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Carbon Monoxide Emissions Effects from Power Generating Plants on Residents of Port Harcourt Metropolis, Rivers State Nigeria

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Abstract: The study examined carbon monoxide emissions from power generating plants on the residents of Port Harcourt Metropolis. The study combined both cross sectional and experimental research methods to accomplish the stated objectives. Measurement were taken using Madur-portable gas analyser, aeroqual gas monitor and questionnaires to measure the point source emissions, ambient CO and the perceptions of the residents on power generating sets respectively. Data analysis utilized (descriptive and inferential) statistical analysis .The study found out that the density of power generating plants in some part of the study area emit larger amount of CO to the ambient air and increases the concentrations above recommended limit as observed in some communities such as UniPort, University of Education, Elekahia and Rumuagholu with the concentrations at about 45.70ppm, 34.33ppm, 16.62ppm and 14.22ppm respectively. The concentrations when compared was above the epidemiological standard baseline of 10-20ppm.. The study found that, there was statistically significant different in the ambient CO concentrations in the various communities (calculated value 3.376> table value 2.080 at 95% significance level) and that there was no relationship between the point source emissions and the ambient CO concentrations (calculated value 0.536< table value 2.086 at 95% significance level). The research recommends that other studies should be carried out directly on human impact by measuring blood samples for CO concentrations in the study area. Also, government should mobilize enlightenment programmes on the menace Co inhalation and its preventive measures. Homes should install CO detector that triggers off alarm when concentrations exceed threshold levels.

Keywords: Carbon monoxide, Emissions, Effects, Residents, Port Harcourt

Introduction

The demand for electricity supply has continued in Nigerian cities and states due to mismanagement by those charged with the responsibility to oversee energy production and distribution. Statistics has shown in the 1990s, the periodic power outages cost Nigeria factories countless man-hours loses of operations and financial cost (Okei, 2007).The major thermal electrical installations in Nigeria are situated at Egbin in Lagos State, Sapele in Delta State and Afam in Rivers state. The generation of Hydroelectricity at Kainji Dam reduces the quality of other dams at the rivers such as Shiroro Gorge and Jebba. To this effect, only a small percentage of the country's potential hydroelectricity capacity has been developed (Okei, 2007). Mismanagement and nonchalant attitude of the government in dealing with power infrastructure has been the major cause of epileptic power supply in the country. It is a fact that Nigeria supplies electricity to her neighbouring countries such as Niger, Togo, and Ghana etc, but these countries do not suffer what Nigerian suffers in terms of the quantity and quality of power supplied. The overall view of power generation in Nigeria has been very appalling despite billions of naira expended and hopes given by successive governments to solve the problem of power in the country (Augustine,2012) . Port Harcourt is among the fastest growing industrial cities in Nigeria and has witnessed irregular power supply over the years till present. The residents of the city and those engaged in businesses, no longer depend on power supply from government agency PHED. In the light of the foregoing, individuals, households, industries etc now resulted to the use of fuel or gasoline generators as a remedy to the epileptic power supply in the city. They do not rely on PHED Company or its subsidiary companies for power supply, but rather, provide generator sets for power supply for their various activities. The town planning laws provides for zoning of different land uses in Port Harcourt such as the commercial, residential, recreational and industrial land uses. These different land uses differ in their level of carbon monoxide emission with respect to the use of gasoline generating sets. Carbon monoxide emitted from these power plants has had tremendous deleterious effects on the inhabitants and other itinerant visitors to the city of Port Harcourt

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(Weli and Adegoke, 2016). The carbon monoxide gas has been implicated to constitute the single largest pollutant in the urban atmosphere which results from insufficient combustion systems of petrol and diesel engines (Balogun, 2014). Carbon monoxide has a strong affinity for the haemoglobin of the blood stream. Exposure to some minutes inhalation of CO causes headache, dizziness and general discomfort. However, continuous exposure to large concentrations above 50ppm can result to death within minutes to hours (WHO, 1997). It has been established that many families including children and pregnant women; infant babies and individuals lost their lives due to poor quality of air control measures and air pollution. Many are suffering with related ailment as a result of CO poisoning and government has done nothing seriously to ameliorate the situation. In the period 1970-1988, 11,547 deaths due to carbon monoxide poisoning occur in the United State (Thom, Mathieu-Nolf and Hamp, 2000). In England and Wales, there was more than 60deaths per year because of accidental exposure to CO and some 500 persons admitted to hospital for treatment of such exposure. Children, pregnant women and individuals with heart problems were mostly affected. However, CO poisoning is not limited to these groups of persons, as anyone can be affected. People of Uburu in Ohaozara local government of Ebonyi State woke up to a catastrophe that claimed the lives of seven family members as a result of inhalation of carbon monoxide emission from a private generating set. Some few days later at Urum in Akwa North local government area in Anambra State was another incident with the death of four persons, plus a 95 years old man in the comfort of their rooms due to suspected fumes from generating source. Also, most recently (30th June, 2017) in Rumuosi in Obio/Akpor local Government Area of Rivers State, a family of six was discovered dead after three days because of carbon monoxide emission from power generating set. Reports of death toll from generator related incidents have risen to an increase which calls for urgent attention. All these incidents come from our routine use of power generating sets in our homes and business places. There is hardly a home, in urban areas that are without a generating set. Despite the noise pollution from these generating sets, they have turned to necessary nuisance in the environments. The increasing death level as a result of carbon monoxide poisoning can be tied to the fact that a good number of Nigerians generate their own power, but very many do so without the awareness of its negative impacts (Oguntoke, and Adeyemi, 2016). It is based on this back-drop that this study aims to investigate carbon monoxide emissions from power generating plants and its impact on the residents of Port Harcourt Metropolis, Rivers State, Nigeria. Arising from the aforementioned problems are the following research questions;

(a)What is the spatial variation in ambient carbon monoxide emission in Port Harcourt Metropolis?

(b)What is the level of carbon monoxide on the various communities in comparison with the National Ambient Air Quality Standards (NAAQS)?

(c)What are the air quality indices of carbon monoxide in each of the sampled location?

(d)What is the ratio of the quantity of CO emitted by different power generating plants to the ambient air in the study area?

(e)What is the spatio-temporal variation of the concentrations of carbon monoxide in Port Harcourt Metropolis?

Aim and Objectives of the Study

The aim of this study was to examine the effect of carbon monoxide emissions from power generating plants on residents of Port Harcourt Metropolis, Rivers State Nigeria.

To achieve this aim, some sets of objectives was followed and they are stated thus to;

(i)Assess the spatial variation in ambient carbon monoxide emission in Port Harcourt Metropolis.

(ii) Establish the levels of carbon monoxide on the various communities and compare with national ambient air quality standards .

(iii)Determine the air quality indices of carbon monoxide for each of the sampled location in the study area.

(iv) Assess the quantity of CO emitted by different power generating plants to the ambient air in the study area.

(v) Assess the spatio-temporal concentrations of carbon monoxide in Port Harcourt Metropolis.

Hypothesis Statement

There are two hypotheses in this study and they were stated as thus;

1 There is no statistically significant difference in the level of carbon monoxide emissions in the various communities of the study area.

2 There is no statistically significant correlation between point source emissions of carbon monoxide from power generating plants and the ambient carbon monoxide concentrations in the study area.

Method of Study:- The study adopted the cross sectional and experimental design. The descriptive design was based on a cross-sectional sampling of the opinions of individuals on the impact of carbon monoxide emissions from power generating plants in the study area. The experimental design involved the measurement of point source emission of carbon monoxide from the generating sets and ambient air as well as the geographic coordinates of the areas sampled.

Sampling and Sample Size: **-** Port Harcourt Metropolis comprises of Port Harcourt city local government and Obio/Akpor local government. The map of the study area was subdivided into ten grids and two communities were selected from each grid plus additional two communities outside the grid to make up the target population. Thus, in each of the communities selected, two sampling points were selected randomly in the study area as well as measurement of the ambient air within the location, making a total of twenty two (21) samples. Furthermore, the selected communities were stratified into five and at the end fifteen communities were selected with a population of (174,191) and household size (29,032) (National population commission, 1991). A total of 200 copies of questionnaires were administered to each of the fifteen selected communities and about 182 were retrieved.

Method of Data Collection:- The method of data collection was primary and secondary sources. The former was by use of questionnaires, interview, and direct measurement of ambient air quality, carbon monoxide emissions from generating sets with the aid of a hand held GPS. The questionnaires were administered by face to face interview with respondents, while the air quality measurement was done by use of an aeroqual gas monitor equipped with infrared. The range of detection was between 0.01-100ppm with alarm set at 2.00ppm and 20.00ppm. The meteorological data was collected with the use of a portable weather station equipped with probes for ambient temperature, relative humidity, wind direction and wind speed. Both the ambient air measurement, indoor and point source lasted for a period of two (2) month. The ambient air was recorded for morning and evening for each station.

Data Analysis

The data analysed was presented by means of tables, bar charts, pie charts and graphs. Also simple percentages and frequencies were also used to analyze the various data. The hypothesis for the study was tested using one sample student t-test to find out if any significant differences exist in the ambient CO emission level in the selected communities. Pearson Product Moment Correlation Coefficient (PPMCC) was used to see if any relationships exist between the Point Source CO emissions and the Ambient CO concentrations.

Air Quality Index (AQI):- This was used to describe surrounding air quality. The indices for carbon monoxide in each of the sample locations were determined using the model below:

$$AQI_{pollutant} = \frac{\text{Pollutant Data Reading}}{\text{Standard}} \times 100$$

The air quality index (AQI) was a rating scale for outdoor air. The lower the air quality index figure, the better their quality.

Rating Description

A stands for very good (0-15)

B stands for good (16-31)

C stands for moderate (32-49)

D stands for poor (50-99)

E stands for very poor (100-over)

Source: (USEPA, 2000)

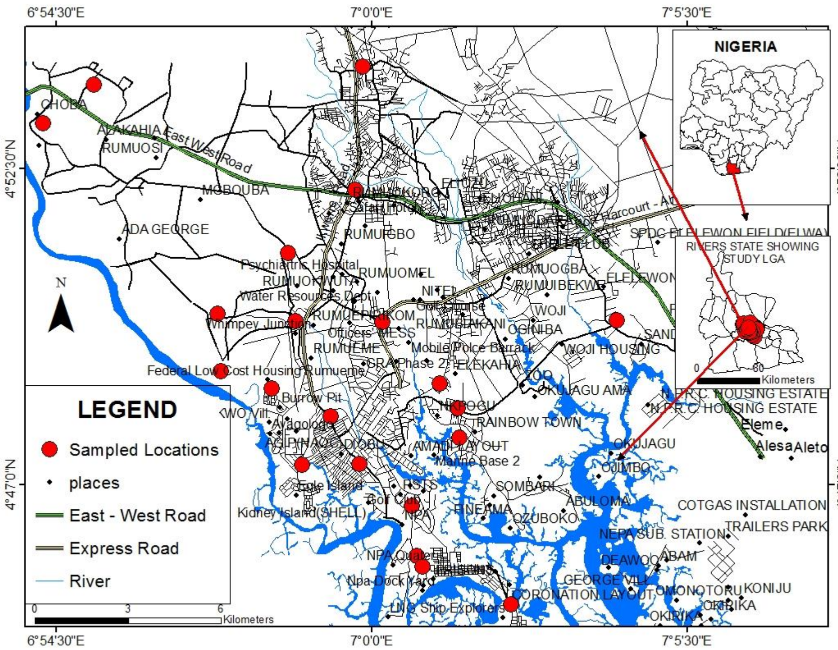

Figure1: Port Harcourt Metropolis showing sampled locations in red symbols.
Source: UniPort, GEM Cartography Laboratory (2018)

Demographic Variables of Respondents
Table 1: Demographic Data of Respondents

Categories	**Frequency (N)**	**Percentage (%)**
Age		
18-25	18	9.8
26-35	105	57.7
36-45	34	8.7
46+	25	13.7
Sex		
Female	54	29.7
Male	128	70.3
Generator Capacity (KVA)		
Those without Generator	16	8.8
0.65-2.2	79	43.4
2.3-5.5	61	33.5
5.6-8.5	20	11.0
8.6 and above	6	3.3
Age of Generator (yrs)		
Those without Generator		
18-25	161	88.5
46 years and above	21	11.5
Type of fuel used in Generators		
Those without Generator	16	8.8
Diesel	21	11.5
Petrol	145	79.7

N=182

From table 1, it shows the percentages of age bracket of respondents. Thus, 9.8% fell within 18-25 years, 57.7% was within 26-35 years, and 8.7% fell into 36-45 years while the remaining 13.7% was from 46 years and above. The sex of the respondents from the same table above indicates 29.7% of the respondents were females while 70.3% were males. The same 1, also revealed the responses of generator capacities in KVA. The table has it that 8.8% of the respondents do not have generator, 34.4% have 0.6-2.2 KVA generator sets, 33.5% have generator of 2.3-5.5 KVA while 11.0% and 3.3% of the respondents have generator sets of 5.6-8.5 and 8.6 and above KVA respectively. The duration of generator usage per year was revealed in table 1, the respondents without generator set were between 16-25 years old (88.5%), while 46 years and above who own generator set were (11.5%). The fuel generator types were 8.8% of respondents those with diesel generator, 11.5%, while 79.7% uses petrol generator.

Table 2: Quantity of Fuel used and Duration of Generator used per day as well as its purpose of usage and Difficulty in Fueling

Categories	Frequency (N)	Percentage (%)
Amount fuel used per day		
Those without Generator	16	8.8
1-5 litres	126	69.2
6 litres and above	40	22.0
Duration of Generator used per day		
Those without Generator	16	8.8
1-5 hours	104	57.1
6 hours and above	62	34.1
Purpose of Generator used		
Those without Generator	16	8.8
Business	19	10.4
Household	147	80.8
Difficult in using Generator		
Those without Generator	16	8.8
No	5	2.7
Yes	161	88.5

N=182

The table 2, above showed the responses on the quantity of fuel per day. Having in mind of that about 8.8% respondents were without generator set, 69.2% upheld 1-5 liters use a day, while 22.0% said 6 liters and above. Duration of generator used per day is shown also. Those without generator set were 8.8%, 57.1% used theirs for 1-5 hours, while 34.1% of the respondents affirmed 6 hours and above. Also the same table showed the purpose for generator usage. Apart from the8.8% without generating set, 10.4%say they use it for businesses, while 80.8% affirmed it was for household purposes. Difficulty in fueling generator was revealed, 2.7% affirmed they don't find it difficult, while 88.5% said they do because of harsh economy.

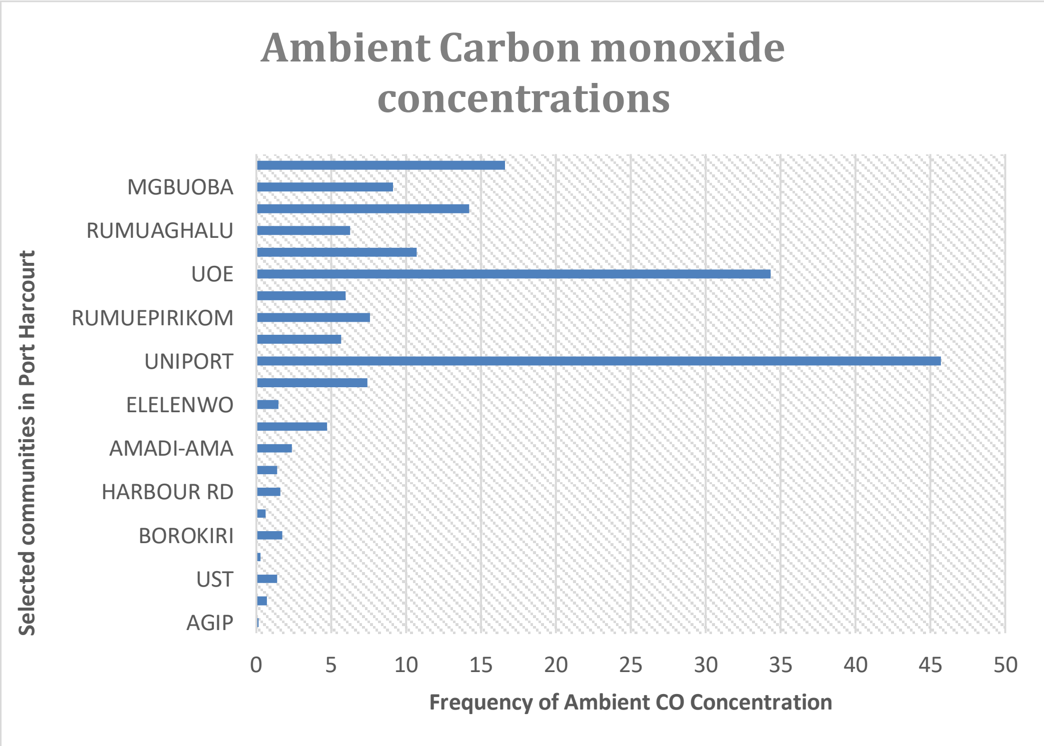

Figure 1: Ambient CO concentrations in the selected Communities

Figure 1 shows the ambient concentrations of carbon monoxide in the selected communities. However, it was higher in communities such as Rumuagholu, Elekahia, U.O.E and UniPort areas with concentrations of 14.22ppm, 16.62ppm, 34.33ppm and 45.70ppm respectively. The rest of the communities were within the accepted limit as stipulated by the national ambient air quality standard.

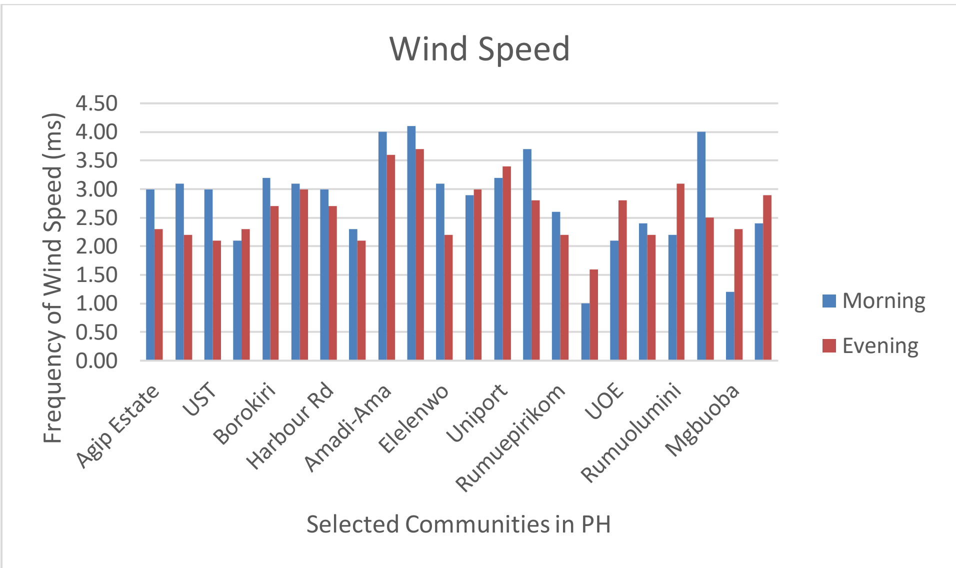

Figure 2: Wind Speed measurement in selected communities

Figure 2, above presents the wind speed in meters per seconds in the various communities. The highest wind speed was recorded around Trans-Amadi (morning and evening), Amadi-Ama (morning and evening), UniPort, axis (morning and evening) and Choba (morning and evening) with the records; 4.1m/s and 3.7m/s, 4.0m/s and 3.6m/s, 3.2m/s and 3.4m/s, and 3.7m/s and 2.8m/s respectively.

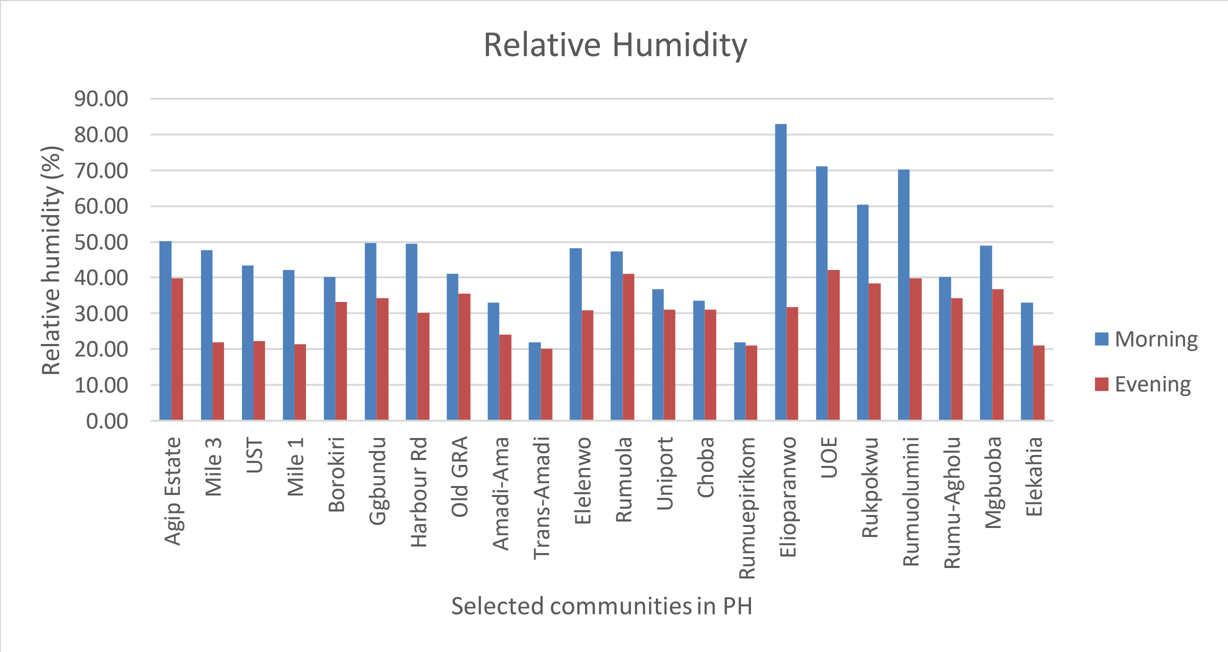

Figure 3: Relative humidity measurement in selected communities.

Figure 3 shows the relative humidity in percentage in the selected communities. It shows that Elioparanwo, U.O.E, Rumuolumeni, Rukpokwu and Agip Estate had the highest water in the atmosphere with the relative humidity of 82.9% in the morning, 71.1% in the morning, 70.3% in the morning, 60.4% in the morning and 50.2% in the morning respectively.

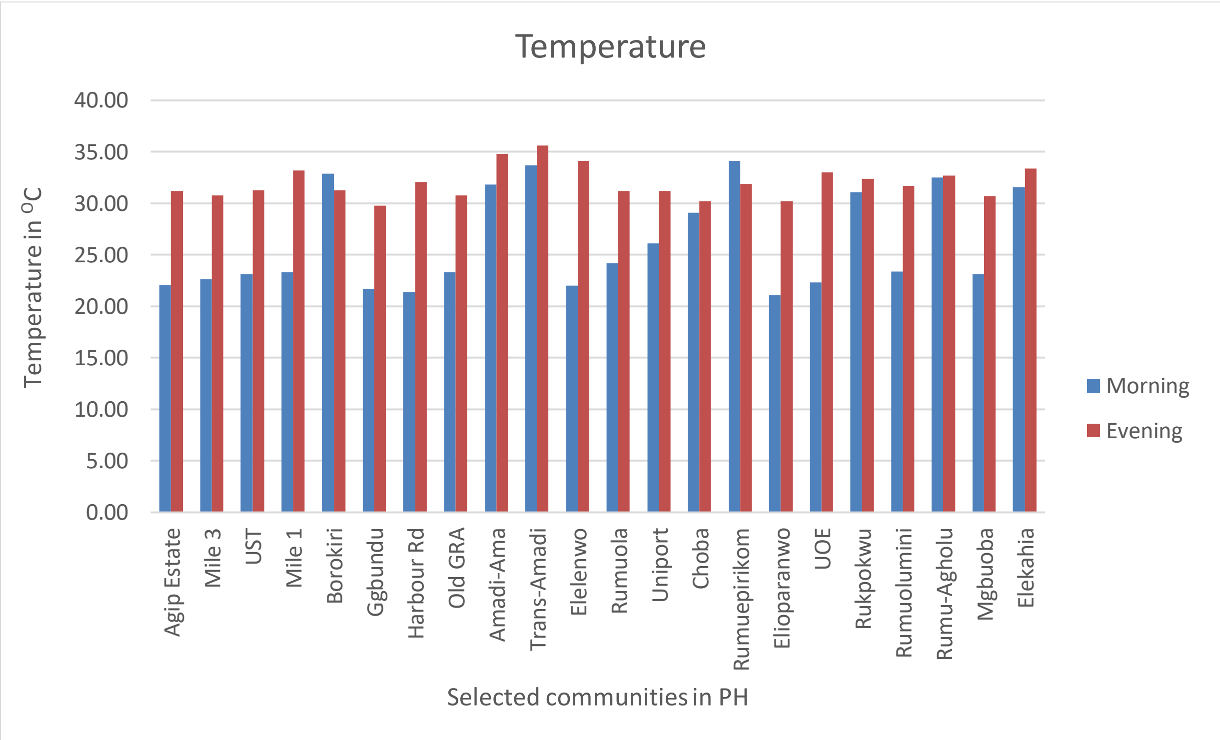

Figure 4: Temperature measurement in selected communities

Figure 4, above revealed the temperature of the selected communities in degree Celsius, with the highest recorded temperature of 35.6^{0}c, 34.3^{0}c and 34.1^{0}c around Trans-Amadi, Amadi-Ama and Elelenwo respectively. While the lowest of 21.1^{0}c, 21.4^{0}c and 21.7^{0}c was around Elioparanwo, Harbour Road and Bundu respectively.

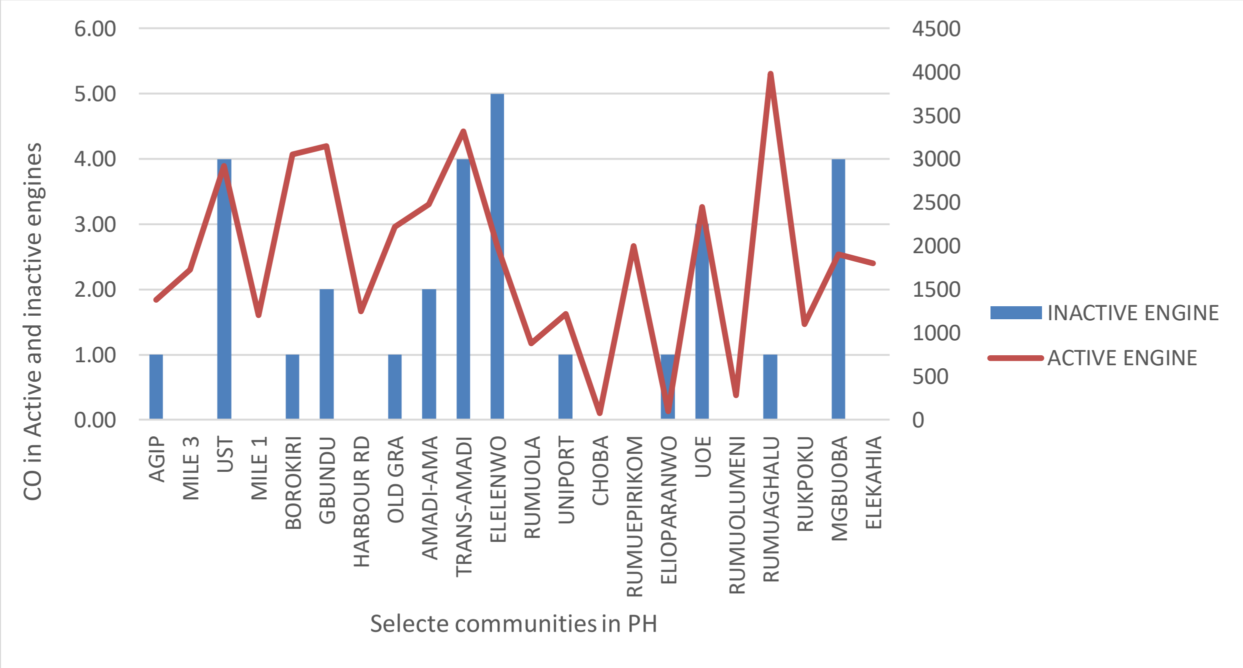

Figure 5: CO concentrations in -active and in-active generating sets

The figure 5, above presents CO concentrations in active and inactive engines in ppm. the highest concentrations of CO in active diesel engine with a temperature of 110^{0}c was 3982ppm, followed by 3320ppm from diesel engine with temperature of 109.3^{0}C, 3150ppm from diesel engine with the temperature of 72.1^{0}C. The highest concentrations for petrol engines was 1800ppm with temperature of 69.4^{0}C, 1723ppm with temperature of 65^{0}c and 1377ppm with temperature of 56^{0}C respectively

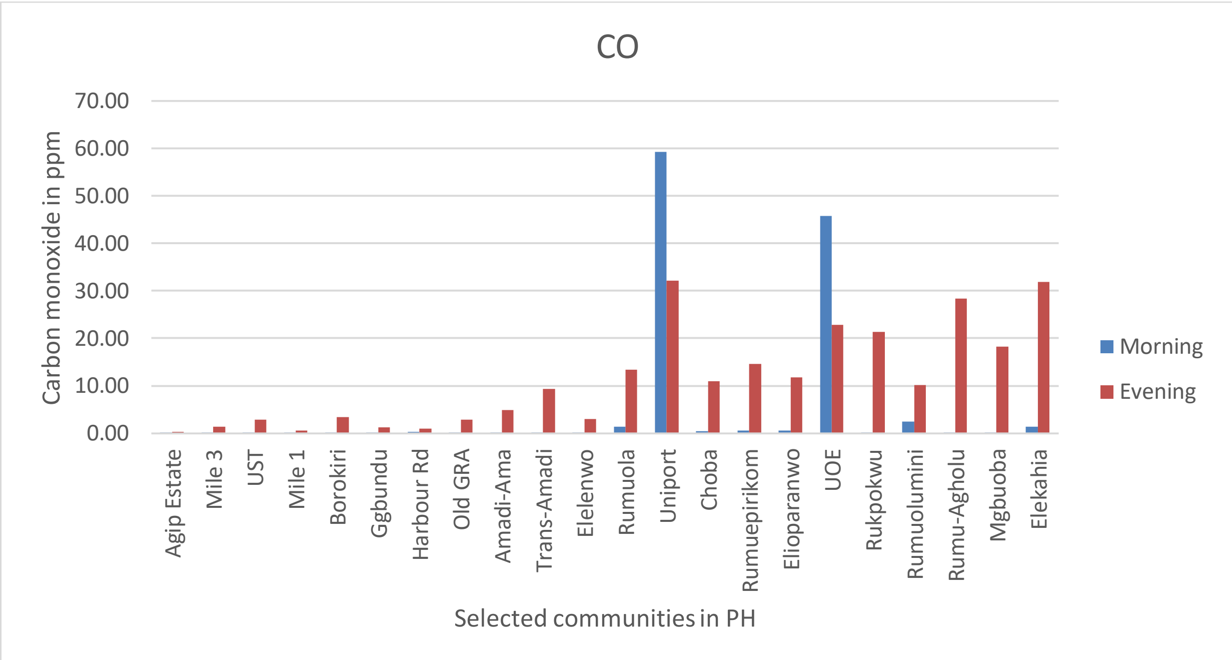

Figure 6: Spatio-temporal concentrations of CO in the selected communities

The above 6, figure shows the temporal concentrations CO in the selected communities. It revealed that UniPort axis had the highest concentrations during the day with concentrations of 59.2ppm and 32.10ppm in the evening. University of Education area followed with 45.82ppm in the morning period and 22.83ppm in the evening. On the other hand, Elekahia and Rumuagholu had the highest concentrations in the evening with 31.90ppm and 28.3ppm respectively.

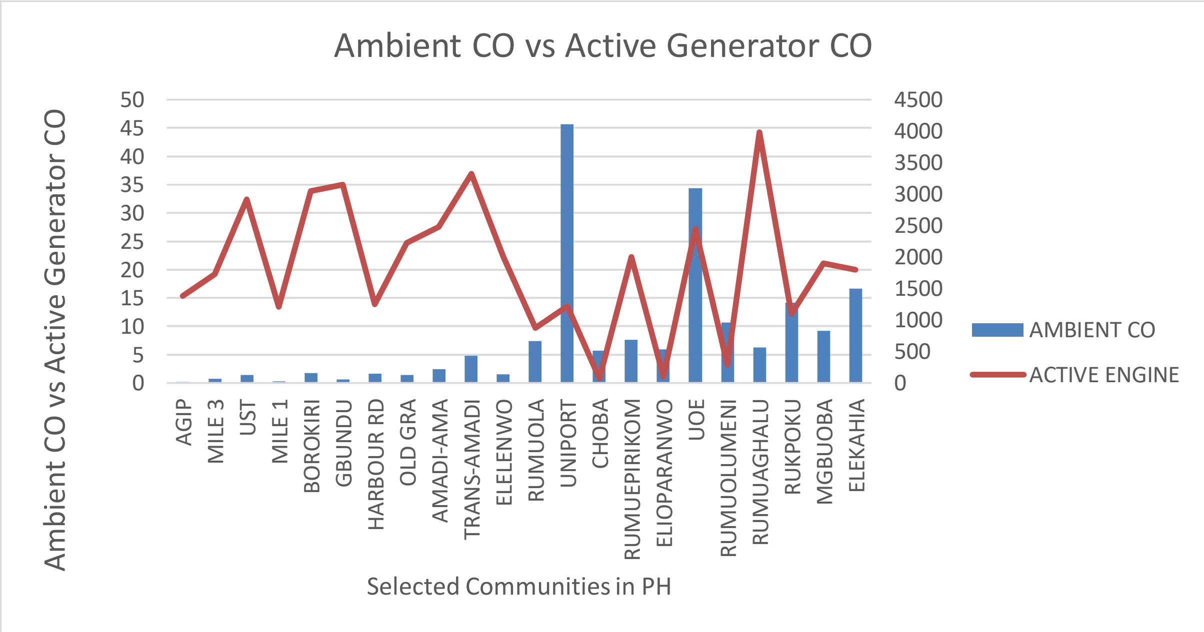

Figure 7: Concentrations of ambient CO and point source in the selected Communities

The above figure 7, presents the ambient CO concentrations and point source emission in the selected communities. The highest CO concentration from point source was 3982ppm while that of ambient air was 45.70ppm. This is followed by 3320ppm from point source and 34.33ppm from ambient air respectively.

Table 3: Air Quality indices for CO and ratings for the selected communities

S/N	STATIONS	INDICES OF AIR QUALITY	RATINGS
1	AGIP	0.46	Very Good
2	MILE 3	2.03	Very Good
3	UST	4.09	Very Good
4	MILE 1	0.89	Very Good
5	BOROKIRI	5.06	Very Good
6	GBUNDU	1.89	Very Good
7	HARBOUR RD	4.63	Very Good
8	OLD GRA	4.03	Very Good
9	AMADI-AMA	6.89	Very Good
10	TRANS-AMADI	13.60	Very Good
11	ELELENWO	4.23	Very Good
12	RUMUOLA	21.26	Good
13	UNIPORT	130.57	Very Poor
14	CHOBA	16.23	Good
15	RUMUEPIRIKOM	21.63	Good
16	ELIOPARANWO	17.09	Very Good
17	UOE	98.09	Poor
18	RUMUOLUMENI	17.89	Very Good
19	RUMUAGHALU	40.63	Moderate
20	RUKPOKU	28.57	Good
21	MGBUOBA	26.17	Good

22	ELEKAHIA	47.49	Moderate

0-15= Very Good; 16-31=Good; 32-49=Moderate; 50-99= Poor; 100> =Very Poor

Table 3, above present's ambient air quality indices for carbon monoxide and its rating in the selected communities. UniPort had a 'very poor' index of 130.57ppm, U.O.E with a 'poor' index of 98.09ppm while Elekahia and Rumuagholu had 'moderate' indices of 47.4ppm and 40.63ppm respectively. However, the rest communities had 'very good' and 'good' air quality indices.

Table 4: Indoor carbon monoxide concentrations in the communities

S/NO	Communities	Carbon monoxide concentration in atmosphere (ppm)
1	Agip Estate	0.10
2	Mile 3	1.50
3	UST	0.01
4	Mile 1	1.20
5	Borokiri	0.01
6	Gbundu	0.80
7	Harbour Road	1.30
8	Old GRA	2.01
9	Amadi-Ama	5.20
10	Trans-Amadi	8.10
11	Elelenwo	2.15
12	Rumuola	2.10
13	Uniport	10.40
14	Choba	5.60
15	Rumu-Epuikon	0.01
16	Elioparanwo	1.10
17	UOE	7.10
18	Rukpokwu	0.01
19	Rumuolumini	3.20
20	Rumu-agholu	2.10
21	Mgbu-ogba	1.01
22	Elekahia	4.02

Table 4, above presents the indoor carbon monoxide concentrations in the various communities. However, UniPort axis recorded the highest concentration of 10.40ppm followed by Trans-Amadi axis had concentration of 8.10ppm and UOE with concentration of 7.10ppm, respectively.

Hypotheses Testing… 1

$H_{0(a)}$: There is no statistically significant difference in the ambient CO concentrations in the various Communities

$H_{1(a)}$: There is……

Table 5: Contingency table for Hypothesis ; one

One-Sample Test

	Test Value = 0						
	t	df	t-cal	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Ambient CO	3.376	21		.003	8.20091	3.1490	13.2528

Variable	N	Df	t-cal	t-crit	S/Level	Decision
Ambient CO	22	21	3.376	2.080	0.05	reject

Decision: From table 5 above, at 95% probability level and 21degree of freedom, the t-critical was 2.080 which was less than the t-calculated of 3.376.Therefore, the null hypothesis was rejected and the alternate accepted. This means that actual differences exist in the concentrations as some were above the regulatory standards a few was within the acceptable limit.

Hypothesis ….2

$H_{0(b)}$: There is no statistically significant correlation between the point source CO emissions and the ambient CO concentrations.

$H_{1(b)}$: There is……

Table 6: Contingency table for Hypothesis; two

		AMBIENT CO	CO from Generator
AMBIENT(CO)	Pearson Correlation	1	-.140
	Sig. (2-tailed)		.536
	N	22	22
CO from Generator	Pearson Correlation	-.140	1
	Sig. (2-tailed)	.536	
	N	22	22

Variable	N	df	r-cal	t-crit	S/Level	Decision
Ambient CO CO from Point Source	22	20	0.53	2.086	0.05	Not reject

Decision: From the table 6 above, at the 95% probability level and 20 degree of freedom, the critical statistics was 2.086 which was also more than t-calculated of 0.536. From the foregoing, the null hypothesis was accepted and the alternate rejected.

Summary and Discussions: - The study adopted the cross sectional survey and experimental research design. In table 1, of the study the age brackets of the respondents were thus; 9.8% between (18-25 years), 57.7% was within (26-35 years) 8.7% was within (36-45 years) ,while about 13.7% were (56 years and above). However, these age brackets showed that there was wide gap between the active age that are experienced and that has in-depth knowledge of the questions. Thus, the sex of the respondents in same table showed that 29.7% were females while 70.3% were male respondents. The different KVA of the various generating sets were assessed, as shown in same table 1, as thus, 8.8% of the respondents did not have generators, 43.4% had 0.65-2.2 KVA generator, and 33.5% had 2.3-5.5kva, while 11.0% and 3.3% of the respondents had generator capacities of 5.6-8.5 and 8.6 KVA respectively. The capacities of the various generating sets differ in their combustion rates of fuel and diesel. Some burns the fuel to near completion while some did not, hence releases much carbon monoxide into the ambient air. Some of these plants have been used for years without adequate maintenance resulting to poor performance. The generating sets consume different fuel types, so they differ in their consumption and combustion rates, figures 4, 5, 6 and 7 confirms the assertion. On the meteorological variables in the study area as shown in figures 2, 3 and 4, this corroborates the assertion in another study by (Weli and Adegoke, 2016). The different concentrations of ambient carbon monoxide in the communities was shown in figure 1, and areas such as Rumuagholu, Elekahia, University of Education and UniPort had CO concentrations of 14.22ppm, 16.62ppm, 34.33ppm and 45.70ppm respectively. The concentrations were below the 35ppm limit set by the national ambient air quality standard, except UniPort axis with 10-20ppm epidemiological standard baseline. These areas had the high CO concentrations due to the volume of business activities. The emission of CO was higher with diesel engines with the temperature of 110^0c emitting about 3982ppm of carbon monoxide into the atmosphere, followed by 3320ppm with temperature of 109.3^0C and 3150ppm with temperature of 72.1^0C. However, for petrol engines, the highest concentrations recorded were 1800ppm (69.4^0C), 1723ppm (65^0C) and 1377ppm (56^0C) respectively. After subjecting the data into rigorous analysis, the outcome was thus; at the 95% probability level and 21 degree of freedom, the critical value was found to be 2.080 which was less than the calculated value of 3.376 and the null hypothesis was rejected and the alternate accepted. Furthermore, the second hypothesis was tested using Pearson product moment correlation coefficient to ascertain if any relationship exists between point source emissions from power generating set and the ambient air concentrations of CO in the selected communities. The result showed that at 95% probability level and 20 degree of freedom, the critical value was (2.086) which was higher than the calculated value (0.536), therefore the null hypothesis of no relationship between the point source emission was accepted and the alternate rejected.

Conclusion: - It was revealed from the study through empirical evidence that power generating plants are almost in every homes. Hence, the constant release of the carbon monoxide gas into the atmospheric environment. The concentration of the poisonous gas in certain communities of the study area was alarming which was a source of concern and its attendant negative impact on the health of the inhabitants. Though power generating set was one of the major emitters of carbon monoxide due to the incomplete combustion of the fuel. Other factors that increase the concentration of the high CO in the atmosphere were also stated in the study. The factors are the fuel type, consumption rate, duration or age of the generating sets, lack of maintenance, duration of operation etc. However, epileptic power supply in Port Harcourt Metropolis has indirectly lead to the increase in ambient CO in the study area as most respondents depends on the use of power generating plants in their homes and for their businesses.

Recommendations

- It was suggested that the study should be carried out to measure directly human impact resulting on CO exposure in residential areas in other cities like Obio/Akpor Local government.
- Government must enlighten the general public by way of education on alternative energy use so as to reduce the patronage of power generating set and thereby reduce the excessive CO in the atmosphere.
- Generating sets should be kept at a reasonable distance away from every home and in business areas.
- Every home should install smoke and fire alarm system devices detector that triggers an alarm when the indoor CO exceeds the recommended limit.

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