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AIR QUALITY ASSESSMENT OF SOME OIL FACILITIES HOST COMMUNITIES IN RIVERS STATE

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ABSTRACT

The study evaluated air quality around host communities of oil companies in Ogba/Egbema/Ndoni Local Government Area in Rivers state. Detailed literature reviews and appropriate multi-gas observing instruments were utilized to obtain air quality information. Results of SO_2 in Omoku, Obrikum, Ebocha land Control (5km) from Oil Company indicated 214.1µg/m^3, 0µg/m^3, 71.4µg/m^3 and 28.5µg/m^3. $NO_2$was 106µg/m^3, 0.0µg/m^3, 51,3µg/m^3 and 0.0µg/m^3 respectively. CH_4 was 98,120µg/m^3, 35,680µg/m^3 and 44600µg/m^3 and 28.7µg/m^3 respectively. $PM_{2.5}$ was 54µg/m^3, 50.5µg/m^3, 64µg/m^3 and 50µg/m^3 respectively. CO was 93.8µg/m^3, 62.8µg/m^3, 78.1µg/m^3 and 0.0µg/m^3 respectively while PM_{10} was 36µg/m^3, 32µg/m^3, 35.5µg/m^3 and 24µg/m^3 respectively. Results indicated that host communities were exposed to reasonable concentrations of air pollutants, especially hydrocarbon, carbon monoxide, nitrogen dioxide, and $PM_{2.5}$which fall within moderate to severe air pollution level. The statistical analysis of results using ANOVA showed that the difference among the pollutants characteristics at $p<0.05$ are statistically significant. Federal and state governments should pay particular attention to air pollution problems in the study area by establishing air quality monitoring stations through relevant agencies.

Keywords: *Pollution, Concentration, Sensitive people, Air quality index, air pollution index, host communities*

1. INTRODUCTION

One of the key issues and challenges that the world is facing today is environmental pollution. Nigeria is known to be one of the leading natural gas flaring countries in the world [1]; flaring proportionally, about 46 percent of Africa's total flaring. Cedigaz [2] and associated gas worth $1.04 billion per year. These flares emanate from oil and gas facilities, most of which are located in the Niger Delta. The danger of continuous flaring of associated oil and gas is that it may become a source of air pollution which changes the composition of atmosphere and affect the biotic environment and threatened the health of humans, vegetation, as well as damage the ozone layer and buildings [3 – 5]. Concentration of air pollutant depends on the quantities of gas emitted by source facilities and the ability of the atmosphere to absorb or disperse these emissions. Many studies have been carried out on air quality over the years yet air pollution issue remains a serious threat to environmental health in many cities of the world [6 – 8] and particularly the oil producing area of Niger Delta of Nigeria [9].

Various pollutants enter the atmosphere through natural and anthropogenic processes such as domestic sources, flaring, vehicular and industrial emissions. High concentration of pollutants such as NOx, CO, SOx, VOC, Total Hydrocarbon Content (THC), H_2S, and Total Suspended particles (TSP)when released to the atmosphere from oil facilities and other anthropogenic sources may constitute environmental and health risks [1, 10-13]. It is known to also contribute to climate change, global warming, environmental pollution, increased carbon foot print and acid rain. Genuine efforts have been made by oil and gas companies in harnessing

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associated gas to reduce the amount flared gas into the environment in Nigeria [14], yet flaring is largely seen in most oil and gas facilities in the Niger Delta.

Oil exploration and production came with a lot of complex activities, laden with environmental issues and challenges including air and noise pollution since its inception in later years of 1950's [15]. The study area is a crucial factor in the development of Rivers State and the entire nation at large and due to the high concentration of oil facilities owed by the multi-national companies. [16, 17, 15].The host communities have become the focal interest for air quality study to confirm their environmental health condition.

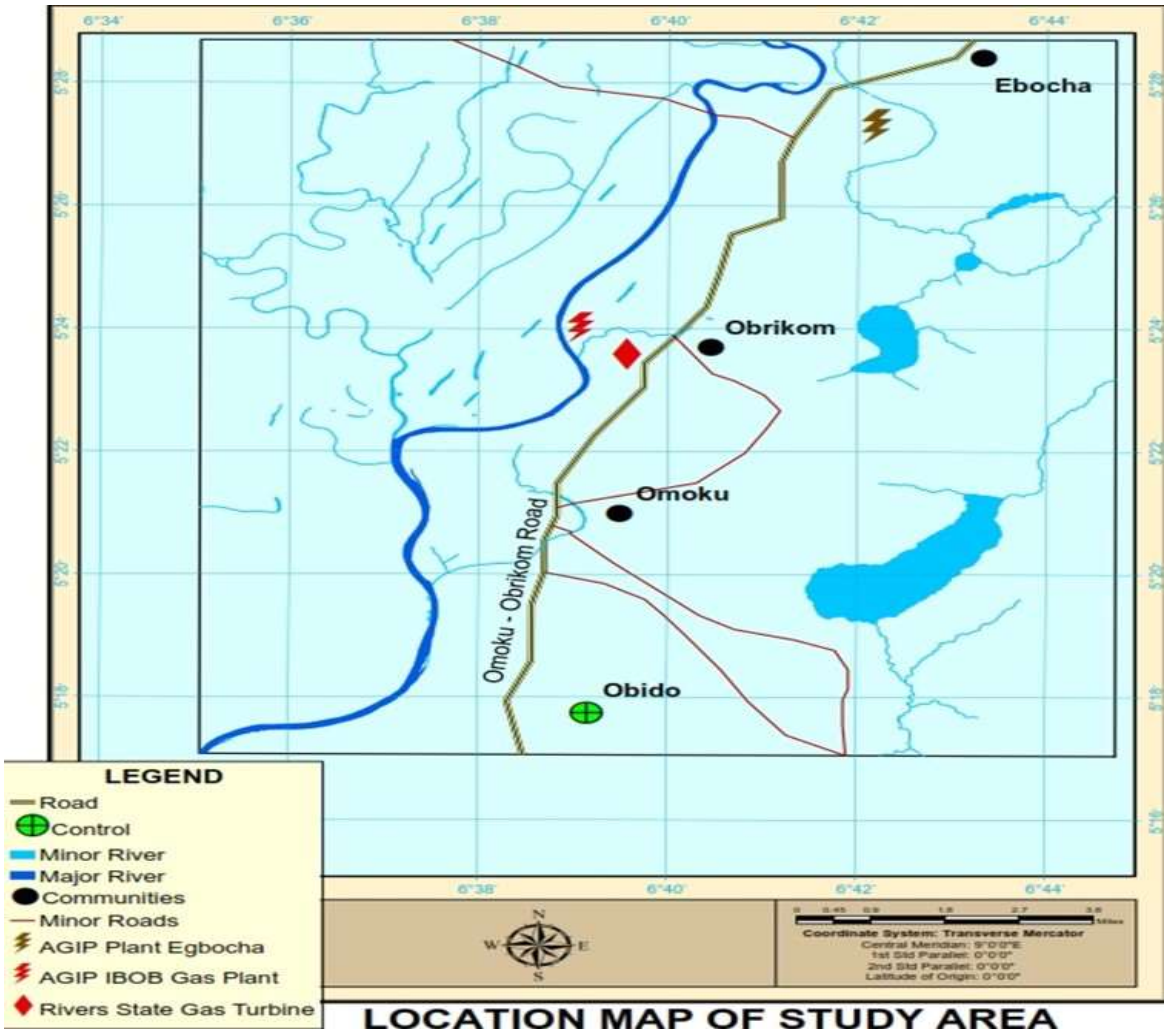
2. METHODOLOGY

2.1 Study Area

The study area (Figure 1) is located between latitude 5.383^0 North and 5.433^0 North; and longitude 6.55^0East and 6.70^0 East [9]. The area hosts major oil companies' such as the Nigeria Agip Oil Company (NAOC), Total Exploration and Production Nigeria Limited (TEPEG) and SHELL Petroleum Development Company (SPDC).Air quality monitoring was carried out within the host communities of Omoku town, Obrikom town and Ebocha town as shown in Figure 1 in accordance to statutory requirements.

2.2 Research Design

The field survey was conducted to assess the existing air quality condition of the study area, and to determine the likely impacts of the oil and Gas facilities operation on potential sensitive receptors in the area. Relevant literatures were reviewed and standard instruments were deployed to carry out the study. Sensitive human settlements in the study area were identified and monitored during field exercise. Map of study area indicating major communities of interest were shown, and measured field data were analysed and presented in Tables and Graphical forms.



Map 1: Schematic Map of Study Area (source: [9])

Table 1: Monitoring locations and coordinates

S/N	Location	Coordinates
4	Omoku Town	E6^0 39'28.914" N5^{0}20'59.189"
5	Obrikom Town	E6^{0}66'85.300" N5^{0}39'48.200"
6	Ebocha Town	E6^{0}41'54.900" N5^{0}27'34.500"
7	Control(5Km)	E7^{0}10'11.106" N4^{0}42'9.991"

2.3 Monitoring Locations

Four areas (three host communities within the study area and one control) were monitored for air pollutants. The control location was chosen about 5 km from study area and monitored. The monitoring points and their coordinates are shown in Table 1.

2.4 Materials and Equipment

Air samplings were achieved using the Enerac 700, a multi-gas analyser. The multi-gas analyser gave an instantaneous reading and results recorded in real time [18]. The equipment was programmed at a range of 3 metres above ground level using a standard tripod cord at the respective sampling locations. Regular intervals of sampling were done for a period of 4 hours in compliance to standard guidelines of [19] during the dry season. Air Metrics Minivol Particulate Sampler and Garmin/Met One Instrument Aerosol Mass Monitor was employed for suspended particulate matter (SPM, PM_{10}, $PM_{2.5}$, etc.), and visible infrared spectrometer was used to analyze the absorbent solution. Digital Compass and Geographic Positioning System (GPS) was deployed to record distances and coordinates. Multi-purpose digital Kestrel 4500 digital Anemometer (that measures air Hydro thermo-anemometer, velocity, temperature and humidity) was used to measure wind speed, temperature and relative humidity, while wind vane was used to determine the wind direction.

The Air Pollution Index (API) of each community was determined using the formula according to [20]:

$$API = \frac{1}{n}\sum_{i=1}^{n} A_i \quad (b)$$
$$A_i = \frac{C_i}{S_i} \times 100 \quad (a) \qquad (1)$$

Where API is the Air pollution Index, C_i is the concentration of pollutants, Si is the Air quality standard for pollutant, and A_i is the Rating scale for Air Pollution Indices (API). A typical Rating Scale for API is given in [20].

3. RESULTS

Results of the monitoring exercise for each location within the study area and its environs were presented in Tables 3-5. The total average values of each pollutant for the communities were shown in Table 6 and Figures 1-8. Ranking of air pollutants for monitored area were presented in Table 8. Distances of sensitive receptors to oil companies were shown in Table 8. Values of the wind rose of the area was shown in Figures 9.

4. DISCUSSION

The Results in Table 3-6 and Figure 4indicated that CH_4 at Omoku, Obrikom and Ebocha Towns were 98,120ug/m, ^{3}35680ug/m^3 and 44,600ug/m^3 respectively. These exceeded Federal Ministry of Environment (FMEnv) limit of 160µg/m^3. The CH_4 at Omoku, Obrikom and Ebocha Towns were rated as high and therefore unhealthy public health wise.This is in line with the study of carried out by [1] which revealed that the oil and gas facilities were the main sources of air pollution in the area. Past study in the same area by [22, 9] indicated a very high methane concentration and established that flora, fauna and properties may continually be impacted if nothing is done to eliminate gas flaring. According to [23] methane gas has been associated with oil and gas production and constitutes 70% and 90% of natural gas. Also, high threshold of methane hydrocarbon may result in chronic health effects among host community [24 - 26].

Table 2: API Rating Scale Source: [20, 21]

Index value	Rating	Classification
0 – 25	Clear air	Good
26 – 50	Light air pollution	Acceptable
51 – 75	Moderate air pollution	Unsatisfactory
76 – 100	Heavy air pollution	Unhealthy
> 100	Severe air pollution	Severe and unhealthy

Table 3 Ambient Air quality monitoring data in Omoku Town

Community	Hourly Readings	Temp (^{0}C)	Rel. Humid (%)	Wind spd (m/s)	Wind direct	SO_2 (µg/m^3)	NO_2 (µg/m^3)	CO (µg/m^3)	H_2S (µg/m^3)	CH_4 (µg/m^3)	TSP (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Omoku Town	1	30.9	77.4	1.2	NE	285.4	ND	ND	151.6	214080.0	51.0	26.0	52.0
	2	31.3	75.2	1.1	NW	ND	205.2	125.0	ND	71360.0	72.0	37.0	61.0
	3	31.8	73.7	1.0	NE	285.4	205.2	0.0	ND	71360.0	66.0	42.0	58.0
	4	32.1	69.8	1.4	NE	285.4	ND	250.0	ND	35680.0	70.0	39.0	45.0
	Range	30.9-32.1	69.8-75.2	1.0-1.4		0.0-285.4	0.0-205.2	0.0-250.0	0.0-151.6	35680-214080	51.0-72.0	26.0-42.0	45.0-61.0
	Mean	31.5	74.0	1.2		214.1	102.6	93.8	37.9	98120.0	64.8	36.0	54.0
FMEnvlimit						260	75	22.8	NA	160	250	NA	NA
NAAQS limit						365	188.7	10000	NA	NA	200	150	35

ND = Not detected; NA = Not available

Table 4: Result of Ambient Air quality monitoring in Obrikom Town

Community	Hourly Readings	Temp (^{0}C)	Rel. Humid. (%)	Wind spd (m/s)	Wind direct	SO_2 (µg/m^3)	NO_2 (µg/m^3)	CO (µg/m^3)	H_2S (µg/m^3)	CH_4 (µg/m^3)	TSP (µg/m^3)	PM10 (µg/m^3)	PM2.5 (µg/m^3)
Obrikom Town	1	31.1	78.2	0.8	NE	ND	ND	126.0	ND	ND	49.0	21.0	48.0
	2	31.4	77.6	0.9	NW	ND	ND	ND	ND	71360.0	53.0	28.0	55.0
	3	32.0	72.1	1.3	NW	ND	ND	125.0	ND	35680.0	50.0	37.0	42.0
	4	32.2	64.8	1.1	NE	ND	ND	ND	ND	35680.0	61.0	42.0	57.0
	Range	31.1-32.2	64.8-78.2	0.8-1.3				0.0-125.0		0.0-71360	49.0-61.0	21.0-42.0	42.0-57.0
	Mean	31.7	73.2	1.7				62.8		35680.0	53.3	32.0	50.5
FMEnvlimit						260	75	22.8	NA	160	250	NA	NA
NAAQS limit						365	188.7	10000	NA	NA	200	150	35

ND- Not detect;NA- Not available

Table 5: Results of Ambient Air quality monitoring in Ebocha Town

Community	Hourly Readings	Temp (^{0}C)	Rel. Humid. (%)	Wind spd (m/s)	Wind direct	SO_2 (µg/m^3)	NO_2 (µg/m^3)	CO (µg/m^3)	H_2S (µg/m^3)	CH_4 (µg/m^3)	TSP (µg/m^3)	PM10 (µg/m^3)	PM2.5 (µg/m^3)
Ebocha Town	1	31.5	77.9	1.0	NE	ND	ND	125.0	ND	35680.0	72.0	35.0	63.0
	2	31.7	77.5	0.9	NW	ND	ND	125.0	ND	71360.0	68.0	40.0	71.0
	3	32.2	75.8	0.8	NE	285.4	205.2	0.0	ND	35680.0	70.0	39.0	63.0
	4	32.3	70.4	1.6	NW	0.0	0.0	62.5	0.0	35680.0	67.0	28.0	59.0
	Range	31.5-32.3	70.4-77.9	0.8-1.6		0.0-285.4	0.0-205.2	0.0-125.0		35680-71360	67.0-72.0	28.0-40.0	63.0-71.0
	Mean	31.9	75.4	1.1		71.4	51.3	78.1	0.0	44600.0	69.3	35.5	64.0
FMEnv Limit						260	75	22.8	NA	160	250	NA	NA
NAAQS limit						365	188.7	10000	NA	NA	200	150	35

ND = Not detected; NA = Not available

Table: 6: Ranking or Rating of air pollutant for each monitoring area

Community	SO_2,	NO_2	CO	H_2S	CH_4	TSP	PM_{10}	$PM_{2.5}$
Omoku Town	High	High	Low	High	High	Low	Low	High
Obrikom Town	Nil	Nil	Low	Nil	High	Low	Low	High
Ebocha Town	Low	Low	Low	Nil	High	Low	Low	High
Control(5Km)	Low	Nil	Nil	Low	Low	Low	Low	High

Table 7: Distance of nearest sensitive receptors from the Existing Facility

S/N	Sensitive receptor	Distance (Km)	Existing Facility
1	OmokuTowm	1.6	OB/OB AGIP gas plant and Rivers State gas turbine
2	Ebocha Town	0.2	AGIP gas plant Ebocha
3	Obrikom	0.7	OB/OB AGIP gas plant and Rivers State gas turbine

Table 8: A Two-factor ANOVA without replication on Omoku pollutants concentration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2345119398	3	781706466	0.99897283	0.412729	3.072467
Columns	33637317196	7	4.805E+09	6.14091778	0.000538	2.487578
Error	16432714971	21	782510237			
Total	52415151565	31				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Table 9: A One-way ANOVA on Obrikom pollutants concentration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4520092721	8	565011590	5.99154275	0.000189	2.305313
Within Groups	2546141048	27	94301520.3			
Total	7066233768	35				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Table 10: A Two-factor ANOVA without replication on Ebocha pollutants concentration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	118780012	3	39593337.2	0.994426282	0.414700577	3.072467
Columns	6945606822	7	992229546	24.9208379	8.17839E-09	2.487578
Error	836120380	21	39815256.2			
Total	7900507214	31				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Table 11: Computed Air Quality Index for the Oil Bearing Communities

Community	SO_2	NO_2	CO	PM_{10}	$PM_{2.5}$	AQI	Rating
Omoku Town	214.1	102.6	93.8	36	54	153.88	Unhealthy
Obrikom Town	0.0	0.0	62.8	32	50.5	80.11	Moderate
Ebocha Town	71.4	51.3	78.1	35.5	64	116.50	Unhealthy for Sensitive Groups
Obite (Control)	28.5	0.0	0.0	24	50	22.57	Good

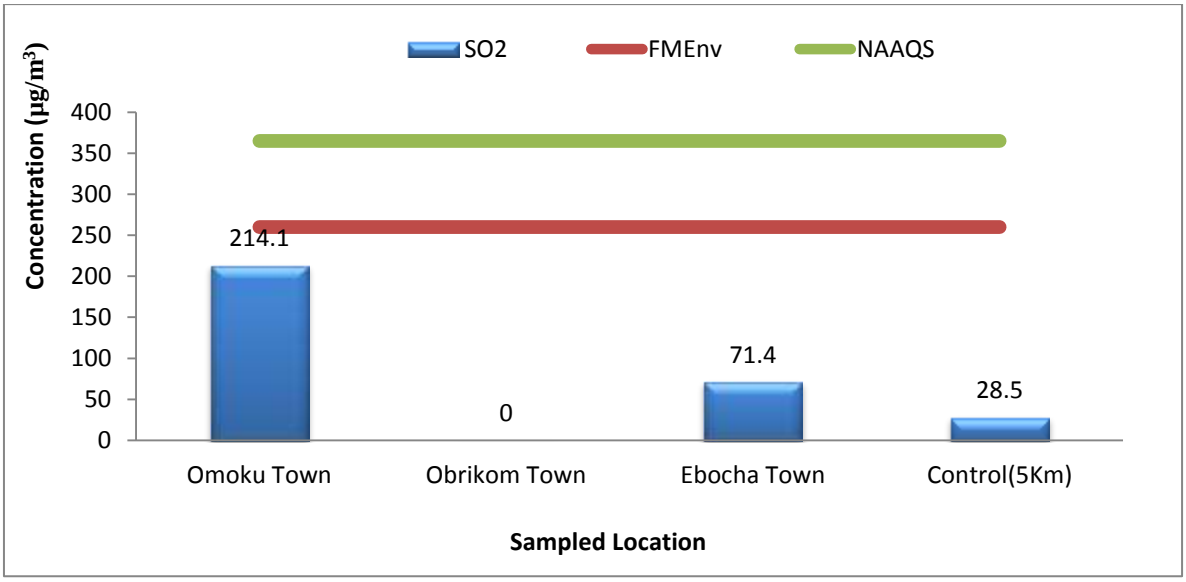


Figure 1: Total average Concentration of SO_2 in each sampled location

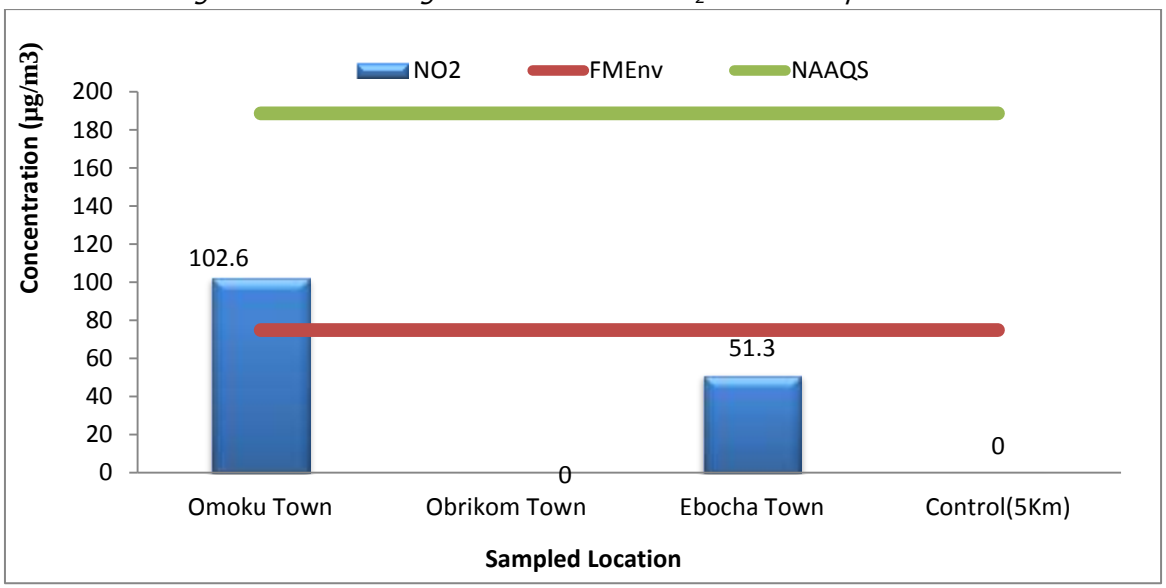


Figure 2: Total average Concentration of NO_2 in each sampled location

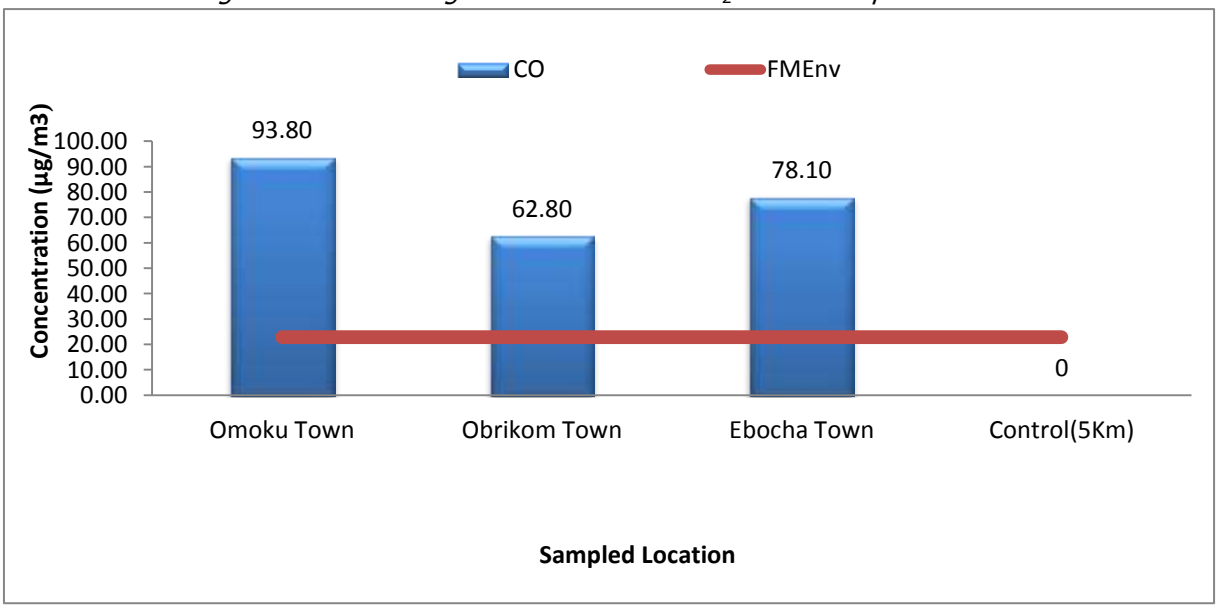


Figure 3: Total average Concentration of CO in each sampled location

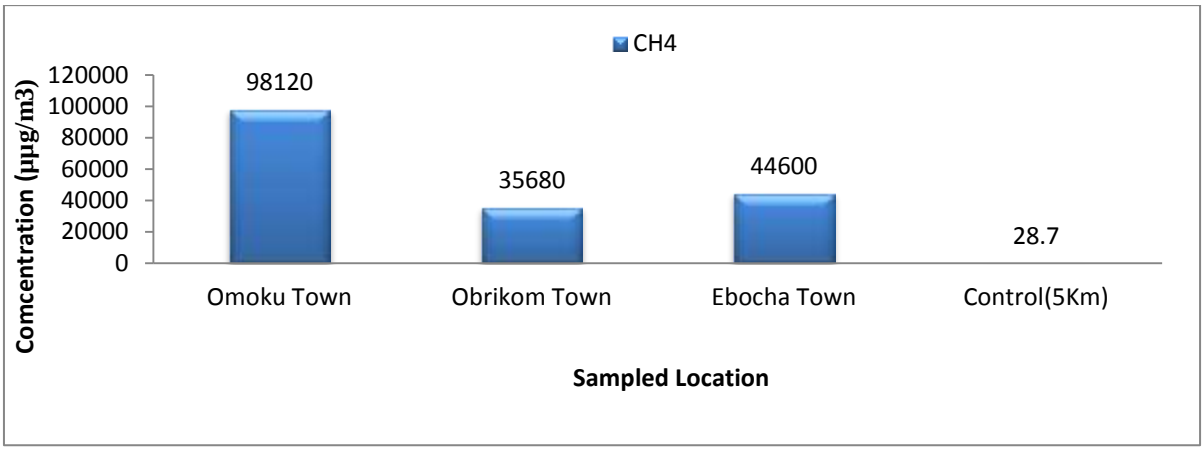


Figure 4: Total average Concentration of CH_4 in each sampled location

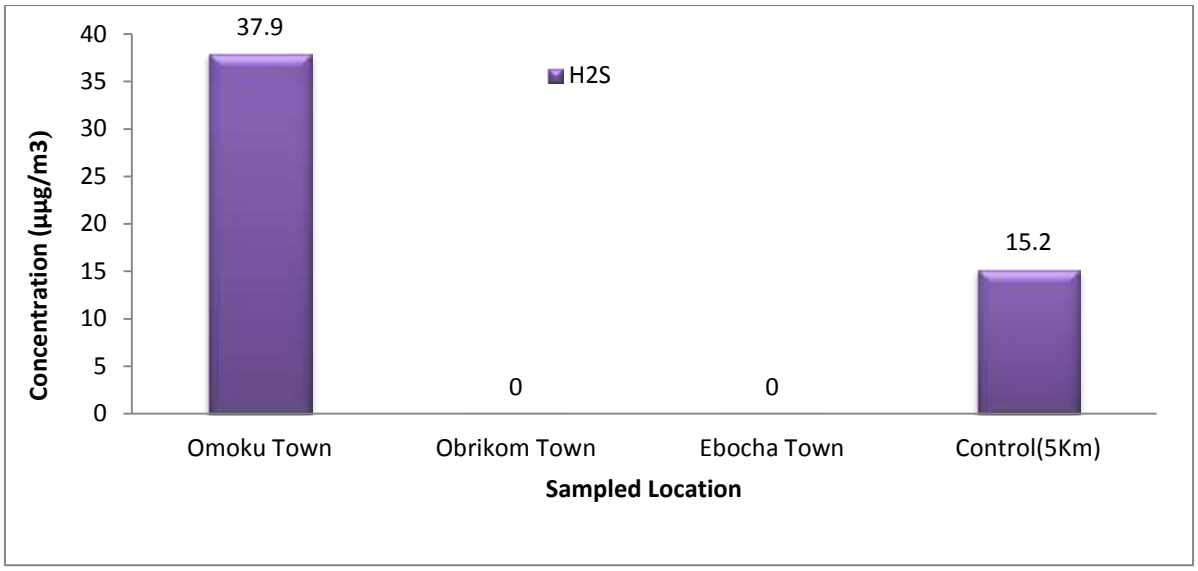


Figure 5: Total average Concentration of H_2S in each sampled location

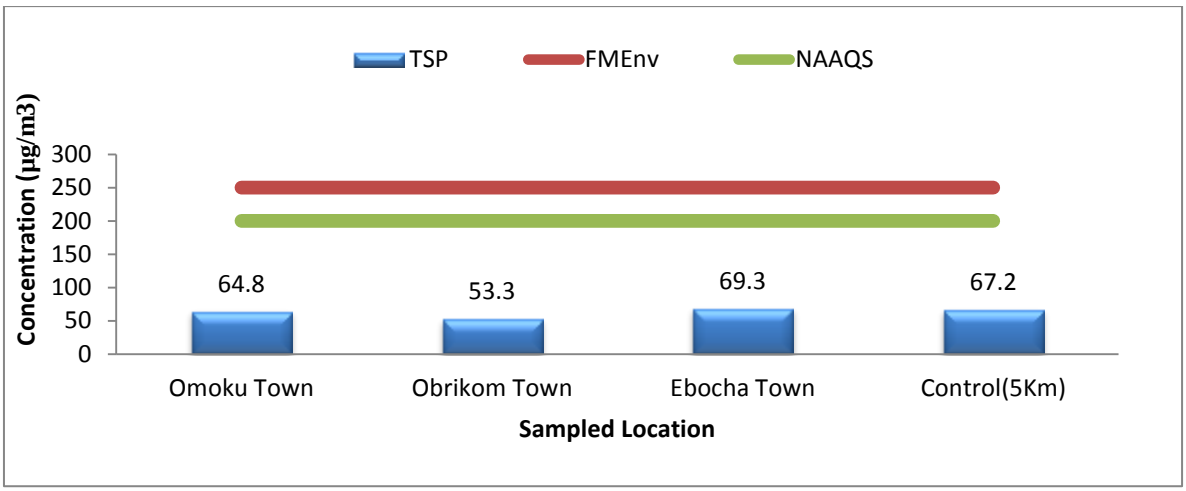


Figure 6: Total average of TSPM in each sampled location

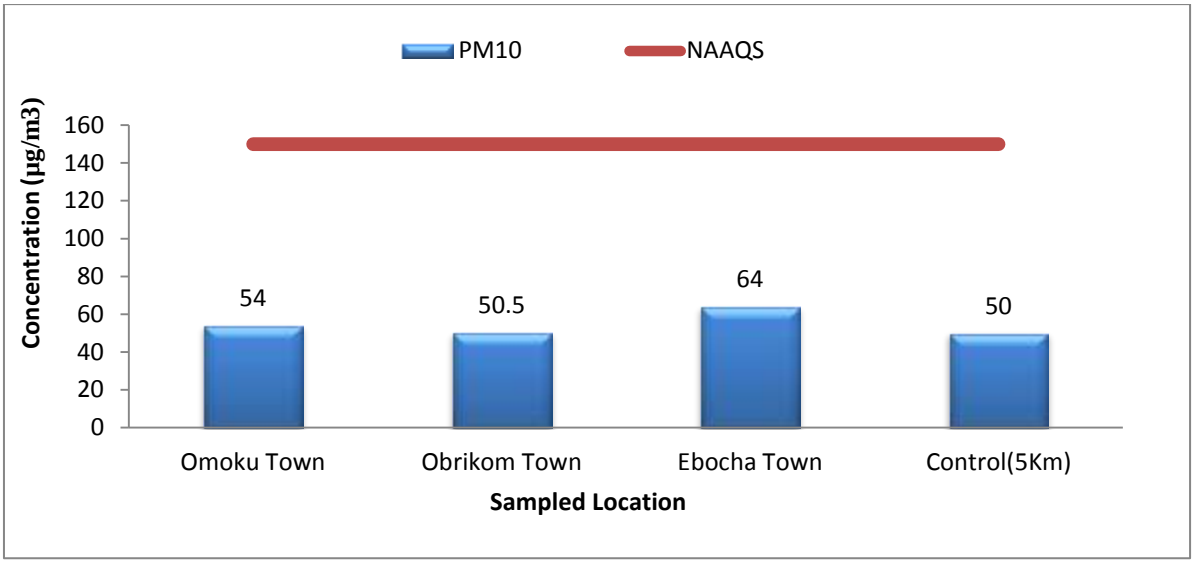


Figure 7: Total average of PM_{10} in each sampled location

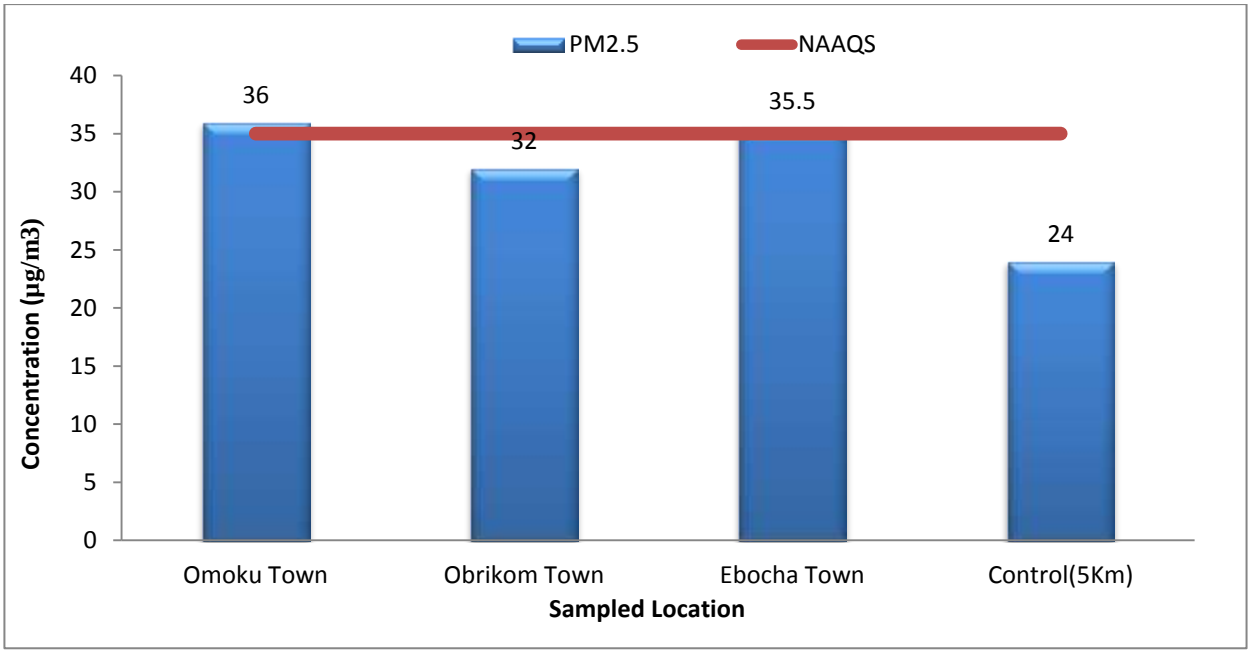


Figure 8: Total average of $PM_{2.5}$ in each sampled location

In Figure 3, CO at Omoku, Obrikom and Ebocha Towns were 93.8µg/m3, 62µg/m^3 and 78.1µg/m^3 which also exceeded the FMEnv Limit of 22.8µg/m^3. The CO at Omoku and Ebocha were rated unhealthy while at Obrikom it was rated moderate pollution (unsatisfactory) [27, 28]. This assertion was confirmed with the aid of the API rating Scale shown in Table 2.

Figure 8, showed that $PM_{2.5}$ at Omuku, Obrikom and Ebocha Towns were 54µg/m^3, 50µg/m^3 and 64µg/m^3 which exceeded National Ambient Air Quality Standards (NAAQS) Limit of 35µg/m^3.The findings were rated unsatisfactory on the API scale (see Table 6). The other measured parameters including SO_2, $NO_2$and H_2S, were high in Omoku Town, while TSP and PM_{10} were below Federal Ministry of Environment and NAAQS Limit indicating that these parameters were low and acceptable on API scale (Table 2).

Prolonged exposure to CH_4, CO, SO_2, NO_2 and H_2S pollutants in air may result in increased cases of Asthma, and respiratory diseases among the habitants of the communities in the study area. The results were consistent with similar results obtained in the same area by [29].

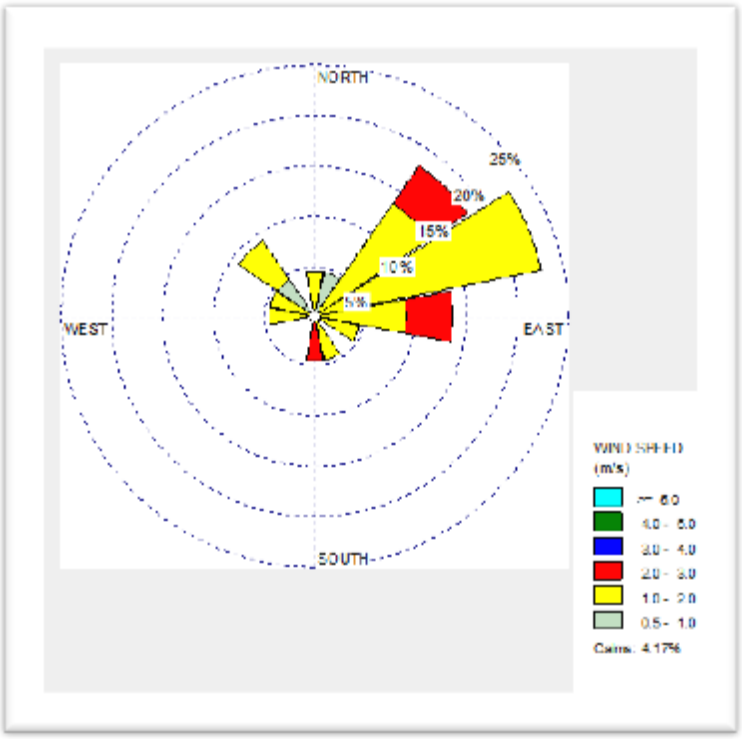


Figure 9: Wind Rose

The distances between Omoku, Obrikom and Ebocha towns from Oil facilities were 1.6km., 0.7km and 0.2km respectively (See Table 7). While carbon monoxide and hydrocarbon were major pollutants of high impacts on study communities; SO_2, NO_2 and H_2S impacts in the towns were ranked low [30, 31, 32].

Tables 8-10 showed the statistical Analysis of Variance (ANOVA) performance at Omuku , Obrikum and Ebocha communities. Results showed that there was no significance difference at the various sampled points at Omuku community but at same time there was significance difference amongst the pollutants characteristics using the 0.05 probability level. There was significant difference at Obrikum community at the 0.05 probability level. At Ebocha community, there was no significant difference between the pollutants characteristics but there a large significant difference in the performance test on pollutants characteristics at the 0.05 probability level during the study period

Air quality indices (AQI) of 153.88, 80.11, 116.5 and 22.57 were computed for Omoku, Obrikom, Ebocha towns and the control town respectively as shown in Table 8. These were rated as unhealthy for Omoku town, Moderate for Obrikom town, unhealthy for sensitive groups for Ebocha town, and good for the control town as shown in Table 8.Themoderate air pollution in Obrikom town may negatively affect the health of few people in the community [33]. It may have minor breathing effects on sensitive people. Also, people with chronic cases of respiratory problems may be at risk. The unhealthy level of air pollution may have harmful impacts on the people of Omoku town. It will aggravate the health conditions of people with respiratory or heart diseases. This level of air pollution in Ebocha was unhealthy for sensitive groups in the community (the elderly, children and people with asthmatic and respiratory cases may be at greater risk).

The surrounding temperature monitored during the study ranged between 30.1^0C and 32.5^0C with mean value of 31.3^0C. These temperature values are common tropical climate with high sunshine in the month of November when the field measurement was taken. Average values of ambient temperature in study area were shown in Tables 3-5.Relative humidity ranged between 68.4% and 78.6% with a mean value of 74.5% during the period of field measurement. Irrespective of the season the area experienced high relative humidity that was maximum at dawn (over 90%) and minimum by late afternoon (<60%).The averages relative humidity in study area were shown in Tables 3-6.Wind speed during the period of field measurement ranged between 0.4m/s to 2.4m/s with a mean value of

1.5m/s. Wind directions were predominantly North-Eastern, South- Eastern, and North-Western as represented in Wind Rose of Study Area (Tables 3-6 and figure 9).

5. CONCLUSION AND RECOMMENDATIONS

The study evaluated air quality in oil bearing communities in Ogba/Egema/Ndoni Local Government Area in Rivers State. Based on results from field monitoring survey and data analysis, the following conclusions were drawn. Activities of oil companies have negative impacts on the natural air quality of the environment within these host communities. Results indicated that host communities were exposed to moderate to high concentrations of hydrocarbon, and carbon monoxide which may adversely aggravate health conditions under prolonged exposure. The researchers advised the government and oil facilities owners to regularly monitor the air quality in the study area. Also, health impact assessment should be conducted on residents of all the host communities to determine the level of impacts on the people.

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