International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 9 Sep 2021, pp: 787-797 www.ijaem.net ISSN: 2395-5252

Spatial Distribution of Noise generated from CBD to outskirts across major land use areas in Port Harcourt, RiversState, Nigeria

*Uchenna-Ogbodo, E.E; Oyegun, C.U.; Elenwo, E.I.
**Department of Geography and Environmental Management, University of Port Harcourt, Port Harcourt, Nigeria*

Submitted: 01-09-2021 Revised: 09-09-2021 Accepted: 12-09-2021

ABSTRACT
Noise pollution is recognized as a major problem for the quality of life in urban areas all over the world. The study focused on the spatial distribution of noise generated from CBD to outskirts across major land use areas in Port Harcourt, Rivers State, Nigeria. Primary data sources involved direct noise measurements with caliberated EXTECH Digital Sound level meter model 407750 at different time periods of the day. A hand held GPS was used to track the geographic coordinates of 10 established stations in residential, commercial, industrial land use areas where noise level measurements were understudied. Descriptive statistics aided the study in data presentation while ANOVA and Students' T-test statistics were used for data analysis. ArcGIS 10.5 software was employed for spatial variability mapping of noise levels using IDW interpolation method for unsampled locations in Port Harcourt. Results showed that noise levels were higher in commercial (86.9 dB(A)) and industrial (86.4 dB(A)) land use areas than at the residential (80.0 dB(A)) land use areas; and this showed significant variation among sampled land use areas ($F=27.383;p<0.05$) in the study area. Findings also revealed that noise levels generated differs significantly between those generated at CBD districts and those around city outskirts ($t=8.747;p<0.05$) in the study area. The study recommended amongst others the need to have a noise Act in Nigeria and increase public enlightenment and awareness on the negative impacts of noise and promote proper land-use definition in the in the study area.

.**Keywords:** Noise pollution, CBD, Spatial distribution, Land use, Outskirts, ArcGIS

I. INTRODUCTION

Noise pollution is a significant environmental problem in many rapidly urbanizing areas and a report on Nigeria indicates that the annual urban population growth rate is 5.8%, resulting in a total urban population of 62.66 million or 43% of the total population (UN Habitat, 2007). The most common challenges of rapid urban growth in Nigeria and the Niger Delta Region, include urban congestion, increase in crime waves, unemployment, massive deforestation, increase in industrial activities leading to increasing greenhouse effect and particularly environmental noise pollution. The noise problems of the past are significant when compared with those experienced by modern city dwellers; noise pollution continues to grow in extent, frequency, and severity as a result of population growth, urbanization, and technological development (Hiral, Huma, Minarva and Yogesh, 2017).

Since the city is regarded as the engine of growth which propels national economic development; the problems emanating from cities' uncontrolled population have undoubtedly constituted critical challenges to sustainable urban development (Adekola and Ogundipe, 2017).An important factor for the life quality in urban centers is related to the noise levels to which the population is subjected. Several factors interfere with the amount of noise pollution throughout the city. Growth in terms of economic, social development and population increases the tendency towards increasing noise generation. Considering the connectivity of vicinities in Port Harcourt city, transport routes could result to an increase in the volume of noise generated. Noise is considered a

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growing health threat, and if, left unchecked could result to hazardous conditions (Adejobi, 2012).The increase in the number of cars on the roads as well as noise coming from industrial sources has increased noise pollution levels in Port Harcourt. Thus, people residing far from noise sources and from almost silent secondary roads within cities are currently very much above average living standard because it has been labeled as choice locations for the rich or wealthydue to low level of noise (Yilmaz and Ozer, 2005; Ozer,Yilmaz and Yesil, 2009).

Despite the fact that much has been written about the health effects of noise, it seems that much of the following information is not appreciated by the medical community and even less so by the general public in Nigerian capital cities. According to WHO (2011) the effects of noise pollution may include population annoyance, interference with speech communication, leisure, or relaxation, and, at very high levels which may occur at work or during certain noisy leisure activities, it may result in hearing loss by causing damage to the hair-cells in the cochlea in the inner ear. Rather than leading to significant adverse physiological responses, however, noise is more often a major problem in terms of quality of human life in specific localities.Most people in the city would agree that much of the environmental noise to which one is subjected serves no useful purpose and is therefore undesirable.Akintuyi et al., (2014) asserts that noise pollution is one of the most critical environmental challenges affecting human health.The ability to measure ambient noise levels and represent them on a map should provide a powerful tool for spatially identifying noise sources, its spread and its impact and make decisions relating to its control and management (Stanfeld, Haines, Brown, 2000).Thus, spatially analyzing noise pollution levels in Port Harcourt city will unravel some inherent noise pollution sources in the study area as one of the commercial hub of the nation. This will create awareness and help the inhabitants in their choice of residence. The information on the spatial distribution of noise pollution from CBD to the outskirts will aid the government with needed information as regards enacting laws that will help to mitigate noise pollution levels across land use types in Port Harcourt. The study is also useful for urban planners in planning and designing of places devoid of excessive noise pollution. GIS was therefore essential for displayingthe spatial distribution of noise pollution levels across major land use types in Port Harcourt city. The use of GIS in noise mapping have been proven effective overtime due to its ability to analyze and provide spatio-temporal information efficiently.

Studies on noise levels mapping and analysis in capital cities in south-south Nigeria such as Anomohanran et al. (2008); Obafemi and Eludoyin (2010; 2012); Obafemi and Ofondu (2015); Arokoyu et al., (2016); and much recently, Wekpe and Fiberesima (2020); and Ajoku and Amadi-Wali (2020) did not involve noise pollution levels across major landuse areas with emphasis on noise generated from CBD to outskirts in Port Harcourt City. Thus, no recent study has revealed the spatial distribution of noise generated across major land use areas from CBD to outskirts at different time periods of the day in Port Harcourt City. The present study therefore examines the spatial distribution of noise generated from CBD to outskirts across major land use areas in Port Harcourt City, Rivers State, Nigeria.

II. MATERIALS AND METHODS

The study area is Port Harcourt City, Rivers State, Nigeria. It is located geographically between latitudes 4^0 42' and 4^0 55'N and between longitudes 6^0 53' and $7^0$08'E (Figure 1). Port Harcourt features a tropical monsoon climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualifies as dry season months in the city. Port Harcourt's heaviest precipitation occurs during September with an average of 3670 mm. Temperatures throughout the year in the city is relatively constant. Average temperatures are typically between 25 °C-28 °C in the city (Obafemi and Eludoyin, 2010). Port Harcourt lies on the low lying coastal plain with mean elevation of about 20 m. The vegetation are trees in the rainforest such as Khayagrandifoliola, Triplochitonscleroxylon, Diospyroscelebica, Elaeisguineensis and economically valuable trees such as Raphiahookeri and mangrove forest such as Rhizophora sp. (Eludoyin et al. 2011). The study area is well drained with both fresh and salt water.The study utilized direct noise measurement using a caliberated EXTECH Digital Sound level meter model 407750. The instrument was held at a height of 1.2 meters above the ground level to the source of the noise for all locations. The study established 10 stations each in three major land use types, namely: residential, commercial and industrial. A hand held global positioning system (GPS) was used to track the coordinates of the established stations in the study area. These stations were established systematically from the CBD to the

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outskirts of the city. Noise measurements were recorded during peak and off-peak periods in the study area. Three time periods were employed, which were morning (6.30am-8.00am), afternoon (12.30pm-2.00pm) and evening (5.00pm-7.00pm). Ten (10) Field assistants aided the study in noise data collection during the field exercise. A total of 30 stations were established, that is, 10 each for each land use type. Descriptive statistics aided the study in describing the noise levels across land use areas; and these were in form of Tables and maps. ANOVA statistics and Students'T-test was used for analyzing variations in noise pollution among land use types and difference in noise pollution levels respectively between CBD districts and the outskirts in the study area. Spatial variability mapping of Port Harcourtin relation to measured noise levels were performed in ArcGIS 10.5 with the use of Inverse Diverse Weighted (IDW) interpolation method. This helps to understand the noise levels of the stationsthat were not sampled in order to determine the areas in square kilometers of low and high noise levels in Port Harcourt in relation to data obtained from noise levels measured at established stations. ArcGIS 10.5 software was used to display the major land use types in Port Harcourt which were residential, commercial, industrial and peri-urban (Figure 2). The land use analysis for the study aided the study in the display of the spatial distribution of noise across land use areas and at different time periods.

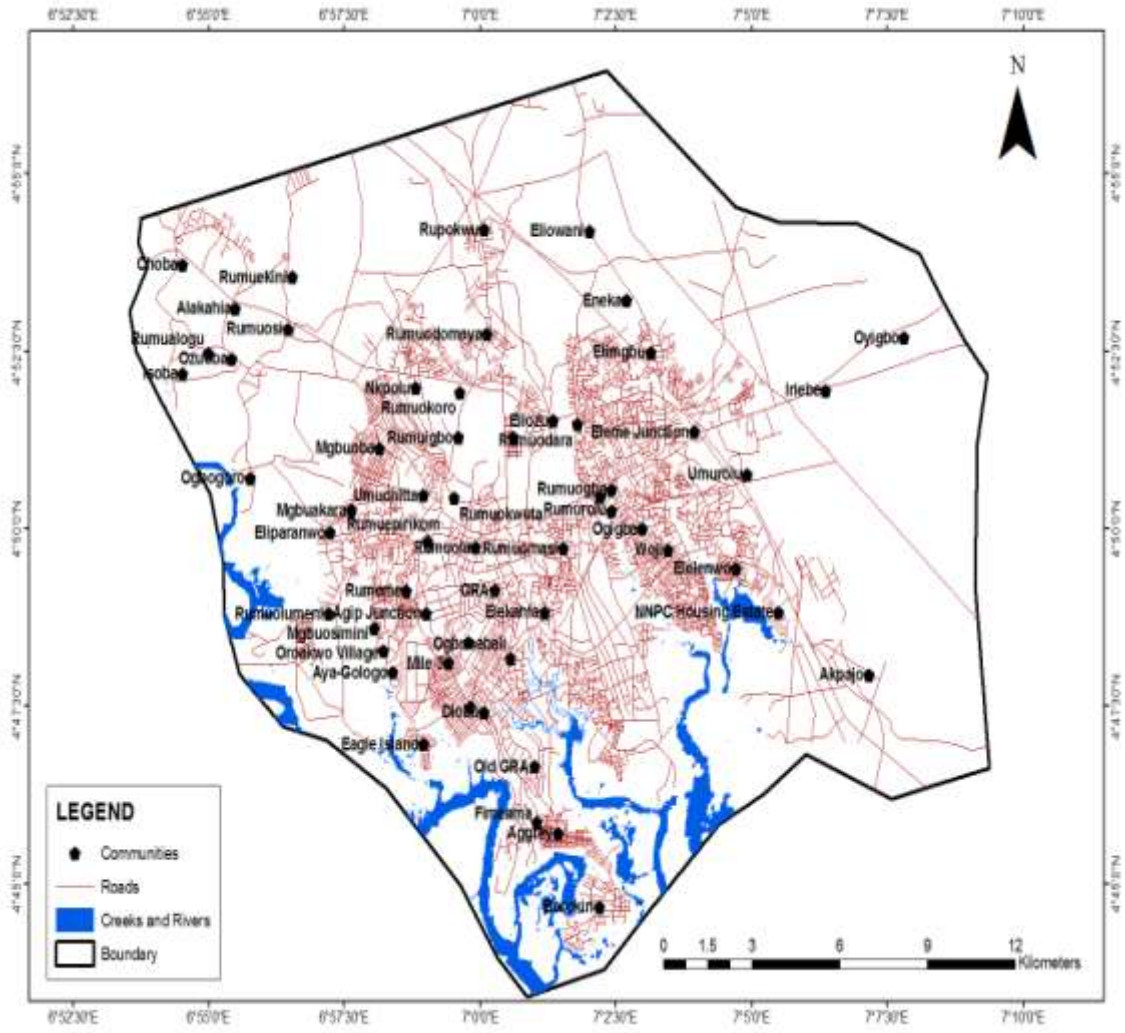

Figure 1: Port Harcourt

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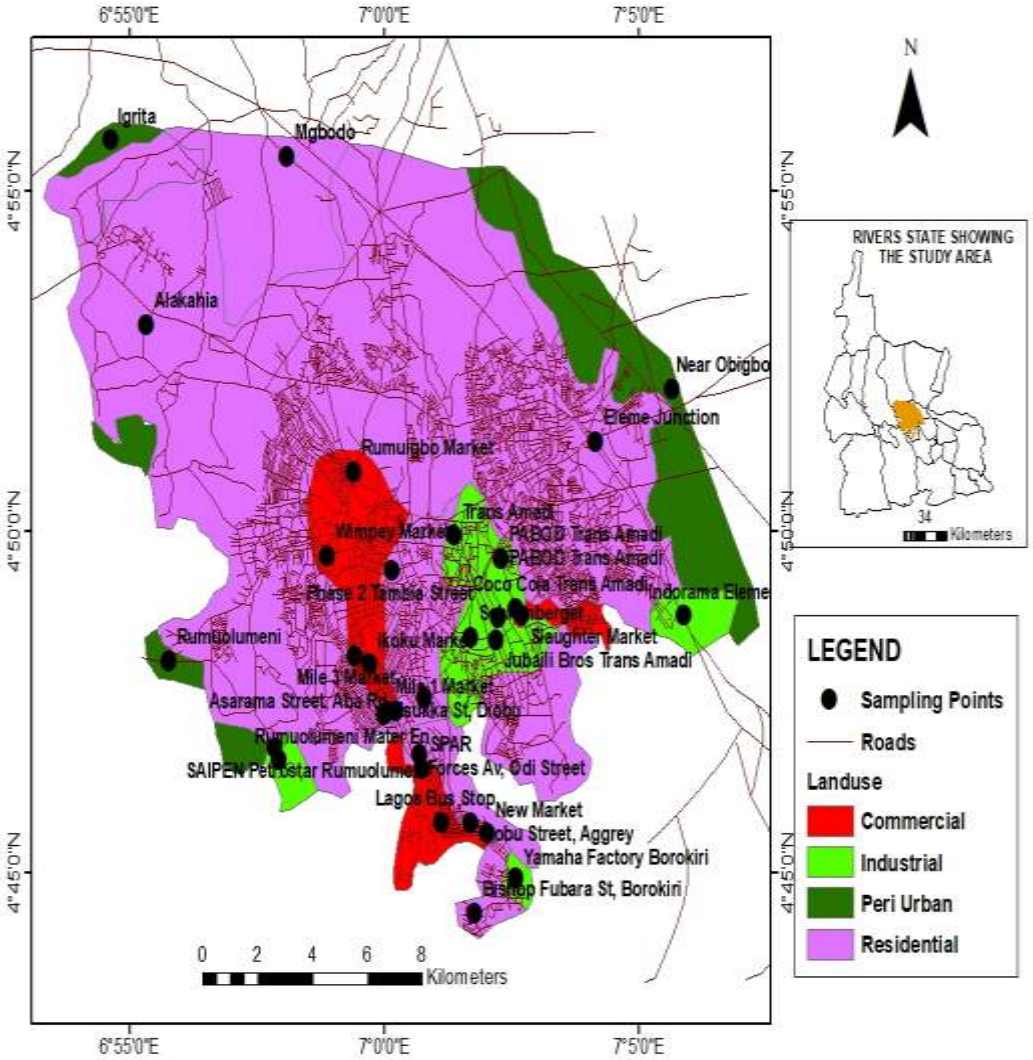

Figure 2: Land use analysis of Port Harcourt

III. RESULTS AND DISCUSSIONS

Noise Levels across Sampled Land use Types in Port Harcourt

The information on Table 1 shows the distribution of noise pollution levels in Port Harcourt at different time periods for the residential land use. The lowest and highest noise level values for morning, afternoon and evening periods were: 40.8 dB(A) and 78.0 dB(A); 46.2 dB(A) and 80.9 dB(A); and 50.8 dB(A) and 84.6 dB(A) respectively. The highest mean values recorded for each time period are 72.3 dB(A) (morning); 75.2 dB(A) (afternoon); and 80.0 dB(A) (evening).

The information on Table 2 displays the noise pollution levels for the commercial land use. It was revealed that the lowest and highest noise level values for morning, afternoon and evening periods were 48.9 dB(A) and 86.4 dB(A); 50.6 dB(A) and 88.3 dB(A); and 66.4 dB(A) and 86.9 dB(A) respectively. The highest mean noise levels in all sampled points at different time periods are 77.8 dB(A), 80.1 dB(A), and 80.5 dB(A) for morning, afternoon and evening periods respectively.

The information on Table 3 displays the noise pollution levels for the industrial area land use in Port Harcourt. The lowest and highest noise pollution values for morning, afternoon and evening periods were 56.2 dB(A) and 86.4 dB(A); 54.1 dB(A) and 86.4 dB(A); and 55.8 dB(A) and 86.5 dB(A) respectively. The highest noise pollution mean values for morning, afternoon and evening periods were 79.1 dB(A), 80.6 dB(A) and 79.0 dB(A) respectively.

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Table 1: Noise Level (dB) in Sampled Residential areas Land use in Port Harcourt

Sampling Points	Morning (6.30am-8am)				Afternoon (12.30pm-2pm)				Evening (5pm-7pm)				Location	
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	N	E
1	46.1	67.2	56.5	9.9	52.4	68.4	59.3	6.3	55.4	71.4	63.4	6.1	4.88383	6.92221
2	40.8	60.1	52.4	5.3	67.1	80.0	71.3	4.4	68.4	78.6	72.8	4.1	4.86850	6.98443
3	56.2	75.5	67.9	8.6	55.2	70.2	65.2	6.0	66.8	80.5	74.0	5.1	4.78835	7.00012
4	60.6	77.4	69.2	7.3	55.1	72.6	65.0	6.7	62.5	75.2	68.6	5.5	4.76199	7.02819
5	55.6	72.8	64.4	6.6	56.8	74.9	66.3	7.2	62.8	75.9	69.5	4.9	4.75547	7.04797
6	60.6	72.2	64.4	5.3	46.2	63.4	56.1	5.3	55.8	70.9	64.4	4.6	4.77860	7.01151
7	61.8	72.4	65.3	1.7	60.8	66.8	64.3	2.5	64.2	74.8	66.7	2.9	4.78931	7.00389
8	60.4	76.9	70.2	6.4	66.5	74.5	69.4	3.1	58.2	70.1	66.3	4.7	4.79236	7.01310
9	67.0	78.0	72.3	3.1	68.3	80.9	75.2	5.3	76.4	84.6	80.0	3.4	4.82128	7.05343
10	56.2	68.4	61.0	4.9	60.4	70.9	67.0	4.0	50.8	78.2	66.9	10.0	4.82355	7.00252

Min- Minimum; Max- Maximum; SD – Standard Deviation; N- Northings; E- Eastings

Table 2: Noise Level (dB) in Sampled Commercial areas Land use in Port Harcourt

Sampling Points	Morning (6.30am-8am)				Afternoon (12.30pm-2pm)				Evening (5pm-7pm)				Location	
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	N	E
1	66.2	78.9	71.7	6.3	60.6	84.2	77.0	9.4	67.2	85.4	78.6	7.1	4.84786	6.99015
2	54.8	85.2	71.1	14.5	76.8	82.4	79.4	2.1	68.4	84.2	76.9	6.3	4.82724	6.98131
3	48.9	86.2	73.1	14.3	50.6	84.4	67.7	14.9	74.9	86.5	80.5	5.1	4.80290	6.99019
4	62.9	80.6	76.1	7.5	69.2	86.6	79.5	6.5	62.5	84.5	76.2	8.3	4.78946	7.00089
5	66.9	82.8	76.4	6.1	66.6	82.6	76.3	6.3	71.6	82.9	79.2	4.5	4.76201	7.01874
6	60.2	81.2	71.8	8.6	60.2	80.6	70.5	9.4	69.2	75.6	72.1	2.9	4.75928	7.03369
7	70.1	85.2	77.8	5.5	70.4	86.8	76.2	7.3	76.4	86.9	80.2	4.2	4.77521	7.01217
8	70.5	86.4	77.6	5.8	77.6	84.1	80.1	4.1	70.1	86.6	79.4	6.2	4.82663	7.03828
9	70.9	85.1	76.6	5.32	70.9	88.3	79.0	6.3	66.4	78.2	70.3	4.6	4.81269	7.04490
10	71.9	84.9	76.5	5.2	70.9	82.7	77.9	4.5	70.1	88.8	70.8	7.1	4.80075	6.99512

Min- Minimum; Max- Maximum; SD – Standard Deviation; N- Northings; E- Eastings

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Table 3: Noise Level (dB) in Sampled Industrial areas Land use in Port Harcourt

Sampling Points	Morning (6.30am-8am)				Afternoon (12.30pm-2pm)				Evening (5pm-7pm)				Location	
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	N	E
1	64.4	85.2	72.7	9.5	54.2	79.9	71.7	11.2	55.8	80.3	68.3	8.9	4.74844	7.04304
2	66.8	84.9	77.6	6.7	78.2	84.6	80.6	2.4	78.2	82.8	79.0	1.8	4.82663	7.03828
3	56.2	85.2	73.6	11.7	68.1	85.2	77.7	7.9	70.8	86.5	79.0	6.5	4.81269	7.09787
4	74.8	82.4	79.1	3.0	60.9	86.4	76.9	9.5	62.5	86.4	76.8	8.8	4.69915	7.17604
5	62.8	82.1	73.6	8.4	66.6	82.2	76.2	6.2	71.6	82.1	77.2	8.6	4.78022	6.96424
6	60.2	81.2	71.8	8.7	54.1	80.8	69.9	12.1	64.7	80.8	74.1	6.7	4.77730	6.96542
7	65.2	79.5	71.9	6.4	70.4	86.2	74.1	6.8	67.9	81.5	74.9	5.6	4.81211	7.03737
8	68.4	79.2	74.0	4.5	74.5	80.2	78.1	2.3	70.1	78.9	76.6	3.6	4.80651	7.03673
9	68.4	80.2	74.8	4.6	70.9	78.3	76.2	3.1	66.4	84.2	75.3	7.1	4.80740	7.02822
10	71.9	86.4	76.8	5.8	68.3	80.9	75.0	5.3	67.8	80.7	75.0	5.7	4.81447	7.04315

Min- Minimum; Max- Maximum; SD – Standard Deviation; N- Northings; E- Eastings

Variation in Noise Levels among Land use Types

The information for the variation in Noise levels among land use types in Port Harcourt is displayed on Table 6. The information on Table 4 was used for this computation while the information on Table 5 shows the descriptive statistics of the ANOVA analysis. The result showed that the F ratio of 27.383 at degrees of freedom (df) of 29 at 0.05 (95%) probability level revealed a level of significance of 0.000. The result therefore showed that there is variation in noise levels among land use types in Port Harcourt since the level of significance of 0.000 was lower than the probability value of 0.05 thus the Null hypothesis (H_0) was rejected.

Table 4: Daily Mean noise Levels across Land use Types in Port Harcourt

	Land uses		
Locations	Residential	Commercial	Industrial
1	59.7	75.8	70.9
2	65.5	75.8	79.1
3	69	73.8	76.8
4	67.6	77.3	77.6
5	66.7	77.3	75.7
6	61.6	71.5	71.9
7	65.4	78.1	73.6
8	68.6	79	76.2
9	75.8	75.3	75.4
10	65	75.1	75.6

Source: Researcher's Field Computation, 2020

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Table 5: Descriptive Statistics

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
Residential	10	66.490	4.3857	1.3869	63.353	69.627	59.7	75.8
Commercial	10	75.900	2.1899	.6925	74.333	77.467	71.5	79.0
Industrial	10	75.280	2.5134	.7948	73.482	77.078	70.9	79.1
Total	30	72.557	5.3405	.9750	70.562	74.551	59.7	79.1

N=30

Table 6: ANOVA Analysis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	553.989	2	276.994	27.383	0.000
Within Groups	273.125	27	10.116		
Total	827.114	29			

N=30; $p<0.05$

Spatial Distribution of Noise Levels from CBD to the out skirts of Port Harcourt

The spread or spatial distribution of noise across land uses in Port Harcourt during the morning periods is depicted on Figure 3. It was indicated that the highest noise levels of between 71.80 dB(A) and 79.11 dB(A) varied among land use with more experienced in the industrial and commercial areas land uses. The minimum noise level value of 43.88 dB(A) and maximum value of 54.38 dB(A) were noted at the semi-urban areas and in few residential areas land use in Port Harcourt. The spatial distribution of noise levels in Port Harcourt during the afternoon periods as shown in Figure 4 revealed high noise pollution values of between 73.58 dB(A) and 80.29 dB(A) (which was slightly higher than morning periods) and these values were observed more around the commercial and industrial land use areas. On the other hand, the lowest noise levels (54.34 dB(A) and 63.50 dB(A)) were also around few residential areas and semi-urban areas. The spatial distribution of noise levels during the evening periods as shown in Figure 5 also recorded higher noise values which were between 74.59 dB(A) and 80.64 dB(A) around the city centres which have a mix of the commercial, industrial and residential areas land use. Similarly, the lowest noise levels of between 53.14 dB(A) and 61.58 dB(A) were recorded around the outskirts of the city and some parts of the residential areas in Port Harcourt.

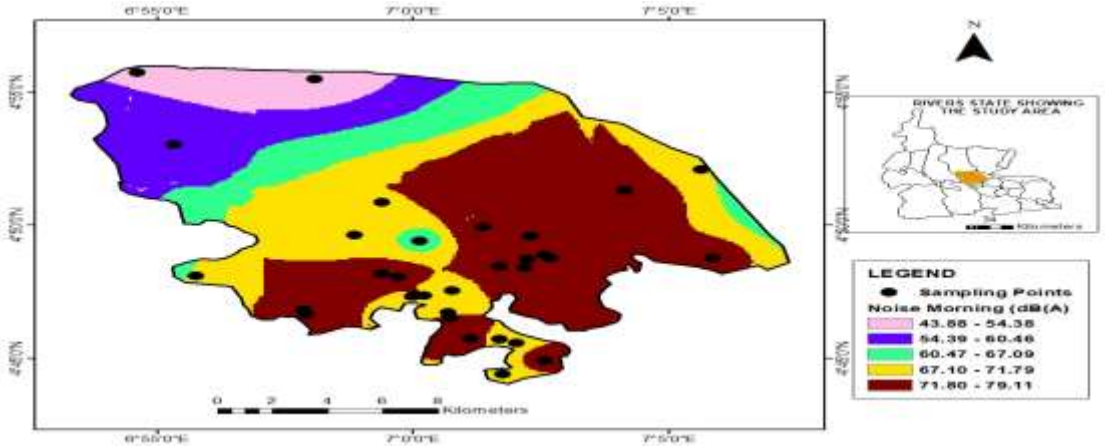

Figure 3: Spatial Distribution of Noise in all Land use Areas (Morning Periods)

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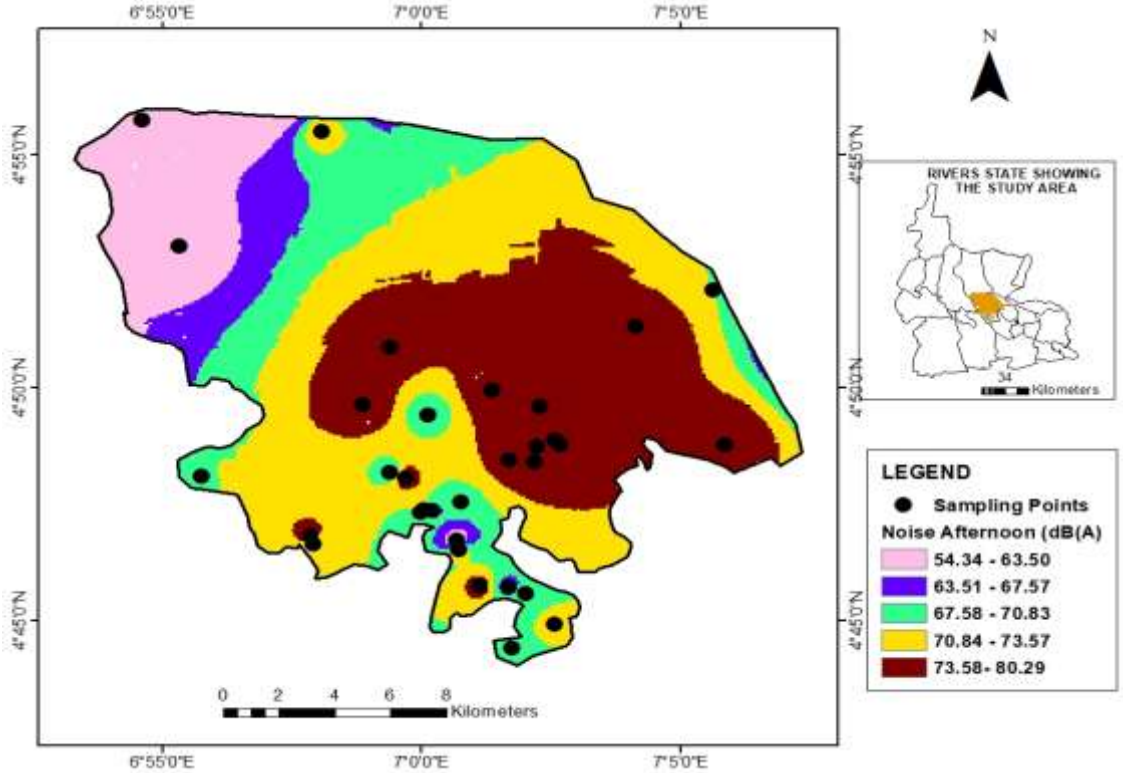

Figure 4: Spatial Distribution of Noise in all Land use Areas (Afternoon Periods)

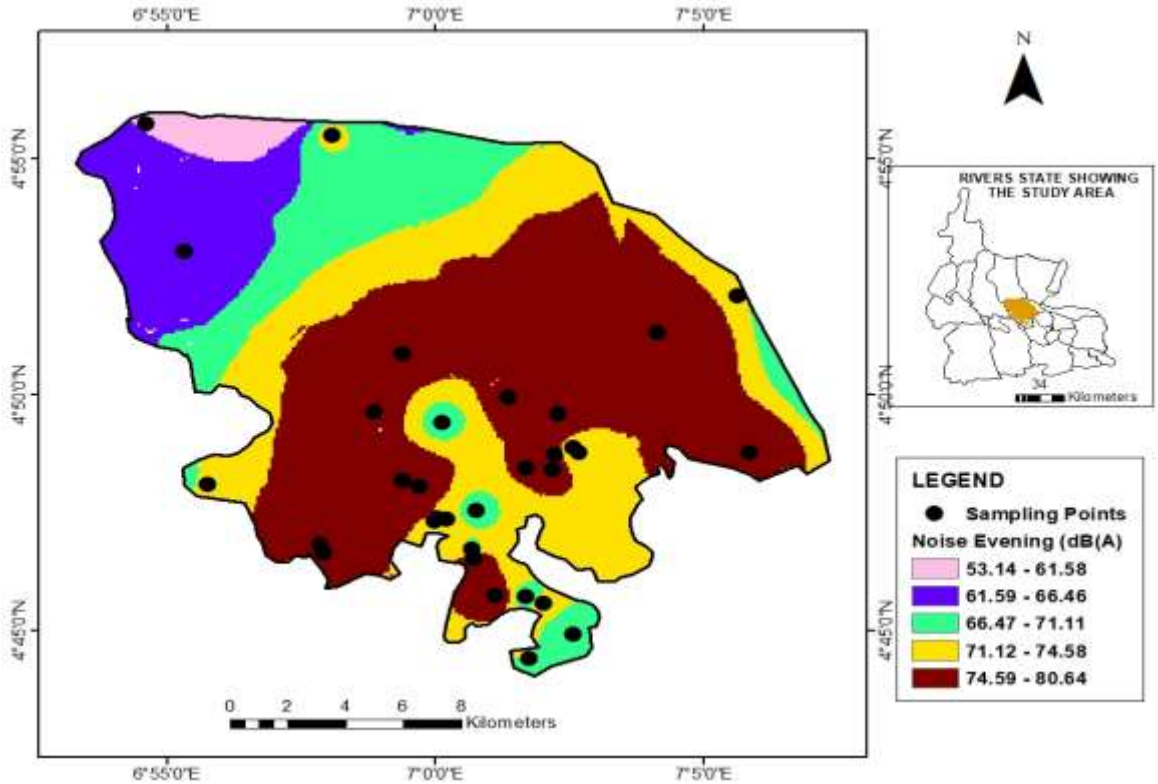

Figure 5: Spatial Distribution of Noise in all Land use Areas (Evening Periods)

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Difference in Noise Levels between CBD and Out skirts

The descriptive statistics of the analysis is displayed on Table 7 while the result of the test of difference between noise generated around CBD and noise generated around urban out skirts is displayed on Table 8. The distribution revealed that the F value of 9.572 for the equal variances assumed between the two groups (CBD districts and Urban Outskirts) recorded a T value of 8.747 at degrees of freedom of 28 (at 95% probability value) indicated a p-value of 0.000. It therefore indicated that noise levels generated in the study area differs significantly between CBD districts and the out skirts.

Table 7: Descriptive Statistics

	Groups	N	Mean	Std. Deviation	Std. Error Mean
CB & Urban Outskirts	CBD	15	76.5867	1.47593	.38108
	Out skirts	15	67.6600	3.66661	.94671

Source: Researcher's Computation, 2020

Table 8: Student's T-test Statistics

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
CBD & Out skirts	Equal variances assumed	9.572	.004	8.747	28	.000	8.92667	1.02054	6.83620	11.01714
	Equal variances not assumed			8.747	18.421	.000	8.92667	1.02054	6.78611	11.06723

Source: Researcher's Computation, 2020
*Significant at p<0.05

IV. DISCUSSION OF FINDINGS

The major land use areas in Port Harcourt were the residential, commercial, industrial and the peri-urban land use types. The noise pollution levels generated at the residential land use areas were discovered to be lower that the noise levels generated around commercial and industrial land use areas in Port Harcourt. The lowest and highest noise levels recorded at the residential land use against the commercial and industrial land use areas during the morning, afternoon and evening periods was between 40.8 dB(A) and 80.9 dB(A) for residential; while on the other hand it was between 48.9 dB(A) and 86.9 dB(A) for commercial and 54.1 dB(A) and 86.5 dB(A). Findings of the study agree with the study by Ighoroje, Marchie and Nwobodo (2004) on the level of noise pollution in selected industrial locations in Benin city and Asaba in Delta state. The findings agree with the work of Dewanga, Dewanaga and Amaresh (2008) which talked about the noise generated from machinery and numerous industrial plants as well as commercial and entertainment centres which increase noise pollution in the city centres. Similarly, noise levels generated at residential land use areas were also high especially during peak periods. The peak periods in Port Harcourt are usually trip generating and it contributes to a lot of traffic/vehicular movements in and around the residential areas

because of the transport routes connections. Thus, the morning periods and evening periods were noted to contribute higher because these periods are peak periods in Port Harcourt and the direct sources of noise during these periods are from the roads. Findings agree with the findings of Arokoyu et al., (2016) on roads and junctions as major contributors to noise in urban centres. Ajoku and Amadi-Wali(2020) also indicated road junctions, commercial and industrial points as noise hotspots in Port Harcourt. The study of Obafemi and Eludoyin (2010) also agrees with the findings of the study as regards noise pollution hotspots in Port Harcourt. Findings of the study on the difference in noise generated around CBD and city outskirts agrees with the study by Baloye and Palamuleni (2010) as well as Anyanwu (2017) on the impact of noise pollution on the residents of Obio/Akpor local government area in Rivers state.

V. CONCLUSION AND RECOMMENDATIONS

The study concludes the spatial distribution of noise pollution in Port Harcourt to be higher in areas around the city centres (CBD) constituting majorly the commercial and industrial land use areas and parts of residential land use. Thus, noise pollution spreads from the city centre (CBD) to the other nearest points/areas and thus decreases as one move further away from the city centre to the semi-urban areas in Port Harcourt, Rivers State. Based on the findings, the study recommended the need to have noise Act in Nigeria, because there is no specific Noise Act in Nigeria; proper public enlightenment on the negative impacts of noise pollution should be advocated especially around commercial and industrial land use areas; proper land use definition is urgently needed as residential, commercial and industrial are not properly delineated and defined as this overlaps is contributing to high noise pollution levels; noise pollution should be included as a public health issue by the government and explore effective methods to combat noise pollution in the study area.

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