IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 7, Issue 5 Ser. II (Sep. – Oct. 2019), PP 67-81
www.iosrjournals.org

Ambient Air Quality Evaluation of Port Harcourt and Environs, South-Southern Nigeria.

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Abstract: *Air pollution constitutes the largest among all of the environmental risks: Pollutants such as TSP, SO_2, CO and NO_2 were measured in association with meteorological parameters. The average wind speed within the dry season was 0.78m/s, while the average wind speed at wet season is 1.53m/s. Average temperature observed within the study area is 26.35^0C in wet season and 33.2^0C in dry season. Trans Amadi, Rumuosi Junction, Choba Junction and Eliozu Flyover record highest temperatures of 34.05^0C, 33.35^0C, 31.05^0C, 31.55^0C respectively. From the analysis of the result gotten from data collation in this work, the measured concentration of TSP,NO_2, SO_2 and CO, at Igbo Etche Junction, Choba, Rumuomasi, and Trans-Amadi are higher than those stipulated by Federal Ministry of Environmental and National Ambient Air Quality Standards. With an average concentration of about 129 ppm, CO was analyzed to be the air pollutant with the highest concentration during the dry season with areas like Trans Amadi being the most affected. Similarly, in the wet season, the concentration of lead (Pb) is very high with a value of approximately 83 ppm within Trans Amadi area. Hence, Trans Amadi would be coded with a high Air Quality Index (AQI) and is necessary that this information be made available by the necessary agencies in charge to the inhabitants to warn them of their level of exposures to these pollutants in these areas within the period under review. Both levels of concentrations are above standard permissible limits as per their relative abundance in the atmosphere. From my research results, seasonal variation plays a major role in pollutant migration and concentrations in PortHarcourt. While appeals for government policies/regulations on this matter should be reinforced and strict compliance should be ensured, It is also advisable that carpooling, and by large, urban mass transit be promoted to reduce traffic emission, while industries should be sanctioned to operate in an ecologically friendly manner. These are some of the corrective measures that should be imbibe to enhance a more friendly atmosphere in PortHarcourt city.*

Keywords: *Air Quality, Concentration Meteorology, Pollution and Standard.*

Date of Submission: 17-10-2019 Date of Acceptance: 02-11-2019

I. Introduction

The requisite to determine whether a standard or guideline has been exceeded is called Assessment of Air Quality. This overshadows another objective of air Quality assessment: providing the information needed to estimate population Exposure to air pollution and the effects on the health of the population.

Consequently, population exposures to toxic air pollution are not really addressed by all air monitoring system available. Given the importance of these data for air quality management, this thesis describes strategies and methods for providing information on air quality that is adequate for health impact assessment.

Human exposure to air pollution may result in a variety of health effects, depending on the types of pollutants, the magnitude, duration and frequency of exposure and the associated toxicity of the pollutants of concern. People are exposed to air pollutants (whether includes indoors and outdoors) and this depends on the activities of individuals. Among the different population groups, children, elderly and chronically ill people are especially sensitive and susceptible to levels of air pollution exposure. It is important to note here that health impact assessment combines estimates of population exposure with information on toxicity of the pollutant or the relationship between exposure and response.

Information on the relationship between exposure and response is necessary to estimate the potential health risks. The estimates of health effects for a population base are typically calculated in terms of predicted excess negative health effects (such as increases in hospital admissions or mortality) caused by exposure to a certain level of air pollution. In doing this, each concentration of air pollution in the community being assessed, is combined with the information on the response to certain concentrations derived from epidemiological or toxicological studies with the number of people exposed.

Records have shown that, of all of the environmental risks, Air pollution constitutes the largest: annual deaths of an estimated 3 million people are associated with outdoor air pollution exposure. In the year of 2012 alone, global deaths of about 11.6 percent equivalent to 6.5 million deaths were outdoor air pollution-related. 94% of the approximately 90% of air pollution-related deaths occurring in low and middle-income countries are as a result of non-communicable diseases, including cardiovascular diseases (CVDs), chronic obstructive pulmonary disease (COPD), and lung cancer WHO [1].

II. Literature Review

Industrial activities release major pollutants into the environment thereby causing air, water and land pollution, as well as noise. Industrial pollution is thus a threat to both human, animal and plant life and it affects the aesthetic quality of the environment. Noise, which could stress, related illness and diseases such as cancer, kidney failure nervous disorders, leukemia, mental retardation, hearing failure or total deafness is a fallout of industrial pollution Ogedengbe and Onyuanyi [2]. Industrialization came into play and was seen initially as a sign of development but bore with it more complicated problems. Major activities during production process involve the use of chemical whose bye-products constitute industrial waste that are sometimes discharged carelessly into the environment through pipes, drains, air and land and find their way into water used for drinking, fishing and other purposes.

Traffic flow in the urban centers has been a contributory factor influencing air pollution and this occurrence has reached the critical level in many cities Höglund and Niittymäki [3]. Understanding the relation between vehicle emissions and traffic control measures is an important step toward reducing the potential for global warming, smog, ozone depletion, and respiratory illness. The clean air which was naturally meant to support human health and wellbeing has be contaminated by various chemicals emitted into them from natural and anthropogenic sources thereby causing major health risk to human dwelling in that vicinity and windward side of the pollution sources. According to Oderinde [4]. transport is a vital part of modern life whereby there is opportunity to travel short and long distances for personal development and professional activities. More importantly, the economic development of entire regions depends on the easy access to people, goods and services assured by contemporary transport technology because of its flexibility WHO[1]; Oderinde [4]. In general, transportation improve overall accessibility in terms of business, education, employment and services; and reduce transportation costs (travel time, vehicle operating costs, road and parking facility costs, accident and pollution damages) to increase economic productivity and development. Unfortunately, these positive aspects are closely associated with the hazards to the environment and human health caused by road transport WHO [5]. Today, motor vehicles are responsible for nearly one half of smog-forming Volatile Organic Compounds (VOCs), more than half of the nitrogen oxide (NO_2) emissions, and about half of the toxic air pollutant emissions in the United States. Motor vehicles, including non-road vehicles, now account for 75 percent of carbon monoxide emissions nationwide USEPA [6].

In recent years, studies carried out to assess the levels of criteria air pollutants in cities of Rivers State, including Port Harcourt, and their probable association with air borne diseases, provide evidence of correlation. Adoki [7] carried out air quality survey in four different locations in Rivers state at varying distances (60, 100, and 500 m) from emission source. Conferring to his findings, virtually all the samples complied with (Department of Petroleum Resources (DPR)) guidelines for annual average apart from SOx and NOx whose annual means surpassed specification at only one location. Non-conformity occurred mostly in the dry season. During that season, the levels of the pollutants were disposed to be higher in the evenings and sustained through the early hours of the morning. In all four locations, suspended particulate matter (SPM) conformed to specification of 230ug/m; with highest annual mean being 129ug/m. Like with NOx and SOx, season significantly influenced their concentrations Adoki [7].

Nwachukwu [8] in their survey of a 5-year (2003 to 2007) epidemiological data discovered that the level of all the criteria air pollutants in Rivers State was significantly higher than the WHO specification. They were able to prove that air pollution was associated with air related morbidities and mortalities in the state. Amongst the air-related morbidity assessed, including cerebrospinal meningitis (CSM), chronic bronchitis, measles, pertussis, pulmonary tuberculosis, pneumonia, and upper respiratory tract infection (URTI), pneumonia was the most prevalent for all of the years that were studied, and was responsible for the highest number of deaths in 2005.

The objective of the study is to ascertain the volume of air pollutants and the air quality status in parts of Porthacourt. The acquisition of ambient air quality data in the study area is necessitated by the paucity of records on atmospheric pollutant concentrations that will determine if the study area are within Global and local permissible limits for living healthy. Air pollution level and concentration of the study area was determined with particulate matter (PM_{10}), sulphur (iv) oxide (SO_2), carbon monoxide (CO) and nitrogen (iv) oxide (NO_2). meteorological factors influenced atmospheric pollutant concentrations, as such, meteorological variables (speed wind and wind directions) were also measured in so as to assess the dynamics of atmospheric dispersion of the air pollutants in the study area. Measured air quality were analyzed with reference to the standard threshold limits prescribed by the Nigerian National Ambient Air Quality Standards (Nigerian NAAQS) Abam and Unwachukwu [9] and the United States National Ambient Air Quality Standards (US NAAQS) EPA [10].

Geology of the Study Area.

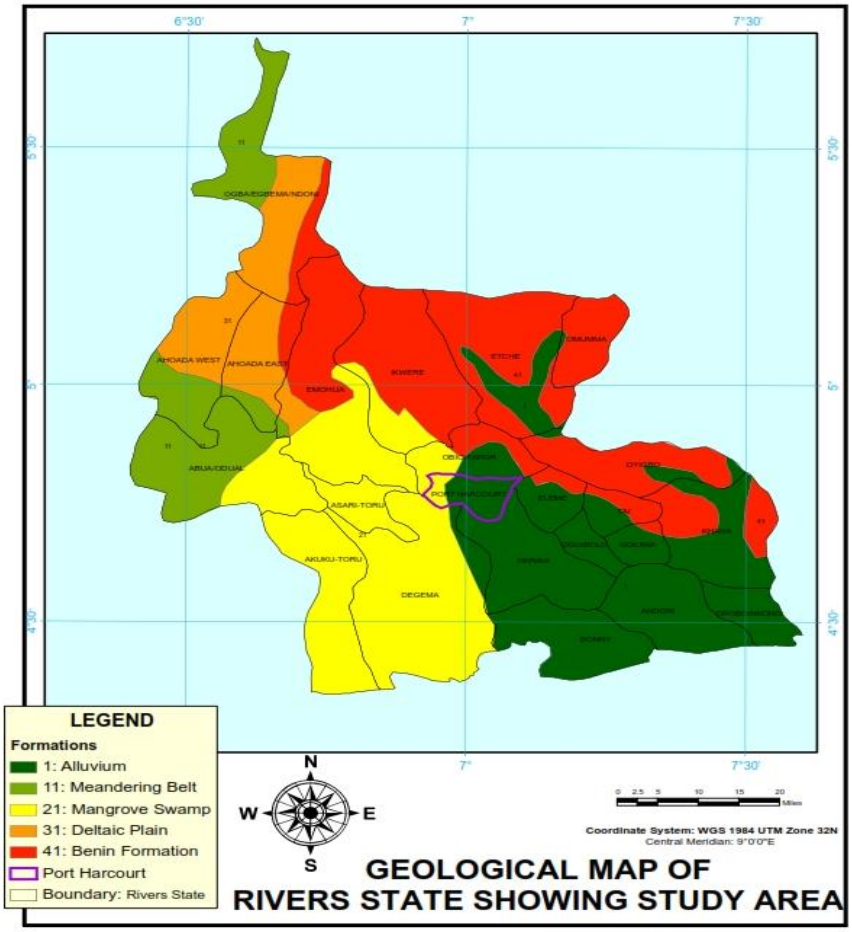
The area under study is part of the Niger Delta basin which has an aerial of 75,00km2. It has an overall regressive classic sequence and is divided into three ranging from Eocene to recent age short and stauble [11]. They include the following:

- The Benin formation
- Agbada formation
- Akata formation.

The Akata formation is composed mainly of shales deposited as turbidity and continental slope channel fills.

The Agbada formation consists mainly of sandstone and shales intercepted by a number of growth faults and a rapidly vertical and lateral facie change.

The Benin formation is made of porous sand and gravels with localized shales/clay interbeds occurring as point bars or channel fills.



ADAPTED FROM NGSA 2006 MAPPING OF NIGERIA

III. Materials and Method

Study area: The study area is parts of Porthacourt which is associated with a lot of commercial and industrial activities including the use of power generators,high volume of vehicular traffic, crude oil related activities like gas flaring.

Procedure: Gas Samplers/Analyzers was used to monitor air quality in-situ at the study area at different communities within the study area. These communities are Choba, Rumuosi, Eliozu, Rumuobiokani, Oil Mill, Igbo Etche, Rumukurushi, Trans-Amadi, and Omagwa as Control point. Monitoring was done at wet and dry season monitoring.

Extech Anemometer: A multi-parameter digital anemometer Model No. 45170 will be used to measure the wind speed, and direction in m/s. It will be held up in an open space with a consideration of a distance as indicated above from source. This is to avoid unnecessary interference from shades. Measurement will be taken on an hourly basis. This anemometer is multi-functional: It has the capacity to measure temperature in ^{0}C, Absolute Pressure in Pascal, and Relative Humidity as %.

Noise Meter: Sound Pressure Level Meter with the model TES1352H will be used to measure the noise level at each point in decibels. Measurement will be taken on an hourly basis for 8hours. The sensor of the noise will be directed towards the source and the main reading taken over a period of 2 minutes. The equipment measured noise via the microphone probe that generates signals approximately proportional to sound waves. Measuring Range: 30 – 130Dba, Accuracy +/- 1.5dB, Resolution: 0.1dB. Frequency: 20HZ TO 8.5KHZ.

Testo Gas Analyser: A portable gaseous emission analyzer, the TESTO 350-XL, from Testo Inc. (Testo, 2009), collects and stores data independently for up to 48 hours. It measures O_2, CO, NO_x, NO, NO_2, SO_2. Features include a menu driven user interface and LCD display. Auto calibration and probe blow back is offered. Flow rate and sensor temperature monitoring for US EPA CTM-030, -034 and ASTM D6522 requirements. For Simple on-site sensor, calibration capability including diagnostics and sensor output is from about (0 – 100%).

Sulphur Dioxide (SO_2)

SO_2 was monitored continuously by pulsed fluorescence. This is the method where air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. SO_2 in the sample is agitated to a higher energy level and upon returning to its original state, fluorescence is released. The amount of fluorescence measured is proportional to the SO_2 concentration.

Oxides of Nitrogen (NO)

NOx are measured continuously by the principle of chemi-luminescence. This is a method where the air sample is split into two pathways; one to measure NO, and the other to measure total NOx. The sample goes directly to the analysis chamber, is mixed with O_3, resulting to the production of light. The amount of light detected is proportional to the NO concentration and is a measurement of NO in the sample air. In the second pathway, a catalytic converter is used to first change all the NO_2 in the sample air to NO_2, and then the sample goes on to the analysis chamber. This measurement is the sum of NO_2 and NO, expressed as NOx. The difference of the readings between the two pathways is determined electronically and is the NO_2 concentration.

Carbon Monoxide, CO

The equipment detects CO via an Electrochemical Sensor that generates a signal linearly proportional to the concentration of the pollutants. CO is monitored continuously by non-dispersive infrared photometry. This detection process is based on the absorption of infrared light by CO.

Non-dispersive infrared photometry or gas filter correlations are instruments by whichCO is monitored continuously. The process of non-dispersive infrared photometry is based upon the absorption of infrared light by CO while the Gas filter correlation is activated on the same standard as non-dispersive infrared photometry but is more specific to CO by reducing water vapor, CO_2 and other interferences.

Total Suspended Particulate Matter (TSPM) and Particulate Matter (PM_{10})

A Mini Volume instrument, Aerosol gas monitor was used to measure Total Suspended Particulate Matters and heavy metals. MiniVol Portable Air Sampler manufactured by Air metrics is a portable ambient air sampler for particulate (PM_{10}, $PM_{2.5}$ and SPM) and/or non-reactive gases (CO, NO_x). This instrument was conjointly technologically advanced by EPA and the Lane Regional Air Pollution Authority LRAPA) to discourse the need for portable survey sampling modalities.

The sampler consists of a vacuum system and filter housed in a shelter and operates on the same principle as a vacuum cleaner. A known volume of air is drawn through a pre-weighed filter for a 8-hour period. The filter is then re-weighed to determine the mass of the particles collected.

Method of data interpretation: Data was analyzed using geospatial and geostatistical techniques with the mean values of the air pollutant concentrations estimated for measurements made in the dry and wet season. The standard deviation (SD) and variance were determined while the estimated co-efficient of variation (CV%) was used to assess the variation in the concentration levels of the air pollutant monitored using Eq.1

$$CV\ (\%) = \frac{SD}{Mean}\ x100 \qquad 1$$

Where:

CV (%) = Coefficient of variation
SD= Standard deviation

ArchGIS software was used to generate the pollutants concentration maps, while Sim-air quality software was used to calculate the air quality index of the air pollutants using Eq. 2:

$$I_P = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}}(C_P - BP_{Lo}) + I_{Lo} \qquad 2$$

I_p = Index for pollutant

C_p = Rounded concentration of pollutant p

BP_{Hi} = Breakpoint that is$>C_p$

BP_{Lo} = Breakpoint that is$<C_p$

I_{Hi} = AQI value corresponding to BP_{Hi}

IL_o = AQI value corresponding to BP_{Lo}

IV. Results and Discussion

This research is a probe to understand the air quality dynamics within Port Harcourt City and its environs. It provides a detail outlook of spatial air pollutant concentration from a non-point source perspective in both seasons of the year (Dry and Wet seasons). Pollutants measured in this studied include: TSP, So_2, CO and NO_2.

Meteorological parameters also analyzed here include ambient temperature, Relative Humidity, Wind Speed and Wind Direction. These results are shown in table 1and table 2.

Table 1: Wet Season Meteorological Data of Study Area

Location	Labels	X	Y	Wind Speed	Wind Direction	Humidity	Temp
Igbo Etche Junction	1	284638	529001	1.9	SW	70.45	29
Oilmill Bus Stop	2	283183	525429	1.5	SW	73	28.6
Rumukrushi Park	3	281397	526421	1.1	SW	69.5	28.5
Rumuobiakani Junction	4	279346	524966	1.4	SW	66.7	29.45
Rumuomasi Junction	5	279082	528009	0.95	SW	70.5	29.1
Eliozu Flyover	6	280074	529927	1.25	SW	68.45	31.55
Omagwa Junction (Control)	7	276965	530919	1.55	SW	69.15	30.65
Choba Junction	8	273568	527820	1.7	SE	55.75	31.05
Rumuosi Junction	9	271055	531708	0.55	NW	49.05	32.35
Transamadi	10	282654	530390	1	NW	63.35	34.05

Table 2: Dry Season Meteorological Data of Study Area

Location	Labels	X	Y	Wind Speed	Wind Direction	Humidity	Temp
Igbo Etche Junction	1	284638	529001	1.7	NW	100	25.15
Oilmill Bus Stop	2	283183	525429	1.05	SE	100	25.6
Rumukrushi Park	3	281397	526421	1.25	SW	100	25.05
Rumuobiakani Junction	4	279346	524966	1.25	SE	100	25.3
Rumuomasi Junction	5	279082	528009	1.9	SE	100	25.15
Eliozu Flyover	6	280074	529927	1	NW	89.2	27.2
Omagwa Junction (Control)	7	276965	530919	1.4	SE	100	25.1
Choba Junction	8	273568	527820	0.75	SE	96	25.55
Rumuosi Junction	9	271055	531708	1.75	SE	96.05	25.55
Transamadi	10	282654	530390	1.3	SE	89.85	27.15

Table 3: Concentration of the measured air pollutants in wet season in the study area.

	LABELS	X	Y	LABEL	Noise	PM_{10}	TSP	NO_2	CO_2	CO	SO_2
Igbo Etch	1	284638	529001	14	71.2667	658.3	944.833	0.33333	0.18333	3.5	0
Oilmill Bu	2	283183	525429	15	90.3333	193.467	246.933	1.13333	0.2	32.3667	1.26667
Rumukrus	3	281397	526421	16	89.4333	184.5	254.767	0.66667	0.2	17.3333	1.13333
Rumuobia	4	279346	524966	20	96.4	177.533	211.533	0.33333	0.26667	13.3333	1.03333
Rumuom	5	279082	528009	21	79.8	167.367	200.133	0.33333	0.23333	21.9	1
Eliozu Fly	6	280074	529927	23	93.5	82.3	117.567	1.1	0.03333	9	1
Air Port J	7	276965	530919	26	69.8333	113.867	136.133	0.66667	0.06667	2.4	1
Choba Jun	8	273568	527820	29	100.933	386.933	537.9	1.04333	0.2	21.3333	1
Rumuosi J	9	271055	531708	30	91.3667	353	496.933	1.04	0.23333	4.3	0.33333
Transama	10	282654	530390	52	90.8	7028.8	7660.77	0	0.36667	4.06667	0

Table 4: Concentration of the measured air pollutants in dry season in the study area.

	LABELS	X	Y	LABEL	Noise	PM_{10}	TSP	NO_2	CO_2	CO	SO_2
Igbo Etch	1	284638	529001	14	71.2667	658.3	944.833	0.33333	0.18333	3.5	0
Oilmill Bu	2	283183	525429	15	90.3333	193.467	246.933	1.13333	0.2	32.3667	1.26667
Rumukrus	3	281397	526421	16	89.4333	184.5	254.767	0.66667	0.2	17.3333	1.13333
Rumuobia	4	279346	524966	20	96.4	177.533	211.533	0.33333	0.26667	13.3333	1.03333
Rumuoma	5	279082	528009	21	79.8	167.367	200.133	0.33333	0.23333	21.9	1
Eliozu Fly	6	280074	529927	23	93.5	82.3	117.567	1.1	0.03333	9	1
Air Port J	7	276965	530919	26	69.8333	113.867	136.133	0.66667	0.06667	2.4	1
Choba Jun	8	273568	527820	29	100.933	386.933	537.9	1.04333	0.2	21.3333	1
Rumuosi J	9	271055	531708	30	91.3667	353	496.933	1.04	0.23333	4.3	0.33333
Transama	10	282654	530390	52	90.8	7028.8	7660.77	0	0.36667	4.06667	0

Table 5: Comparison of air pollutants concentrations against NAAQS / FEPA permissible limits.

Air pollutants / location	Igbo Etche Junction	Oilmill Bus Stop	Rumukrushi Park	Rumuobiakani Junction	Rumuomasi Junction	Eliozu Flyover	Air Port Junction omagwa (control point)	Choba Junction	Rumuosi Junction	Transamadi
TSP.Wet	64.067	95.833	77.87	54.63	51.37	48.6	40.5333	51	48	49.6
TSP.Dry	944.83	246.93	254.8	211.5	200.1	117.57	136.133	538	496.9	1661
NAAQS Limit	200	200	200	200	200	200	200	200	200	200
FM Env Limit	250	250	250	250	250	250	250	250	250	250
FEPA	1	1	1	1	1	1	1	1	1	1
CO.WET	1.9467	4.5	4.267	4	4.567	4.31	0.6	10	2.667	2.343
CO.DRY	3.5	32.367	17.33	13.33	21.9	9	2.4	21.3	4.3	4.067
FM Env limit	10	10	10	10	10	10	10	10	10	10
NAAQS limit	9	9	9	9	9	9	9	9	9	9
$SO_{2.WET}$	0	0.1467	0.74	0.333	0.247	0.4633	0	0.62	0	0
SO_{2Dry}	0	1.2667	1.133	1.033	1	1	1	1	0.333	0
FM Env Limit	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NAAQS Limit	0.14	0.14	0.14	0.14	0.1	0.14	0.14	0.1	0.14	0.14
NO_{2Wet}	0	0	0	0	0	1	0	1	1	0
NO_{2Dry}	0.3333	1.1333	0.667	0.333	0.333	1.1	0.66667	1.04	1.04	0
FM Env limit	0.06	0.06	0.06	0.06	0.1	0.06	0.06	0.1	0.06	0.06
NAAQS limit	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Metrological Analysis:
Wind Speed/Direction.

The dominant wind direction in the wet season was within the SE direction, with a few exceptions within the NW direction as indicated in figure 2, while in the dry season, the dominant wind direction is SW, with a few exceptions in the NW as indicated in figure 1. Pollutant dispersion is influence greatly by wind speed and direction. Wind speed is dominantly higher in the dry season, than in the wet season except in locations 10, 9 and 5(Trans Amadi, Rumuosi, and Rumuobiakani junctions), which records higher values of wind speed in wet season than in the dry. This exception is shown in figure 1. The least value of wind speed in recorded in the dry season at location 9 (Rumuosi Junction) as shown in the table 1, while highest value of 1.9m/s is recorded in both seasons.The average wind speed within the dry season was 0.78m/s, while the average wind speed at wet season is 1.53m/s.

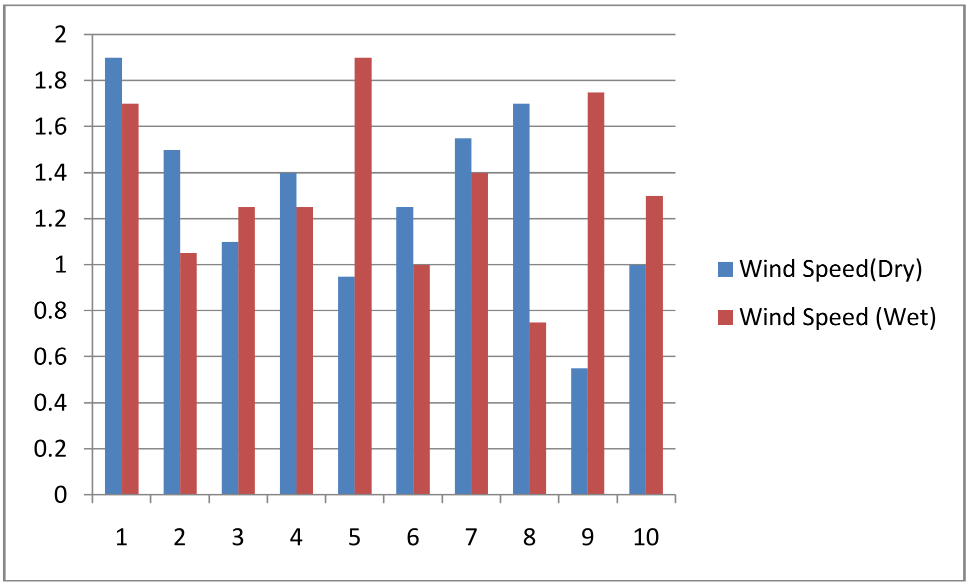


Figure 1: Seasonal Variation of Wind Speed in the Study Area

Relative Humidity Distribution.

Relative humidity recorded within all the sampling location is higher in wet season than in dry season as shown in figure 2. The least value is recorded at location 9 (Rumuosi) in the dry season, while the highest is recorded at locations 1,2,3,4,5,7(Igbo Etche Junction, Oil Mill Buststop, Rumukurishi park, Rumuobiokani junction,and Eliozu Flyover) during the wet season as shown in table 2.

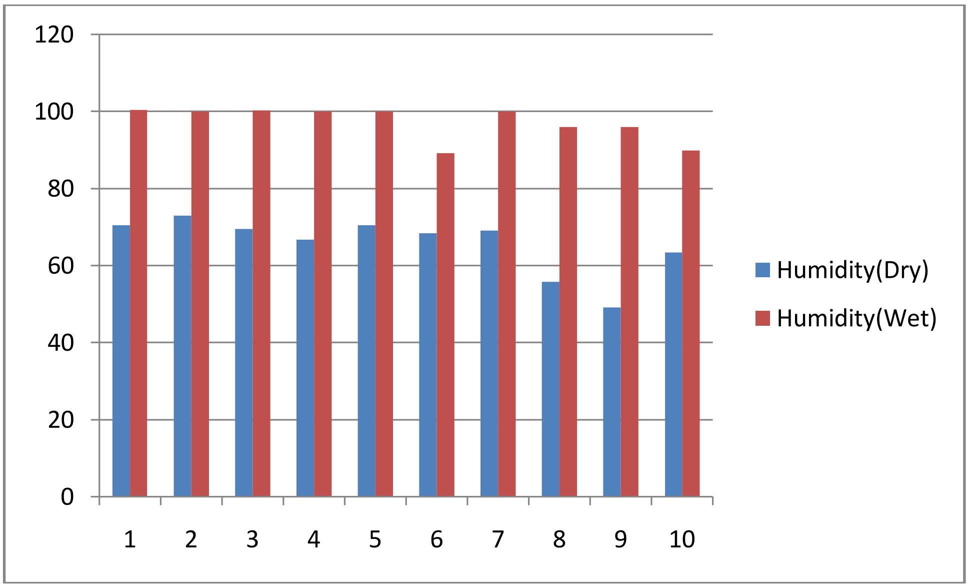


Figure 2: Seasonal Variation of Relative Humidity in the Study Area

Temperature

The temperature has a direct correlation with relative humidity. Higher temperature drives a lower relative humidity, while lower temperature accounts for the higher values of relative humidity. Temperature observed with the area of study is higher in dry season than in wet season and follows the same trend with Relative Humidity as shown in figure 3. Average temperature observed within the study area is 26.35^{0}C in wet season and 33.2^{0}C in dry season. Trans Amadi, Rumuosi Junction, Choba Junction and Eliozu Flyover record highest temperatures of 34.05^{0}C, 33.35^{0}C, 31.05^{0}C, 31.55^{0}C respectively. This is shown in table 2.

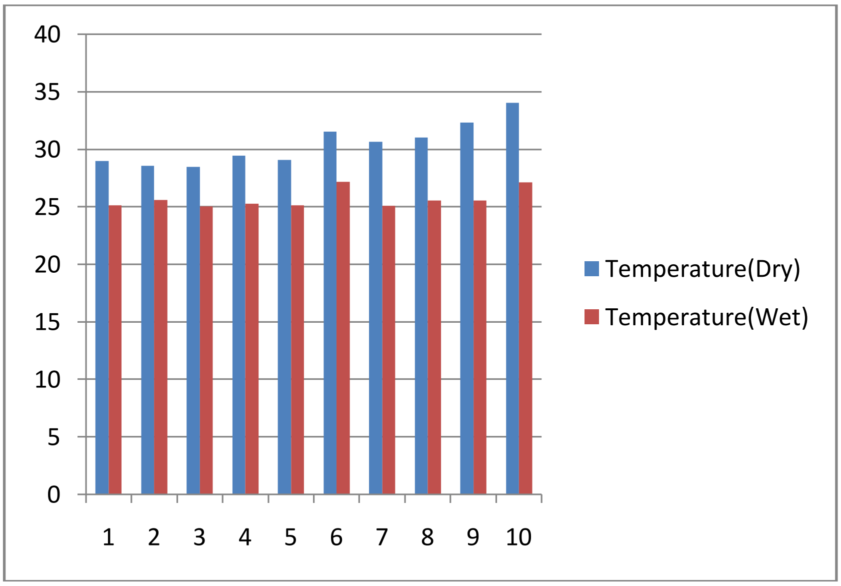


Figure 3: Seasonal Variation of Temperature in the Study Area

Spatial Distribution of Pollutants.

Total Suspended Particles: The measured concentration of Total Suspended Particles within the study area in rainy season shows a lower concentration values than those stipulated by Federal Ministry of Environmental and National Ambient Air Quality Standards as shown in figure 4. Howbeit, there are exceptions of measured dry season values in locations 1,8,9,10 (Igbo Etchejuction, Choba, Rumuomasi, and Trans Amadi) higher than the aforementioned standards. This is shown in figure 4. Measured dry season concentrations of TSP at locations 6 and Control are below those of the stipulated standards.

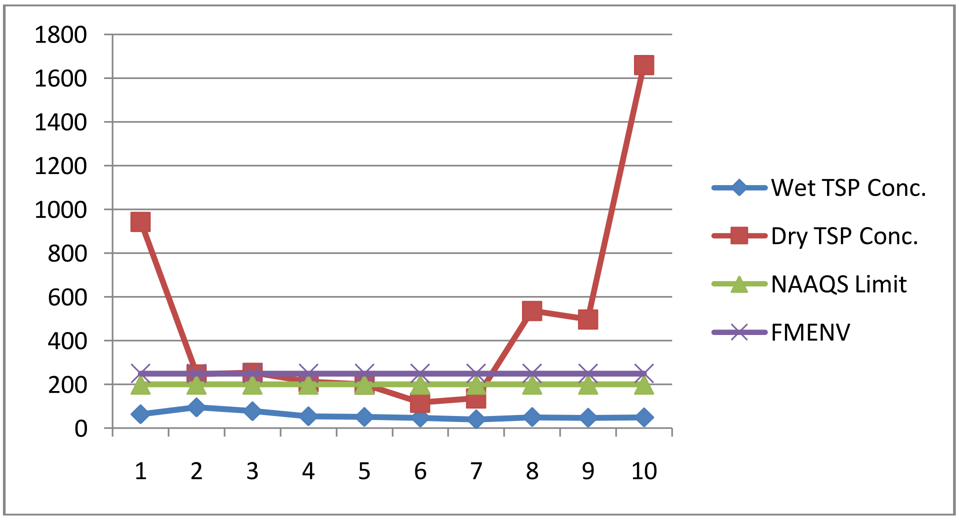


Figure 4: Chart showing a Comparism of Measured TSP Values with Standards

The spatial distribution map shown in figure 18 and 19 shows that the measured concentration values of TSP is higher in dry than in wet season. Concentration values during wet season are below 50µg/m3, while that of dry seasons are higher than 100µg/m3, which is at least doubled. Hotspots of TSP identified during the wet season are Oil Mill Bus Stop, followed by RumukurishiPark with a concentration of 89.5µg/m3 to 95.6µg/m3, and 77.3µg/m3 to 83.4µg/m3. This could be caused by the high human and vehicular traffic in the region.

In the dry season, the hotspot shifts to Trans-Amadi with the highest concentration ranging from 6795.8 µg/m3 to7629.6 µg/m3. The favorable weather during this period creates a resurgence of TSP emission due to increased industrial activities in this area which was reduced in the wet season. The North Western part of Port Harcourt is least affected by TSP emission.

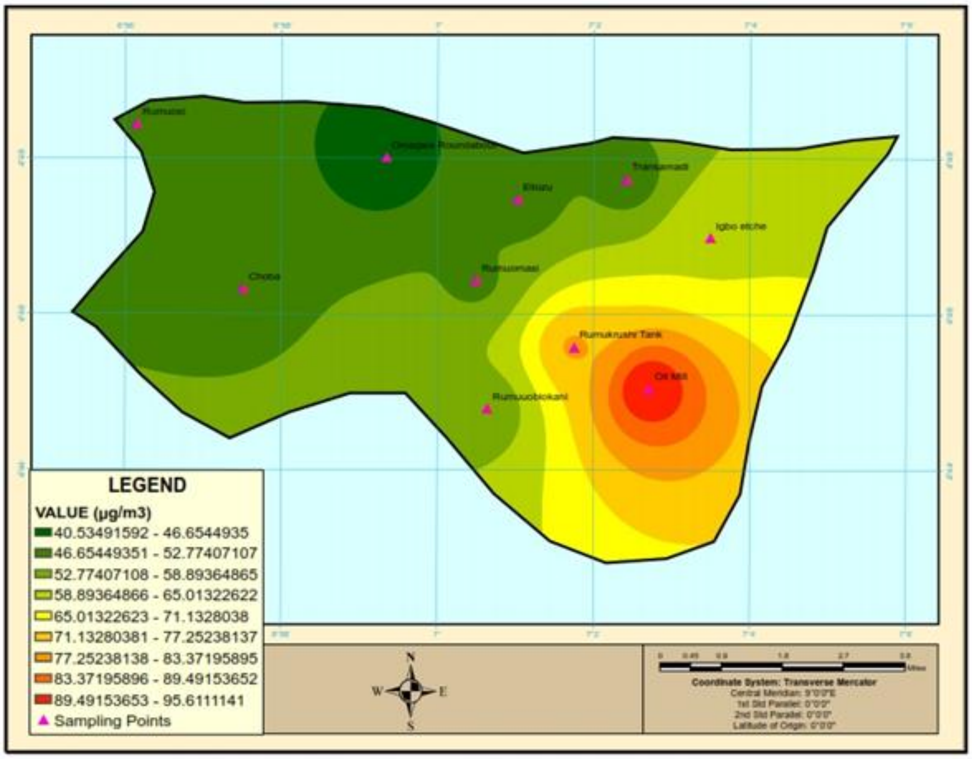


Figure 5: TSP Map (Wet Season) of the study area

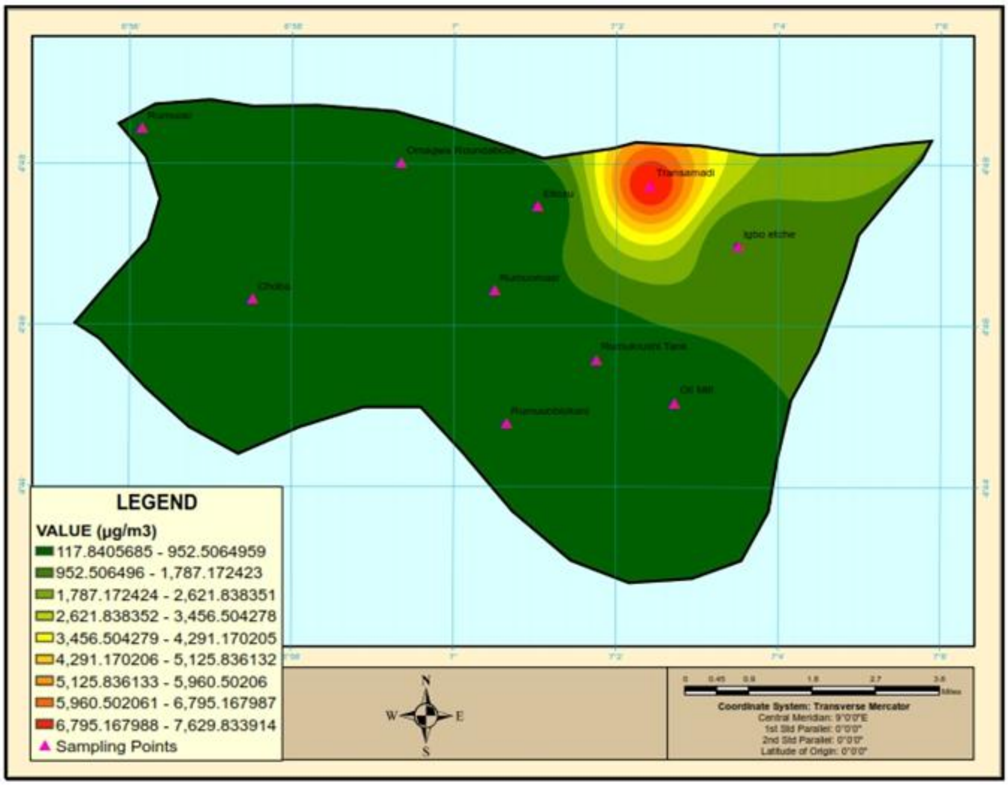


Figure 6: TSP Map (Wet Season) of the study area

SO_2 Distribution:

The spatial distribution map shown in figure 7 and 8 shows that the measured concentration values of SO_2 is higher in dry than in wet season. Concentration values during wet season are below 0.75ppm, while that of dry seasons are higher than 1ppm. Hotspots of SO_2 identified during the wet season are Rumukurishi Park, followed by Choba Junction with a concentration of 0.74ppm, and 0.67ppm. This could be caused by the high human and vehicular traffic in the region.

In the dry season, the hotspots shifts to Oil Mill Bus Stop and Rumukurishi park with a concentration of 1.12ppm to 1.26ppm, and 0.98ppm to 1.12ppm. The North Eastern and Western part of Port Harcourt is least affected by SO_2 emission. The reduction of moist (Relative Humidity) in the atmosphere makes dispersion of pollutant rapid and intense, therefore accounting for a high dispersion and concentration of pollutant within the area of study.

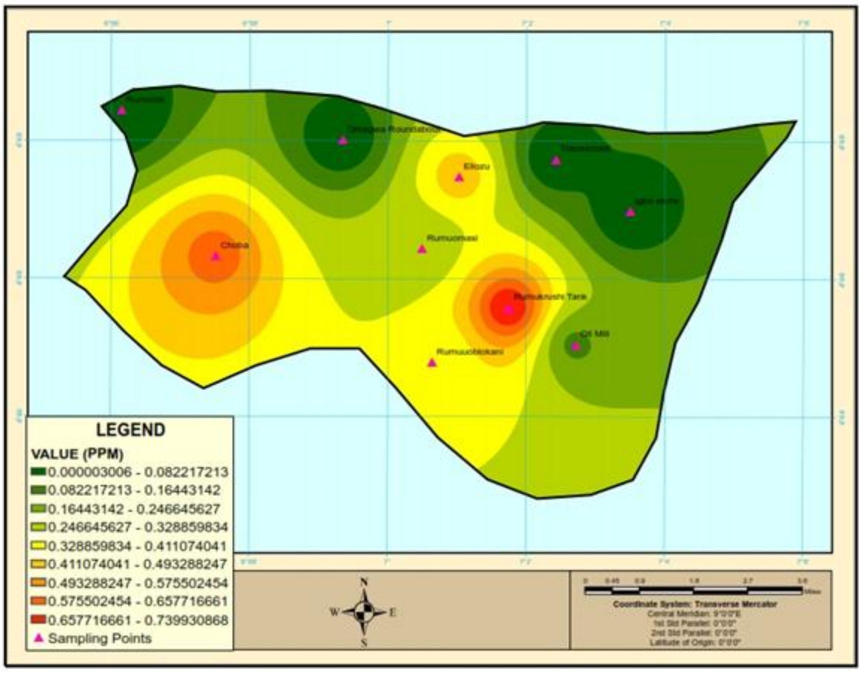


Figure 7: SO2 Map (Wet Season) of the study area

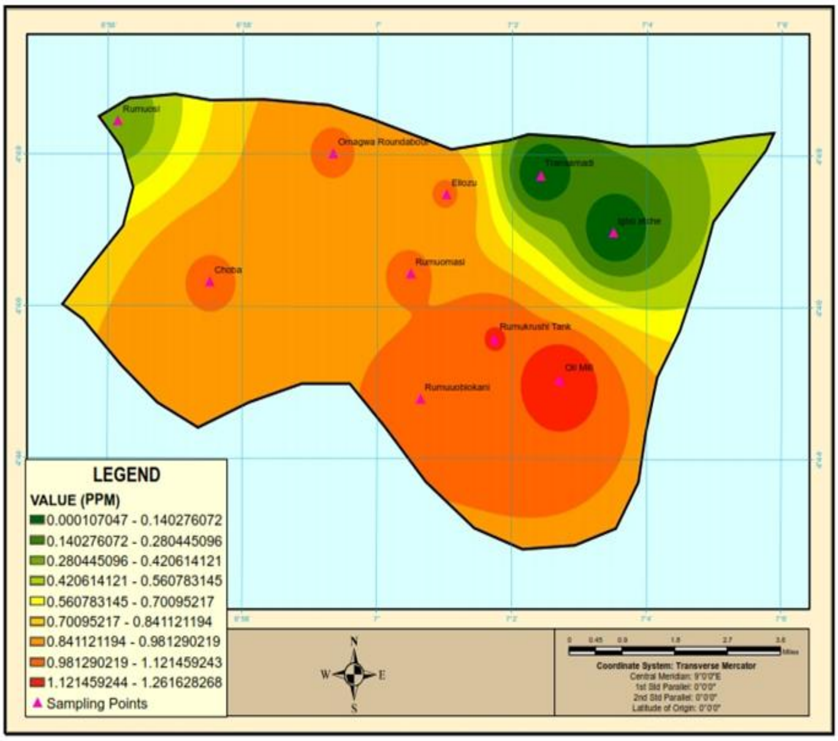


Figure 8: SO_2 Map (Wet Season) of the study area

The measured concentration of SO_2within the study area in both dry and rainy season shows a higher concentration values than those stipulated by Federal Ministry of Environmental and National Ambient Air Quality Standards as shown in 9. Howbeit, there are exceptions of measured wet and dry season values in locations 1, 10 (Igbo Etchejuction, and Trans Amadi) lower than the aforementioned standards. Measured wet season concentrations of SO_2 at locations 9 (Rumuosi Junction) and Control are below those of the stipulated standards.

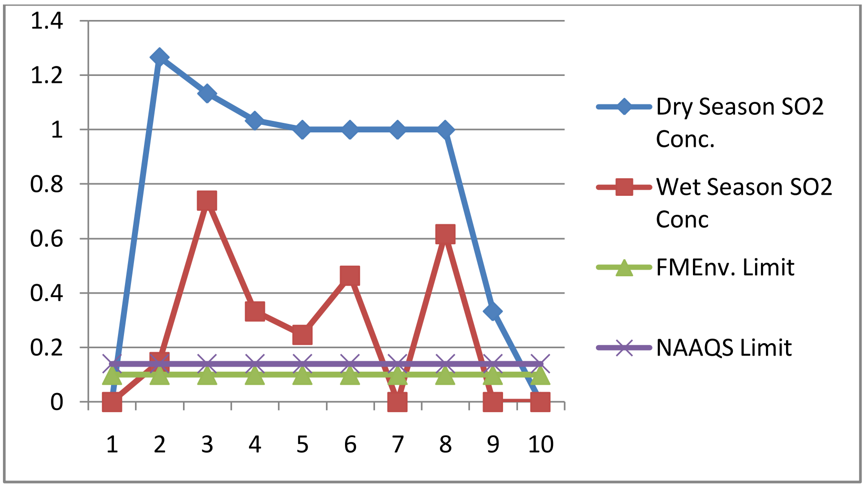


Figure 9: Chart showing a Comparism of Measured SO2 Values with Standards

CO Distribution:

In the wet season, areas of high CO emissions include Choba, Rumuobiakani and Rumukurushi and record concentration ranging from 15.7ppm to 22.3ppm which are higher than stipulated standards. The hotspots shifts to Oil Mill Bus Stop with a concentration of 28.9ppm to 32.4ppm as shown in figure 10 and 11. This could be caused by the high human and vehicular traffic in the region. Activities within the market, parks in this area account for these high concentrations. The Southern part of Port Harcourt is affected most by CO emission, while the North region is least affect.

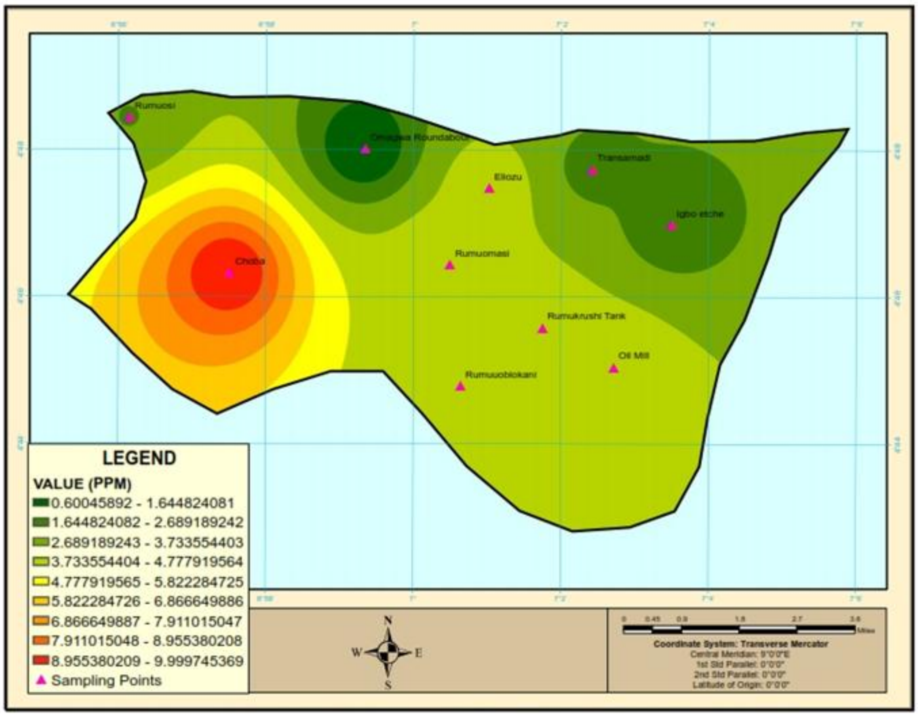


Figure 10: CO Map (Wet Season) of the study area

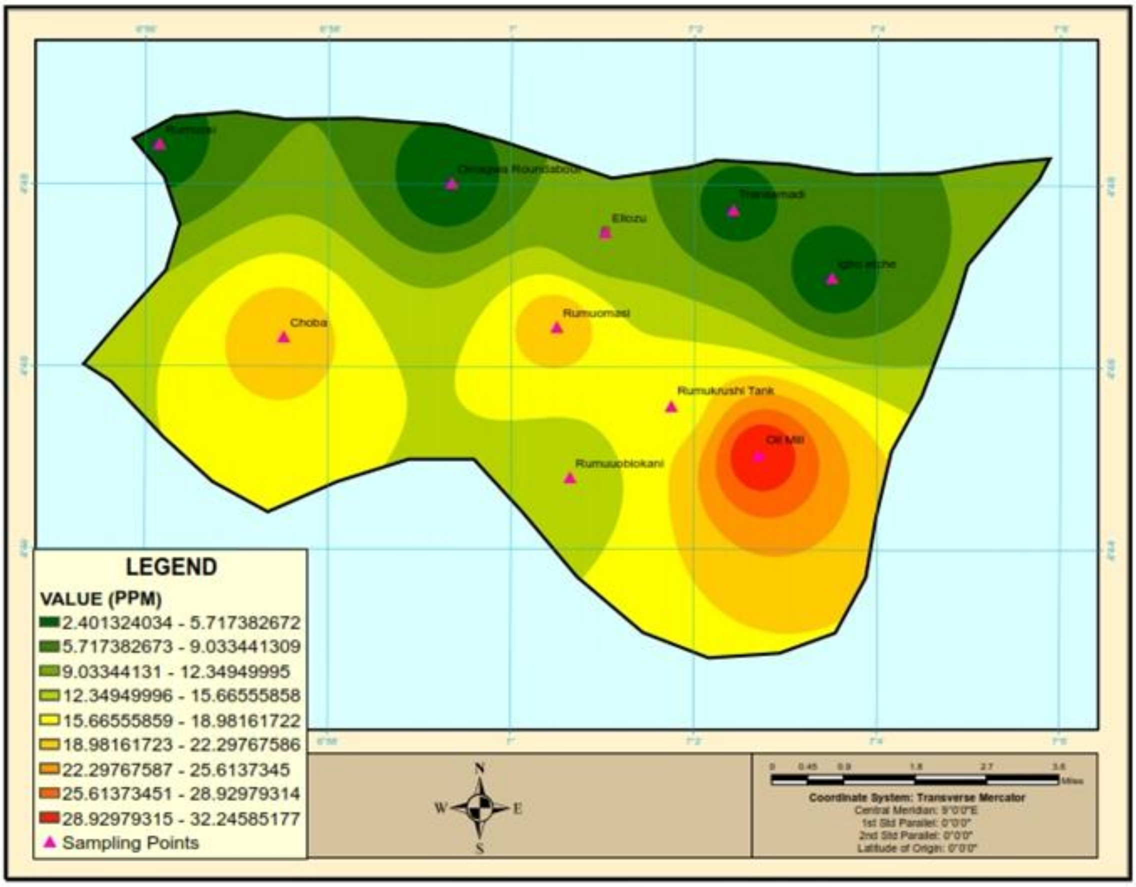


Figure 11: CO Map (Dry Season) of the study area

The measured concentration of CO within the study area in dry season shows a higher concentration values than those stipulated by Federal Ministry of Environmental and National Ambient Air Quality Standards as shown in figure 12. Howbeit, there are exceptions of measured values in locations 1,9,10 (Igbo EtcheJunction, Rumuosi Junction and Trans Amadi) lower than the aforementioned standards.

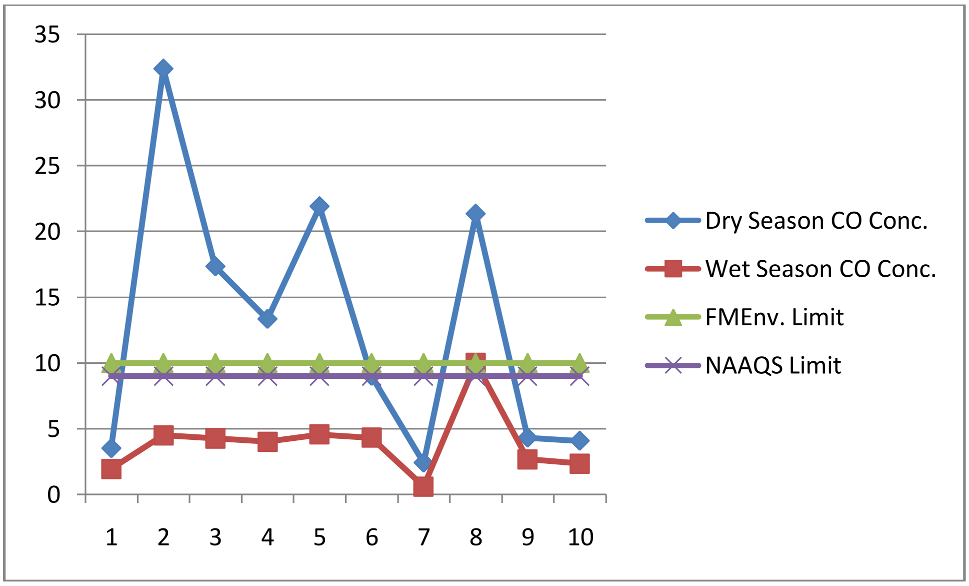


Figure 12: Chart showing a Comparism of Measured CO Values with Standards

NO_2 Pollutant Distribution:

In the dry season, hotspot of NO_2 is localized within Choba, Rumuosi Junctions, Eliozu Flyover and Oil Mill Bus Stop with concentrations ranging from 1.00ppm to 1.13ppm as shown in figure 14. This hotspot indicate environmental menace as it occurs above stipulated limits of 0.06 and 0.1ppm of Federal Ministry of Environment and National Ambient Air Quality Standard respectively. This could be caused by the high human and vehicular traffic in the region. Activities within the market, parks in this area account for these high concentrations. Communities in the North Eastern part of Port Harcourt like Igbo Etche are least affected by NO_2 emissions.

Scientific substantiation links short-term NO_2 exposures, with ranges from 30 minutes to 24 hours, with adversative respiratory effects including airway inflammation in healthy people and an increased in respiratory symptoms in people with asthma (WHO Regional publications, European series page No. 85). Studies also show a connection between short-term exposure and increased emergency room visits and hospital admissions for respiratory illnesses [6].

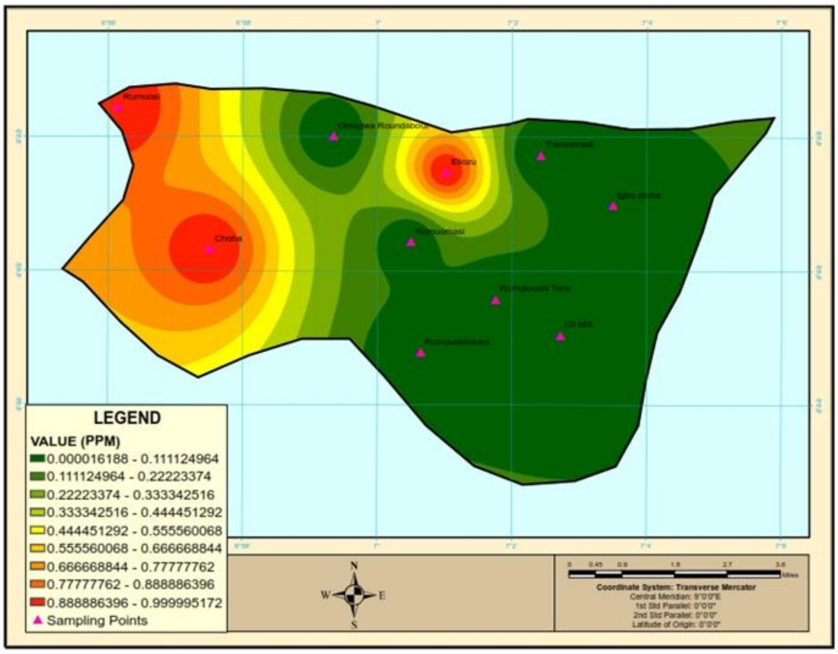


Figure 13: NO_2 Map (Wet Season) of the study area

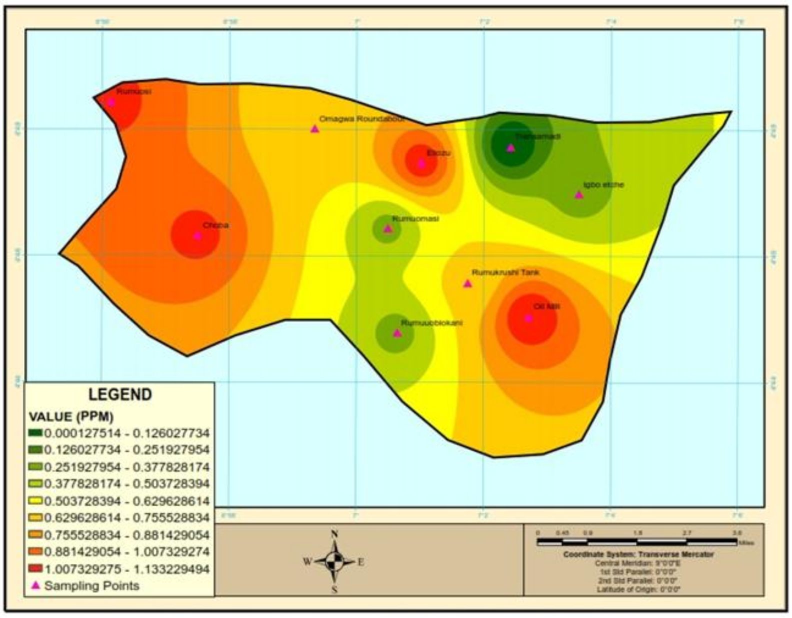


Figure 14: NO_2 Map (Dry Season) of the study area

The measured concentration of NO_2 within the study area in the dry season shows a higher concentration values than those stipulated by Federal Ministry of Environment and National Ambient Air Quality Standard as shown in figure 30, while those recorded in the wet season are lower. Howbeit, concentration recorded at locations 6,8,9 (Eliozu Flyover, Choba Junction and Rumuosi Junction) in the wet season are higher thanthe aforementioned standards.

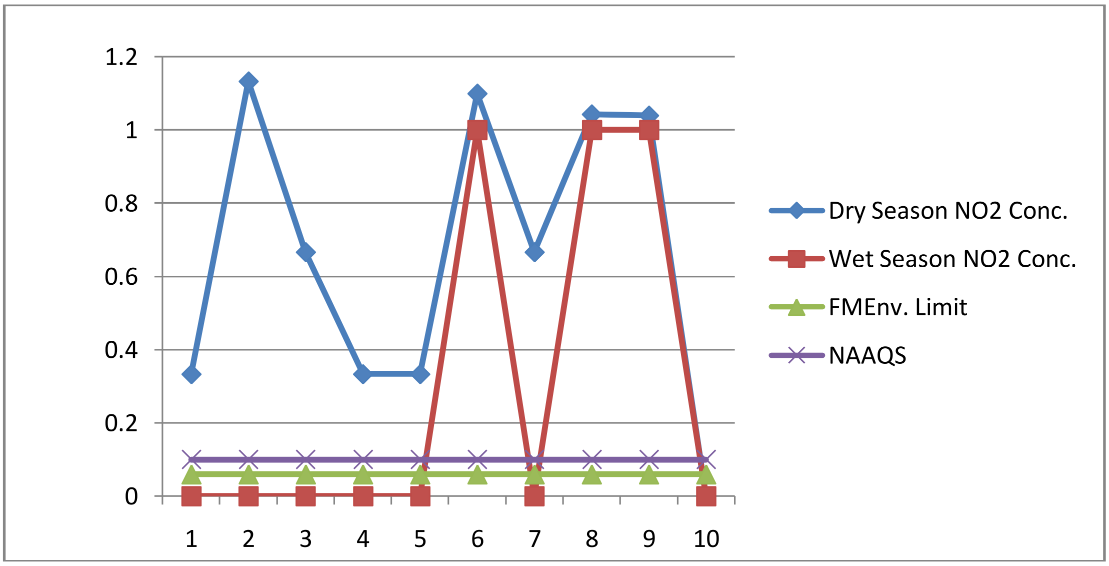


Figure 15 showing a Comparism of Measured CO Values with Standards

V. Conclusion

Generally,there is high concentration levels of the measured pollutants. The dominant wind direction in the wet season was within the SE direction, with a few exceptions within the NW direction as indicated, while in the dry season, the dominant wind direction is SW, with a few exceptions in the NW. Pollutant dispersion is influence greatly by wind speed and direction. The high concentration of atmospheric pollutants may be due to gas flaring,vehicular traffic and open burning of solid waste[12].

Activities to manage air quality should be considered to improve the environmental conditions air wise of the study area. In a case where the ambient concentrations are considered to be too high, it then means, the state of the environment needs to be improved. Preventing pollution requires reducing emissions. Emission reduction should be targeted so that the population exposure is decreased effectively. It is usual to control the major sources of emission, such as implementing changes in industrial processes or exhaust filtering. Supplementary example strategies may include changing the demand for certain exceedingly polluting activities. An increase in the energy efficiency is an excellent example of reducing emissions by controlling the demand for the product.

Besides controlling emissions, another measure to reduce exposure levels is urban development planning: how the emissions should be placed in the community in relation to the areas where people live and work. Transport systems are critical here, as the population density and the density of road traffic are closely connected. Moreover, motor vehicle exhaust is emitted close to the ground level where people are located.

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IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) is UGC approved Journal with Sl. No. 5021, Journal no. 49115.

Swemgba Henry, Ahiarakwem Cosmas Ahamefula, Adikwu Stephen Onum, Usen Osahon Samuel, Nnadozie Chibuike Kenneth." Ambient Air Quality Evaluation of Port Harcourt and Environs, South-Southern Nigeria. "IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) 7.5 (2019): 67-81.