering eight local government areas, with the main city being Port Harcourt City and Obio/Akpor which was aggregated thereafter and is the extent to which the research covers McKenna [7].

It is located within latitude $04^{o}42'$ and 04^{o} 55'N and longitude $06^{o}52'$ and 07^{o} 10'E and is surrounded by seven local governments, which are Ikwerre, Etche, and Oyigbo on the northern

part, Eleme on the eastern part, Okrika and Degema on the southern part and finally Emohua on the western part of Rivers State. It is one of the popular cities in Nigeria that is located in the southern Nigeria and the traditional inhabitants of the people are the Ikwerre people. The primary activities of the people are farming and fishing. According to a sample survey conducted by the Federal Ministry of Agriculture and Natural Resources in 1983 that forty per cent of the people are farmers. The main root crops are yam, cassava and cocoyam; while the grains are maize, and beans. Other crops grown for food include vegetables, melon, pineapples and plantain. The major cash crops are: oil palm products, rubber, raffia palmandcoconut. The climate is dominated with rainy season with about 182 rainy days in a year. The mean maximum monthly temperatures range from 28^{o}C to 33^{o}C.The mean monthly temperature is in the range of 25°C to 28°C. The mean annual temperature for the State is 26°C. The hottest months are February to May. The difference between the dry season and wet season temperatures is only about 2°C. Relative humidity is high in the State throughout the year and decreases slightly in the dry season (World Weather Information Service Port Harcourt, 2016 [13]).

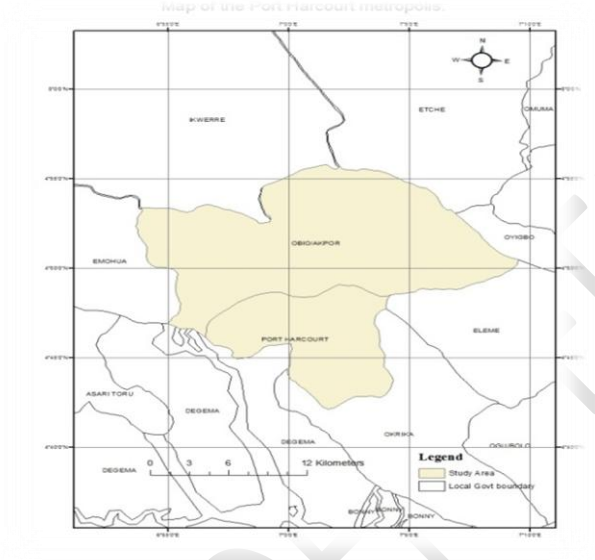

Figure 1. The Study Area
Source: GIS Unit, University of Port Harcourt.

2. Literature review

This section critically reviews some literatures on the concepts of hotspot and noise pollution.The use of the word ‘hotspot’ appears first in a seminal work by the noted conservation scientist and activist Norman Myers in 1988. Then, he was concerned with saving endemic plant species unique to tropical forests, not biodiversity per se, but he made the case that densities of endemic species are particularly high in tropical forests, and, therefore, such sites should be given priority in conservation efforts. In this first attempt, Myers identified ten specific regions of tropical forests he designated as hotspots which possessed exceptionally high levels of endemic plants and were threatened with significant habitat loss Van Dyke [12]. There are several definitions or meanings of hotspots, but in this context, hotspots are areas with high level of

concentration of anthropogenic activities that constitutes noise especially from public address system, traffic and communication gadgets among others within the urban environment.

In a study by Concha-Barrientos, M., Campbell-Lendrum and Steenland K [3], a quantitative risk assessment approach was adopted to assess environmental burden of disease caused by environmental noise. The peril appraisal was identified as hazards. The method used was numerical meta-analyses appraisal exposure response relationships between community noise and cardiovascular, cognitive impairment and sleep disturbance among others. The results of their study revealed to a great extent that epidemiological works are linked to population vulnerability to environmental noise with respect to health implications.

Khaki and Forouhid (5) in their study titled Estimate of the noise pollution and the amount of air pollutions with simulation of road traffic in Tehran, Iran revealed that most common noise pollution problem is resulting from uncontrolled population growth together with industrial, technological development and road traffic. The methods of the research used routes map of the study area to investigate traffic changes so as to estimate the noise levels and air pollution which they asserted that it is better to determine the traffic volumes in order to study the level of noise pollution. The results of their study revealed thatnoise level in the study area is higher than the standard and they recommended that attention should be paid to the following points to prevent or reduce noise pollution caused by vehicles which has destructive effects on human health such as physical damage inflicted on the hearing system thereby reducing the lifetime.The use of sound insulation in buildings are important in order to have a desirable sound levels, Correct traffic signal timing at the intersection of forked road, the use of plant cover and suitable green spaces in building construction so as to reduce noise pollution.

Serkan, Murat and Hasan [10] in their workDetermination of the Noise Pollution on University CampusesAtaturk, Turkey, revealed that noise pollution is among environmental problems associated to proximity to school campuses with the increase in vehicular noise levels and it implication in learning performance. In the result of their testing, their study measured the levels of noise pollution on the Ataturk University campus. In methods of mitigation,they adopted the principles of campus planning in order to reduce noise pollution in the areas tested for newly founded universities in Turkey and other areas of the world. The scope of their work was limited to twelve (12) different locations of the University faculties where there is dense population of vehicular traffic flow and streets where there is relative less traffic. The selection of the location for measurement was done using two principles: sites that have proximity toservice buildings and sites for movements of vehicles. Measurement of noise were done using Cell 254 K2 model device, 1.2m above the ground and 3m away from the noise source in the morning, noon and evening periods, the value of their reading was converted to Leq units and analyzed with variance and Duncan multiple comparison tests. Also modeling of noise levels was carried out using ArcGIS 9.1 software which Inverse Distance Weighted (IDW) is embedded for interpolation. Their result revealed that average noise levels were above the allowable limits of 55 dB(A) and the mean noise levels measured at all sites was 62.70 dB(A) which exceeded the allowable value of 7.7 dB(A). The mean values of the morning, noon, and evening measurements are similar, measuring 62.65 dB(A), 62.51 dB(A), and 62.95 dB(A) while on the model that shows the sampling points of the noise in the campus, their study indicated that the prevalent range of noise values on the map of the campus is 55 - 65dB(A) and they

recommended that newly founded universities implement their study so to achieve low levels of noise on campuses.

Omubo-pepple, Briggs-kamara and Tamunobereton-Ari [8] carried out a research on noise pollution in Port Harcourt metropolis. The study represented a cross section of different age groups, sex, geography, educational levels, and income levels across the residents of the metropolis. Their data were collected by using a structured questionnaire blended with suitable open-ended questions. The statistical tools used for their analysis was percentage and cross-classifications on sources of noise, effects of noise, reaction to noise, and suggestions to control noise in terms of age as well as sex. It was found out that generators, automobiles and public address systems (loudspeakers) turn out to be the major sources of noise pollution. That loudspeakers and generators are frequently used for religious and social functions and have caused more harm than the benefits. The study further stated, that despite the evidence of medical, social, and economic effects of noise, as a society, we continue to suffer from the same inertia with its consequent effects such as hearing loss, sleep disruption, cardiovascular disease, social handicaps, reduce productivity, impaired teaching and learning among others. The study recommended improved methods of local control that should include public education, enlightenment, legislation, and active enforcement of noise ordinances. Government and NGOs can play a significant role in the process.

Oyedepo and Saadu [9] conducted a study titled: A statistical Analysis of the Day-time and Night-time Noise Levels in Ilorin Metropolis, Nigeria. Their research was based sound level measurements carried out in 42 different locations in the morning, afternoon, evening and night periods. The instruments used for their field measurements consists of sound level meter according to IEC 651, ANSI S1.4 type), 1/2- in. condenser microphone and 1/3-octave filter with frequency range and measuring level range of 31.5 Hz-8 KHz and 35-130 dB.The instruments were calibrated by the internal sound level calibrator and all were complied with IEC standards. The instrument was held comfortably in hand with the microphone pointed at the suspected noise source at a distance not less than 1m away from any reflecting object. LAi (A-weighted instantaneous Sound pressure level) measurements were recorded at intervals of 30 sec for a period of 30 min, giving 60 m readings per sampling location. The result of their statistical analysis conducted on the day-time noise levels and night-time noise levels revealed that the noise levels differ significantly in the two periods ($P<.5$) and also their research further revealed that there is significance difference in noise exposure levels from one location to another. Finally, the A-weighted sound levels (LAeq) measured varies with the condition of the location and period of the day.

3. Methodology

The population of the study covers twelve (12) selected areas which include Trans Amadi, Eleme junction, Mile 1, Mile 3, Rumuokoro, Waterlines, Township, Choba, Agip, Artillery and Rumuokwutaand stratified random sampling of all the points were carried out and in each area,two (2)points were sampled making a total of twenty-four (24) sample points.The study used two sources of data (primary and secondary), the previous is the coordinates of the selected points that formed the spatial data captured with handheld Garmin 78sc Global Positioning System (GPS) receiver which was configured to UTM zone 32N based on WGS 1984 geodetic datum as it matches the location of the area understudy. In the same vein, the noise reading of A-weighted instantaneous sound pressure level measurements of the points were recorded at

intervals of 1-5mins with respect to mean noise using decibel X applicationin an infinix note 3 smart phone which was calibrated with a digital noise meter, SET 1350, with a measuring level range of 20–120 decibels while the secondary data was the baseline vector map of the study area processed with a geospatial software ArcGIS 10.4version developed byEnvironmental Science Research Institute (ESRI).The data were subjected to the analysis of variance(ANOVA)and t-test using the SPSS version 21to quantify the hypothetical statements that says:

Ho1: There is no statistical significant difference in the Mean Noise Levels (dB) obtained from different hotspots in the morning periods.

H_1: There is a significant difference in the Mean Noise Levels (dB) obtained from different hotspots in the morningperiods.

Ho2: There is no statistical significant difference in the Mean Noise Levels (dB) obtained from different hotspots in the Evening periods.

H_1: There is a significant difference in the Mean Noise Levels (dB) obtained from different hotspots in the evening periods.

Ho3: There is no significant difference in the Mean Noise Levels (dB) obtained for Morning and Evening in Port Harcourt metropolis.

H_1: There is a significant difference in the Mean Noise Levels (dB) obtained for Morning and Evening in Port Harcourt metropolis.

Interpolation model were carried out in ArcGIS usingInverse Distance Weighting (IDW) in the morning and evening mean noise level.IDW is an Interpolation model that predicts each given point local influence over others that shrinks with space; thereby giving greater weights to points closest to the prediction location, based on distance decay effect' (Ajoku and Amadi-Wali [2]).

4. Results and Discussion

The result of the raw data collected reflects the Mean noise level distribution across the twenty four (24)sample pointsand was compared with the World Health Organization (WHO) allowable noise limit standard of 85decibels (dB).The mean noise level distribution across the twelve (12) sample areas in Port Harcourt metropolis is presented in table 1, figure 2, and 3.

According to the statistical analysis, the differences in mean noise levelsin the morningand evening indicates that there were no statistical significant differenceas (P<.05) wasp =.89 and$P$ =.124 respectively (Table 1 and 2). Therefore, we accept the hypotheses of significant mean noise levels. However, table 3 indicates that there is a statistical significant difference in mean noise levels in Rumuolumeni, Artillery andRumuokwuta as p-values were P =.002, .001 and .005 respectively while the other areas were not statistically significant.

4.1 Results of the hypotheses

Ho1: There is no statistical significant difference in the Mean Noise Levels (dB) obtained from different hotspots in the morning periods.

Table 1: ANOVA of Noise Level (dB) of different hotspots for Morning Session

		Sum of Squares	df	Mean Square	F	p-value
Morning Noise Level (dB)	Between Groups	160.865	11	14.624	.472	.89
	Within Groups	371.465	12	30.955		
	Total	532.330	23			

Sig=Significant=*P*<.05; N/S=Not Significant=*P*>.05; df=Degree of Freedom
Sources: Researchers' Fieldwork Results (2020).

Ho2: There is no statistical significant difference in the Mean Noise Levels (dB) obtained from different hotspots in the Evening periods.

Table 2: ANOVA of Noise Level (dB) of different hotspots for Evening Session

		Sum of Squares	df	Mean Square	F	p-value
Evening Noise Level (dB)	Between Groups	591.555	11	53.778	2.001	.124
	Within Groups	322.455	12	26.871		
	Total	914.010	23			

Sig=Significant=*P*<.05; N/S=Not Significant=*P*>.05; df=Degree of Freedom
Sources: Researchers' Fieldwork Results (2020)

Ho3: There is no significant difference in the Mean Noise Levels (dB) obtained for Morning and Evening periods in Port Harcourt metropolis.

Table 3: Mean Comparison (t-test) of Morning and Evening Noise Levels (dB) of different hotspots

Area	Morning Mean±SD	Evening Mean±SD	t-test	df	p-value	Remark
Trans Amadi	86.30±0.56	83.95±5.44	0.6071	2	.61	N/S
Eleme Junction	88.30±3.67	86.05±6.15	0.4440	2	.70	N/S
Mile 1	86.25±4.17	87.60±1.69	0.4239	2	.71	N/S
Mile 3	85.95±7.56	82.30±7.07	0.4984	2	.67	N/S
Rumuokoro	87.70±4.38	85.15±6.01	0.4847	2	.68	N/S
Waterline	86.60±8.48	85.45±5.30	0.1625	2	.89	N/S
Township	80.25±0.91	75.80±1.27	4.0084	2	.06	N/S
Choba	86.45±1.06	77.05±4.45	2.9030	2	.10	N/S
Rumuolumeni	86.10±0.56	78.75±1.20	7.8239	2	.02	Sig

Agip	79.60±13.71	83.70±9.89	0.3428	2	.76	N/S
Artillery	85.75±.07	71.70±1.69	11.6979	2	.01	Sig
Rumuokwuta	86.70±1.13	74.85±3.74	4.2808	2	.05	Sig
Total	85.49±4.81	81.02±6.30	0.79	2	.51	N/S

Sig=Significant=*P*<.05; N/S=Not Significant=*P*>.05; SD=Standard Deviation
Sources: Researchers' Fieldwork Results (2020)

Table 4. Mean summary distribution of noise pollution in the morning and evening.

Areas	Morning Mean (dB)	Evening Mean (dB)
Trans Amadi	86.3	83.9
Eleme Junction	88.3	86.1
Mile1	86.2	87.6
Mile 3	85.9	82.3
Rumuokoro	87.7	85.1
Water line	86.6	85.4
Town ship	80.2	75.8
Choba	86.4	77.1
Rumuolumeni	86.1	78.7
Agip	79.6	83.7
Artillery	85.7	71.7
Rumuokwuta	86.7	74.8

Sources: Researchers' calculation from the raw data 2019.

Table 1 revealed high rate of noise pollution in the morning than in the evening periods as there are ten (10) noise pollution occurrence in the mean sample points such as Eleme junction 88.3dB, Rumuokoro 87.7dB, Trans-Amadi 86.3dB, Choba 86.4dB and Rumuokwuta 86.7dB among others than in the evening periods as compared toWHO standard limit of noise of 85 decibel.

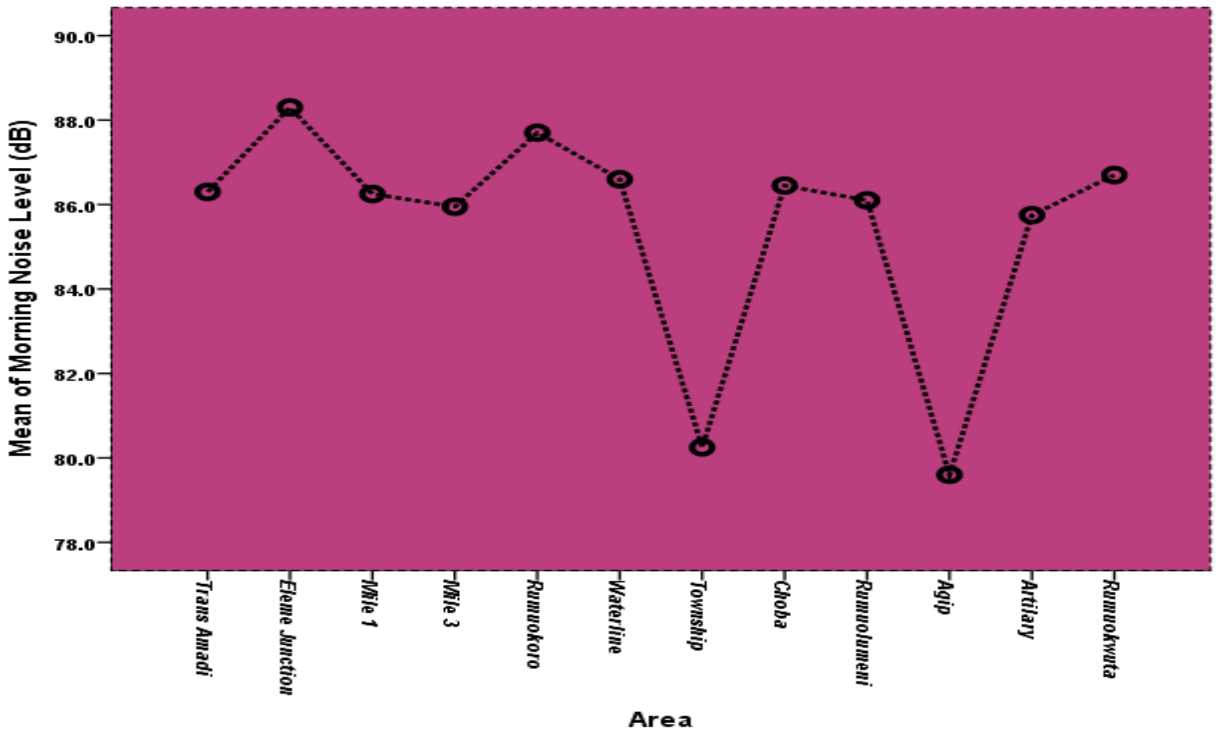

Figure 2: Line graph mean noise level in the morning.

The line graph above indicates that there are variations in the meannoise level across the hotspot areas in the morning periods and also majority of the area understudy such as Eleme junction, Rumuokoro, Trans-Amadi, Choba, Rumuokwuta, Waterlines, Mile 1, Mile 3 and Rumuolumeniexceeds WHO standard of 85 dB, hence, there is noise pollution in the morning periodsin Port Harcourt metropolis.

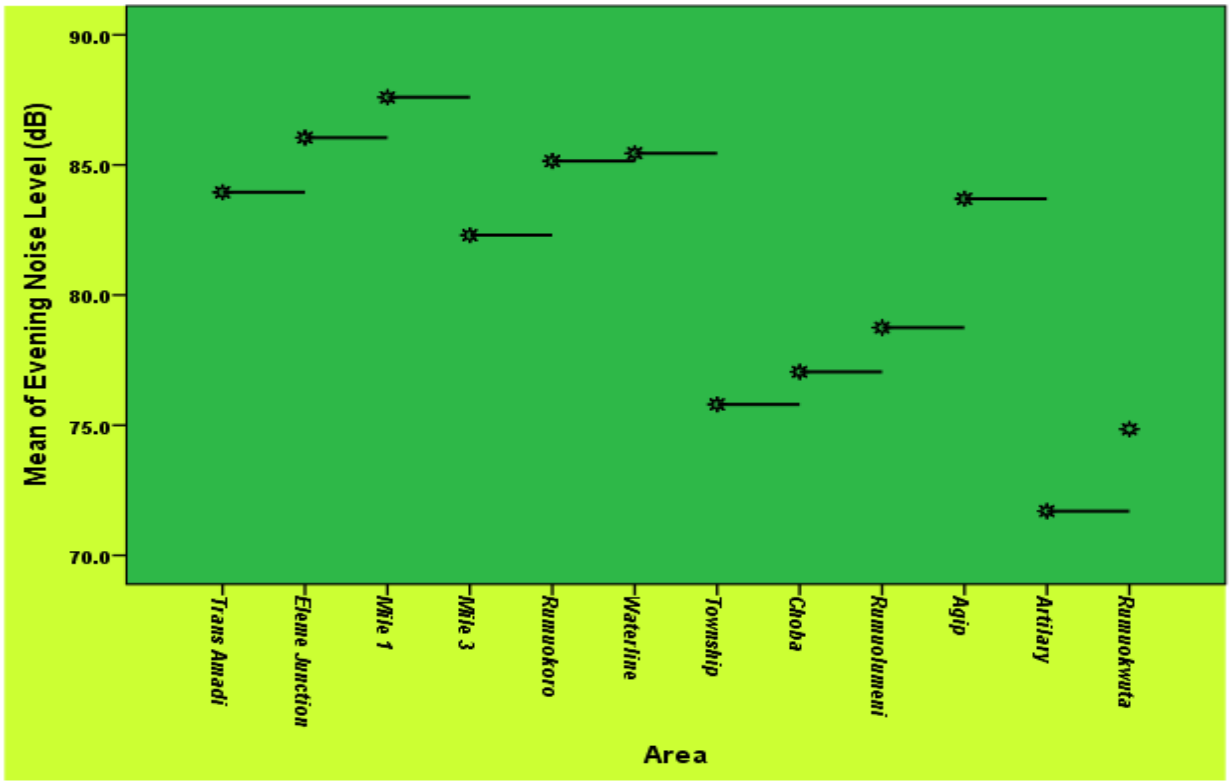

Figure 3: Line graph mean noise level in the evening.

Line graph evening mean noise level indicates that majority of the area such as Artillery, Township, Choba, Rumuolumeni among others,do not exceed 85 dB of the bench mark of WHO, as in this period,anthropogenic activities are torpid in those areas.

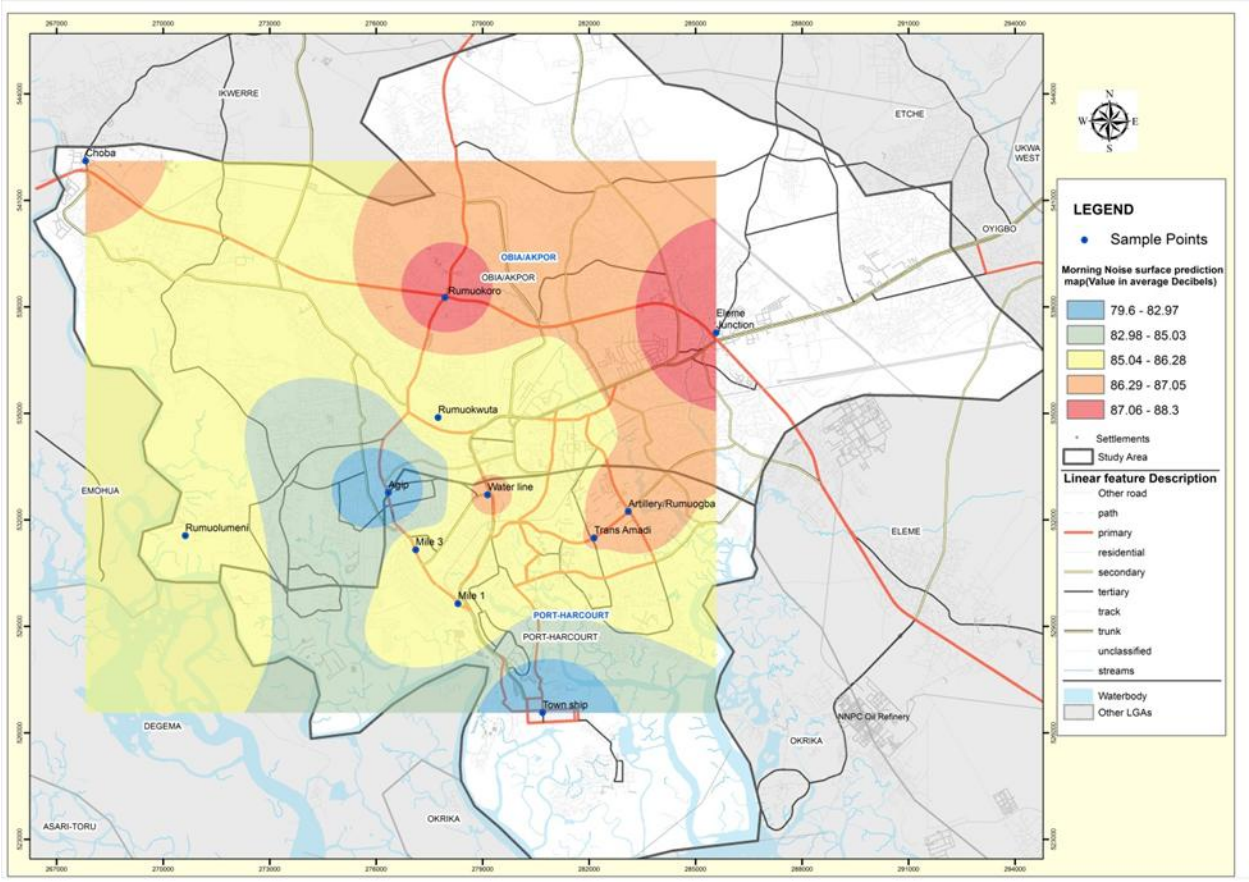

Figure4: Morning Noise Surface Prediction Map

The morning periods surface prediction map revealed a high rate of noise pollution occurrence within Eleme junction, Rumuokoro, Choba, Town ship, Mile 3, Rumuokwuta, Artillery among others,with a range of 85 – 88 dB which shows color yellow, brown and red on the legend.

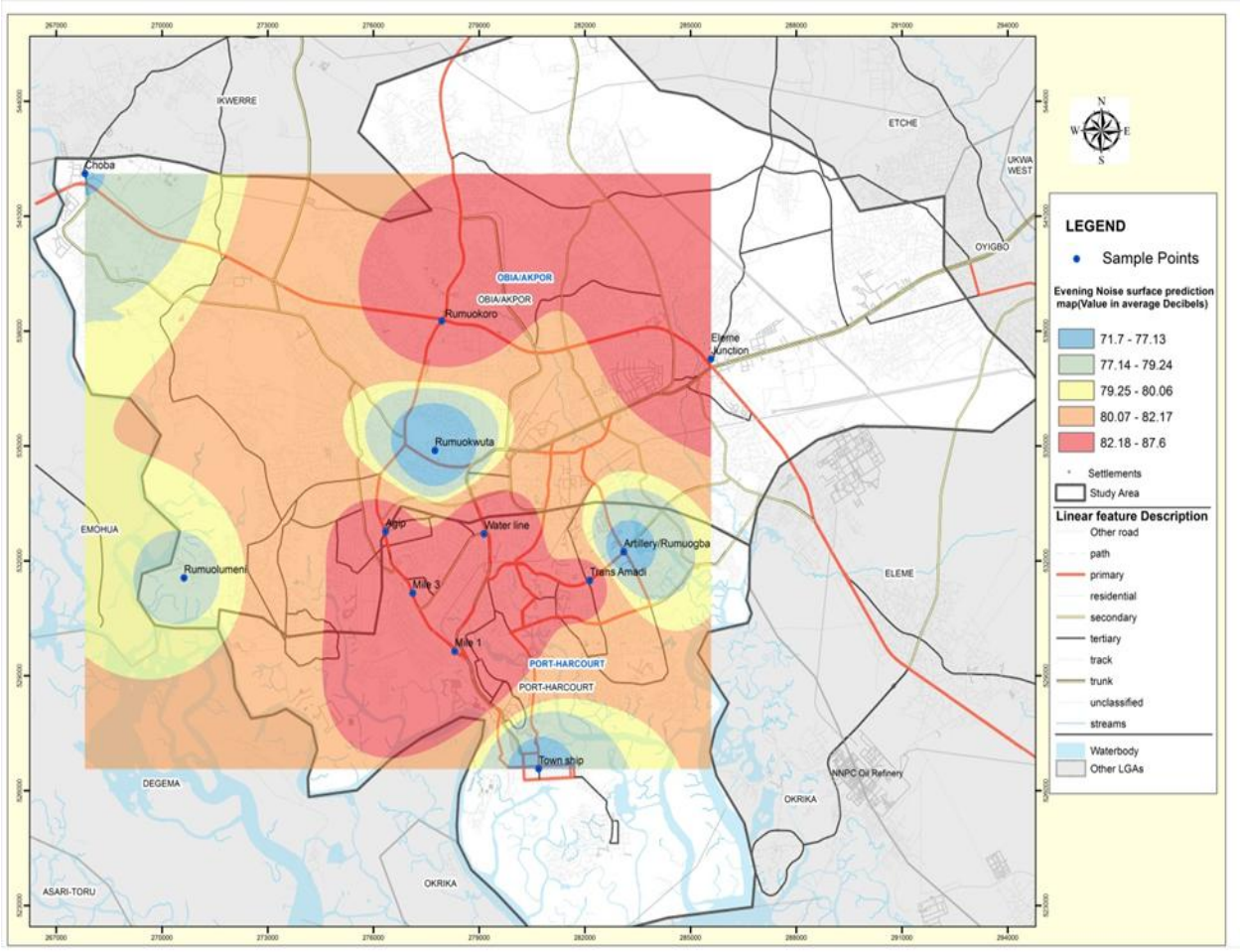

Figure: 5Evening Noise Surface Prediction Map

The evening noise surface prediction revealed that noise pollution hot spot areas are predominantly in Mile 1, Mile 3, Waterlines, Agip and Trans Amadi, having average noise pollution range of 82.1 – 87.6 dB which falls within the red color shading as indicated on the map. Furthermore, it is observed from both periods,that Port Harcourt City experiences more noise pollution than Obio/Akpor, as anthropologic activities and sampled size are more in Port Harcourt City.

4.2. Discussion of findings

The noise pollution level in Port Harcourt metropolis as observed from the study shows high level of noise due tosome anthropogenic activities, mainly traffic and public address systems used for advertisement mostly in the morning periods.Noise is one of the spatial phenomenon that require professional attention in the spatial dimension in the area of noise mapping as it isone of the methods adopted for this research. The mean noise level of the sample points were calculated and compared with the WHO noise regulations standards of 85 dB in time periods and mapped using IDW in ArcGIS 10.4 version. The study also used statistical tools variance (ANOVA) and t-test to justify the hypothesesin SPSS version 21.Based on the statisticalfindings

of this study, it was revealed thatthe differences in mean noise levels in the morning and evening indicates no statistical significant difference,therefore, the hypotheses of significant mean noise levelswere accepted.The t-test also indicates no statistical significant difference in mean noise levels in the majority of the area understudy which is also in line with a study by Ajoku and Amadi-Wali [1] on Analysis of noise pollution levels across landuse types in Port Harcourt Metropolis Rivers State. Their study focused mainly on noise on four land use types: residential, commercial, silence and industrial.Furthermore, the findings of the results of this study also revealed that noise pollution occurrences are more in the morning periods than in the evening periods because of much human activities which are in agreement with a study carried out by Oyedopo and Saadu [9] on statistical Analysis of the Day-time and Night-time Noise Levels in Ilorin Metropolis, Nigeria. Their research revealed that noise levels differ significantly in the two periods and that there is a significant difference in noise exposure levels from one location to another. Furthermore, this study revealed an increase in noise pollution occurrence as majority of the area understudy exceededallowable noise limit of WHO of 85 dBstandardswhich is in agreement with a study by Omubo-Pepple, Briggs-Kamara, and Tamunobereton-Ari [8]on noise pollution in Port Harcourt metropolis. According to their study, noise pollution in Port Harcourt is on the increase and is above the recommended National regulation standard.

5. Conclusion

The results of this research which focused on variation of noise levels in Port Harcourt metropolis found that noise level varies from different areas ranging from 85 – 88 dB and that most areas in the morning periods exceeded bench mark of 85 dB World Health Organization than the evening periods. As observed, most of the noise can be attributed to vehicular traffic and public address system. From the result, there is a need for urgent attention of the environmental authorities and further research in some areas this study could not cover.

6. Recommendations

The results from the analyses conducted during this study indicate that there is noise pollution in the study area as there is need for a well-planned expansion of the city to sub-urban so as to decentralize the current trend of unplanned urban areas.

1. It is needful to decongest the two local government areasof Port Harcourt City and Obio/Akpor, as they stand to be the only city in Rivers State; so that associated problems caused by noise pollution will be reduced.
2. There should always be checks onanthropogenic activities. This could be achieved through the use of Geospatial science and technology so as to ascertain situational areas to study.
3. Noise planning controls should not be compromised butrather operate at higher dimension through planting of trees and monitoring to ensure strict compliance to the law.

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