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Assessment of the Effects of Hot-Mixed Asphalt on Air Quality in Owerri, Imo State, Nigeria

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Abstract:- Industrialization and infrastructural development projects disturb the stability of the environment. Environmental degradation arising from industrial and construction development have sometimes impacted negatively on the quality of human life, wild life and eco-system in general. The aim of this study was to develop a strategy for the harmonious existence of Hot-mix Asphalt production factories within the Owerri Environment, so that asphalt factories can become good neighbours. The study was quasi experimental. Purposeful sampling was used to select two (2) Asphalt factories out of eight (8) factories identified in the study area, using location and length of time in operation as criteria. Data was collected at the Asphalt factories through observations and recording with appropriate instruments. Data was tasted for homoscedasticity and further analyzed with ANOVA. Findings reveal that the average air quality between the old and new Asphalt factories environment is the same. Results also shows that the asphalt factory emission have effect on the Air quality in both the raining/wet and dry seasons. The emission loads are however within Federal Ministry of Environment, Housing and Urban development and world health organization standards. The study recommended inter alia that Asphalt factories be sited at least one (1) kilometer from the nearest human settlement, insist on the use of only completely New Asphalt Equipment and discard the use of second hand asphalt plants. Supervising agencies should regularly carry out environmental audit with a view to ensuring that emission loads around these facilities remain within World Health Organization (WHO) and Federal Ministry of Environment Standards.

Keywords:- *Hot-Mix Asphalt, Pollution, Emission, Environmental Management Plan.*

I. INTRODUCTION

The world is at present experiencing unprecedented trends in Urbanization and Urban growth rates. Growth in developing nations are exceeding those of the developed countries while Africa and Asia expected to grow exponentially (Lekan, Sanni, and olusiyi Ipingbemi, 2008). Many urban and rural areas of the world, have been adversely affected by large scale air pollution and contamination that resulted in human, Financial and material looses (Lombi, zhao, Dunham and McGrath, 2001). One of the most important causes of pollution is the high rate of energy usage by modern growing population and industrialization, Harrison (2006).

According to the United States Environmental Protection Agency (US, EPA, 2011), asphalt plants mix gravel and sand with crude oil derivatives to make asphalt use to pave roads, highways and parking lots. These plants release millions of pounds of chemical to the air during production each year, including many toxic pollutants.

At the creation of Imo state in 1976, Owerri was made the capital city. The citing of Owerri as the state capital resulted in the massive movement of people to the new capital. This movement increased the demand for infrastructure like roads, electricity, water, telecommunications etc. The topography of Owerri is generally flat low lying. Major occupation of the inhabitants is commerce and civil service supported by subsistence farming. As a political hub, Owerri is the center of governance and the receptor of innovative ideas and best practices which found expression in the existence of eight tertiary institutions. As a commercial city, Owerri enjoys the influx of business men and women from neigbouring towns like Onitsha, Aba, Portharcourt, Enugu and Umuahia. Owerri has over two hundred and fifty (250) hospitability and tourism establishments with a robust social life.

Before the creation of imo state, there were only two (2) Asphalt plants in Imo state owned by Monier Construction Company (MCC) and Reynolds Construction Company (RCC) respectively, both companies were located at Aba. To date there are eight Asphalt plants in active use in Owerri. Activities relating to over thirty-four (34) year of asphalt production and Hot-mix Asphalt laying process in the area may have affected Air quality, contaminated soil and streams, thus endangering lives of men and other organisms, Obiekezie (2005).

Hot-mix asphalt(HMA) is used primarily as a road paving material. HMA consist of a mixture of aggregate and liquid asphalt cement which are heated and mixed in measured quantities. At the creation of Imo state, these plants were located away from residential areas. This is no longer the case. Development has come very close to these asphalt factories. Observations at HMA factories reveal the emission of thick black smoke during the production process. There are also soot deposits inside dwellings and roof tops. Residents around these facilities complain of cough, catarrh and skin rashes (Ruiz, Paola, Azeredo and Puello, 2014).

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The National Environmental Standard and Regulation Enforcement Agency (NESREA) states Asphalt processing and asphalt roof manufacturing facilities are major sources of hazardous air pollutants. These pollutants are dangerous because they tend to bio-accumulate (Montgomery, 2007).

Outdoor Particulate Matter (PM) levels in cities of developing countries including Nigeria are generally much higher than in developed countries because of dispersed heating with small scale solid fuel use, uncontrolled industrial emissions and large numbers of non-catalyst two stroke engine vehicles (Mazumber, Vedaraman, Seonja, 2016). Apart from the discharge of untreated effluents into water bodies and wet lands used for Agriculture, the air is also polluted through gaseous emissions during asphalt production, transportation and laying (El-Kady, 2011).

The impact of the deposition of large amount of dust particulates and gaseous pollutants on the environment are enormous and yet to be given due attention in Owerri, the study area, the multiplier effects and the concomitant environmental degradation, underscore the need to preserve the environment in a state that can be harnessed for sustainable human development.

This study evaluated the physiochemical parameters of air around the Asphalt factories. The study assessed the quantum of the emissions and analyzed its effect on the air quality of the study area, Owerri.

Sustainable Environmental development postulate development that satisfies the need of the present generation without jeopardizing the existence of the future generation.

This study seeks to develop a strategy for the harmonious existence of Hot-mix asphalt factories can become good neighbours. There is need to examine the emission load from HMA facilities and compare these emission values with Federal Ministry of Environment and Urban Development standard values. The study will also ascertain the effects of this emissions on the air quality of the study area, owerri.

II. METHODOLOGY

This study is essentially Ex-post facto.

This is a quasi experimental study examining how an independent variable present prior to the study of the participant affects a dependent variable.

In designing this experiment, two groups were set up, an experimental group and a control group.

The only different between the two groups is the variable. The variable tested is the emissions.
The population of the study comprises eight (8) asphalt plants in Owerri, see table 1.

Table 1. Hot-mix asphalt plants and their location in Owerri.

S/N	NAMES	LOCATION
1	MACOL	OWERRI-ABA ROAD
2	JALINGO	OWERRI-ABA ROAD (GPS 5^0,27^1,43.44^{11} N, 7^0 02 34.3E)
3	ROYAL ROCK	ONITSHA ROAD INDUSTRIAL LAYOUT
4	MACON	ONITSHA ROAD INDUSTRIAL LAYOUT
5	RUDO	ONITSHA ROAD INDUSTRIAL LAYOUT
6	FRANK & G	ONITSHA ROAD INDUSTRIAL LAYOUT
7	NEW IDEA	ONITSHA ROAD INDUSTRIAL LAYOUT
8	RHAS	ONITSHA ROAD INDUSTRIAL LAYOUT(GPS $5^0$$30^1$$47.3^{11}$N,$6^0$$34^1$$47.9^{11}$ E

Purposive sampling was employed in selecting two asphalt factories namely Jalingo asphalt factory at Naze kilometer 2, owerri-aba highway and Rhas Asphalt factory at Irete, along Owerri-onitsha federal highway. The criteria for choosing both asphalt factories, are their location and number of years in operation., Jalingo asphat factory is located on owerri-aba highway and has been in operation for seven (7) years, while Rhas asphalt factory is on owerri-onitsha road and has been in operation for twenty two (22) years

Primary data was collected from the two asphalt factories through observation and recording with requisite instruments. Secondary data was sourced through libraries, professional journals and magazines.

Air samples were taken in the afternoon (1-1:30pm) when humidity were at its lowest at four sampling locations at intervals of 100meters, (zhang 2007). Sampling locations are;
AS1---------- Fence of the asphalt factory
AS2 ----------100 meters from the fence
AS3 ---------- 200 meters from the fence
AS4 ---------- 300 meters from the fence
AS5 ---------- Control ----- 10 kilometers from AS1

Air samples for suspended particulate matter (TSP) was collected with Absolute instrument system, Aerosat, model 5315, measurement was done by holding the sensor at the height of two (2) meters in the direction of the prevailing mind, with readings taken at stability. Other air quality parameters CO, SO_x, NO_x were taken with MX6

programmable multi-gas monitor equipped with an electronic sensor. VOC was measured with MX6 multi-gas monitor with an electro-chemical sensor. The gas was detected via a plug in the catalytic head. Date generated was tested for homoscedasticity.

Furthermore, a one way Anova with Post-Hoc Turkey test was employed to generate the statistical difference between the parameters analyzed in this study and the control site using statistical package for social science (SPSS).

III. DATA PRESENTATION AND ANALYSIS

Data generated from the field were recorded in a table and presented as a chart

AIR QUALITY DRY SEASON

Table 2. Comparison of dry season emission for newer plant and old plant

NEWER PLANT			OLDER PLANT			
ELEMENT/ UNIT	**RANGE**	**MEAN**	**RANGE**	**MEAN**	**CONTROL**	**FIVE**
CO (ng/ml)	1000-2100	1490	950-2400	1600	1000	1000
NO_X	16.75-50.71	33.28	20.5-60.5	37.91	16.27	25
SO_X	29.2-100	67.64	35-120	92.10	29.2	40
VOC	1100-3200	1960	1200-4000	2280	1100	6000
TSP	25-83.00	58.4	25-90	61.6	25	60

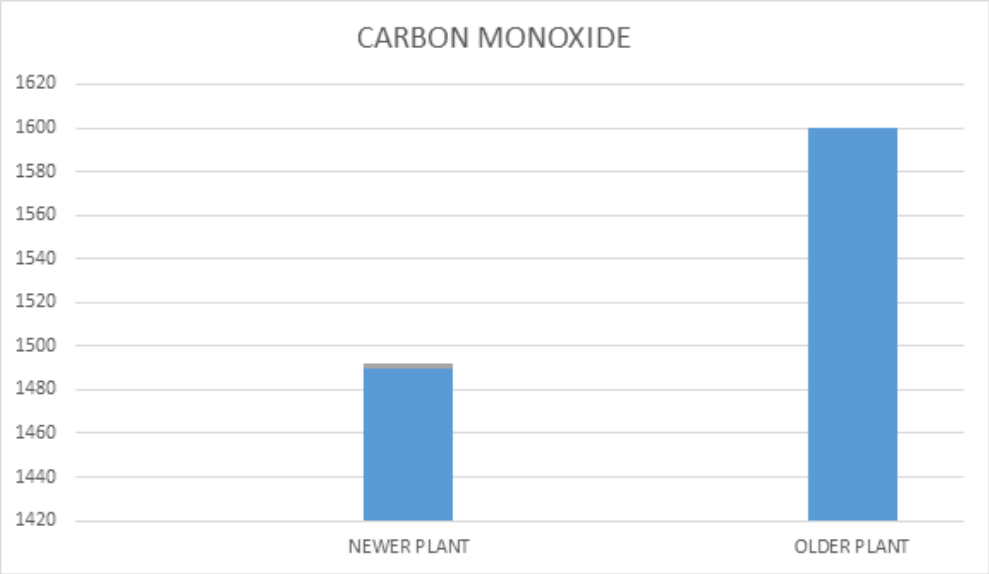

Figure 1. Relationship between emission of CO from new asphalt and old asphalt plant in dry season

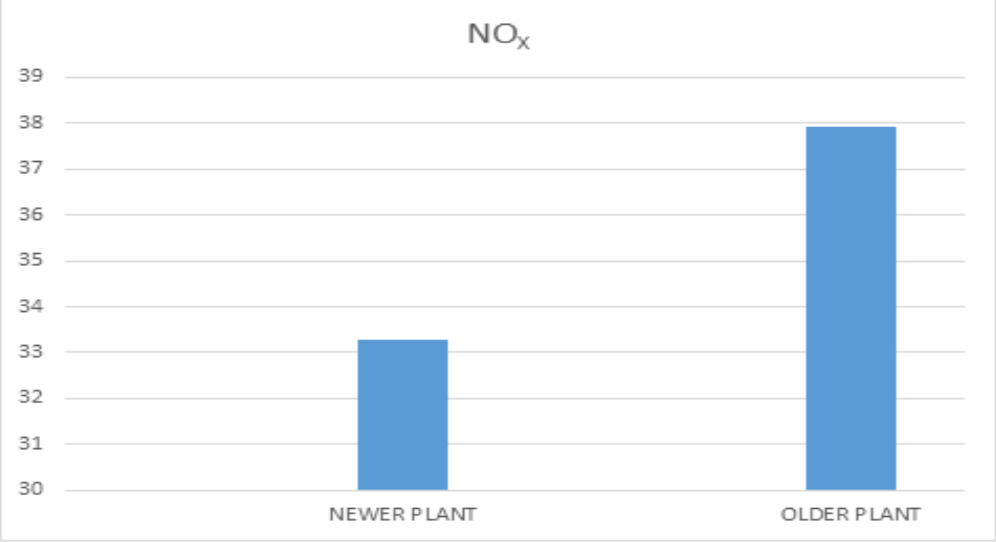

Fig 2. Relationship between emission of NO_x from new asphalt and old asphalt plant in dry season

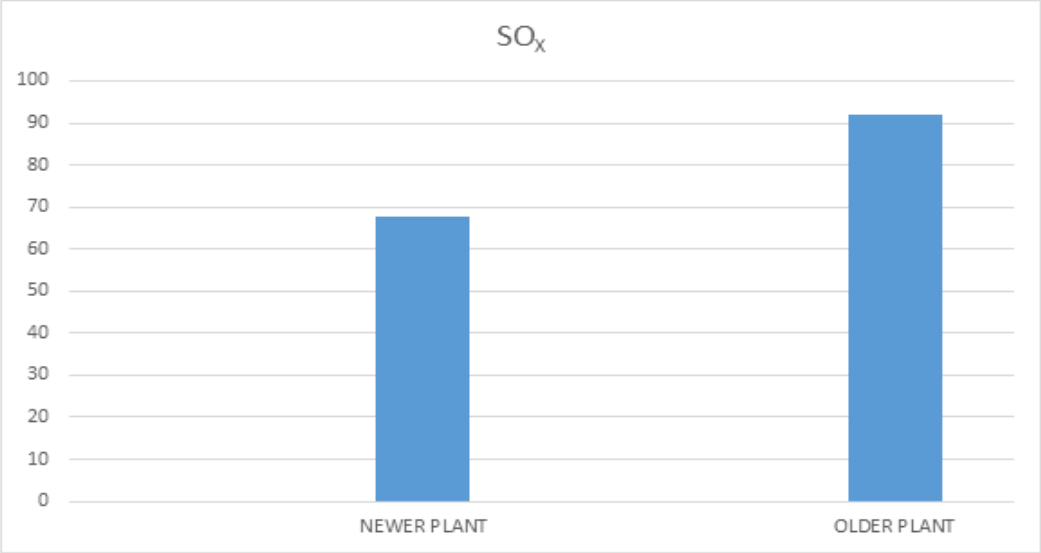

FIG 3. Relationship between emission of SO_x from new asphalt and old asphalt plant in dry season

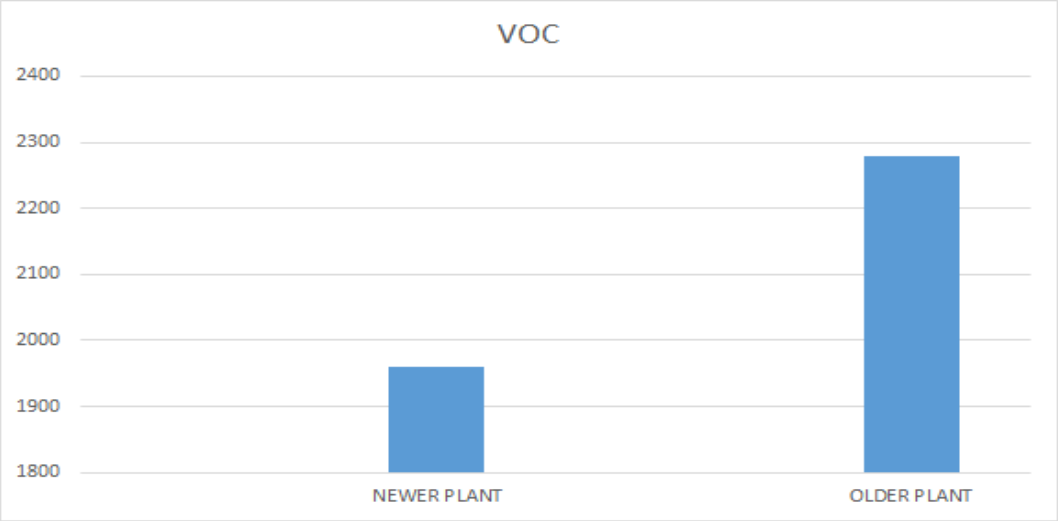

Fig 4. Relationship between emission of VOC from new asphalt and old asphalt plant in dry season.

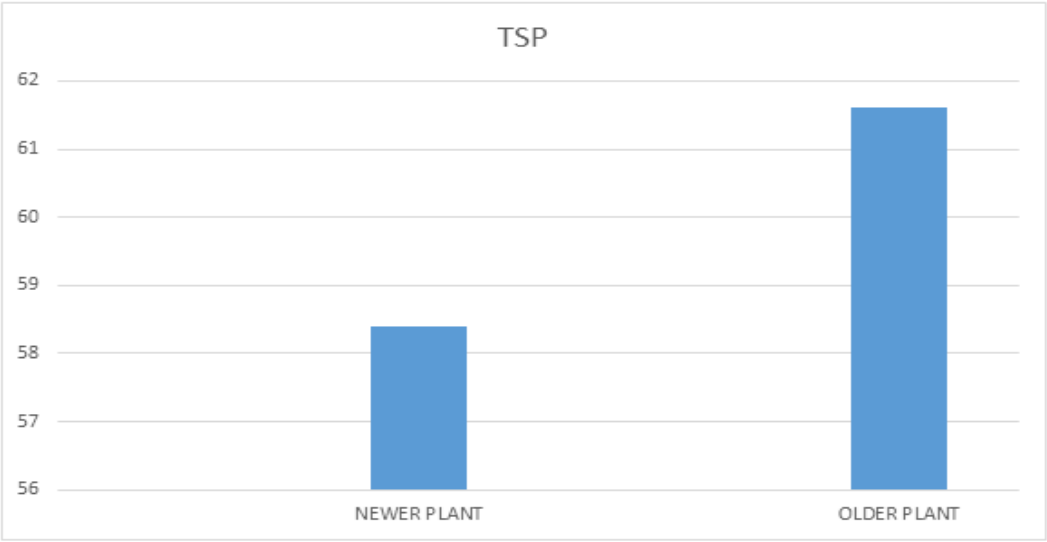

Fig 5. Relationship between emission of TSP from new asphalt and old asphalt plant in dry season

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The mean values in table 2 were derived from data in appendix 1and 2.

All the parameters followed a trend. Highest values were obtained at the fence of the plant premises. These values decreased with an increased distance away from the plant.

The mean values obtained from the newer plant for the parameters CO, NO_X, SO_X and TSP were all higher than Federal Ministry of Environment standard except VOC with a value that is within FME range.

IV. AIR QUALITY RAINING SEASON

Table 3. Comparison of rainy season emission for the newer plant and old plant.

NEWER PLANT			OLDER PLANT			
ELEMENT/ UNIT	**RANGE**	**MEAN**	**RANGE**	**MEAN**	**CONTROL**	**FIME**
CO (ng/ml)	1000-1850	1476	1100	1580		1000
NO_X	15.5-40.5	30.02	20.5-40.2	33.04		25
SO_X	38.0-85.6	60.9	45.00-130	84.4		40
VOC	1000-3000	1600	1200-3100	1784		6000
TSP	25-65	43.00	20-70	44		60

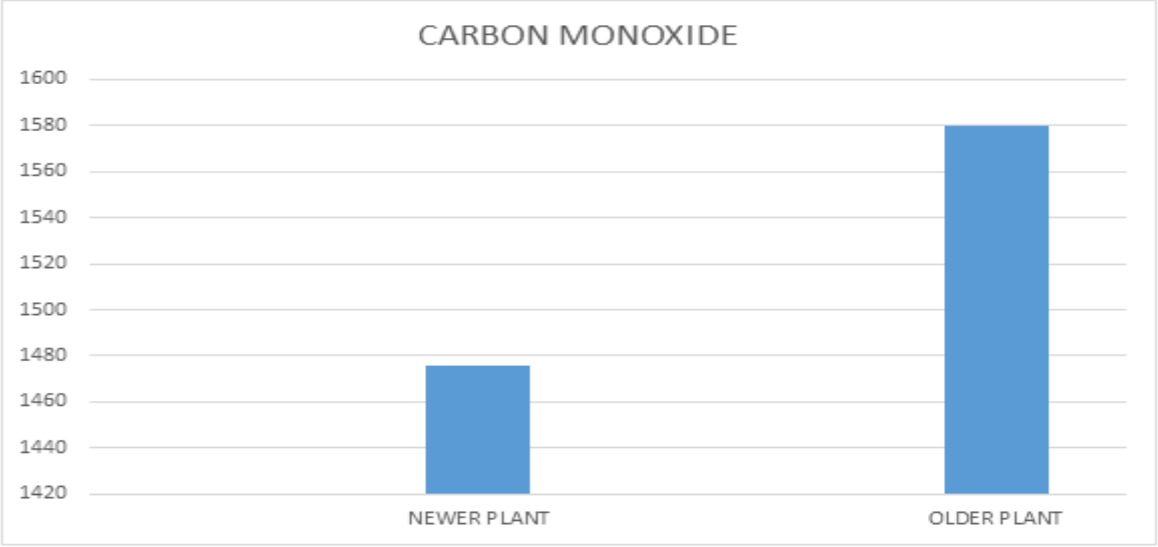

Fig 6. Comparison of mean values of emission of CO between new an old asphalt plants in rainy season

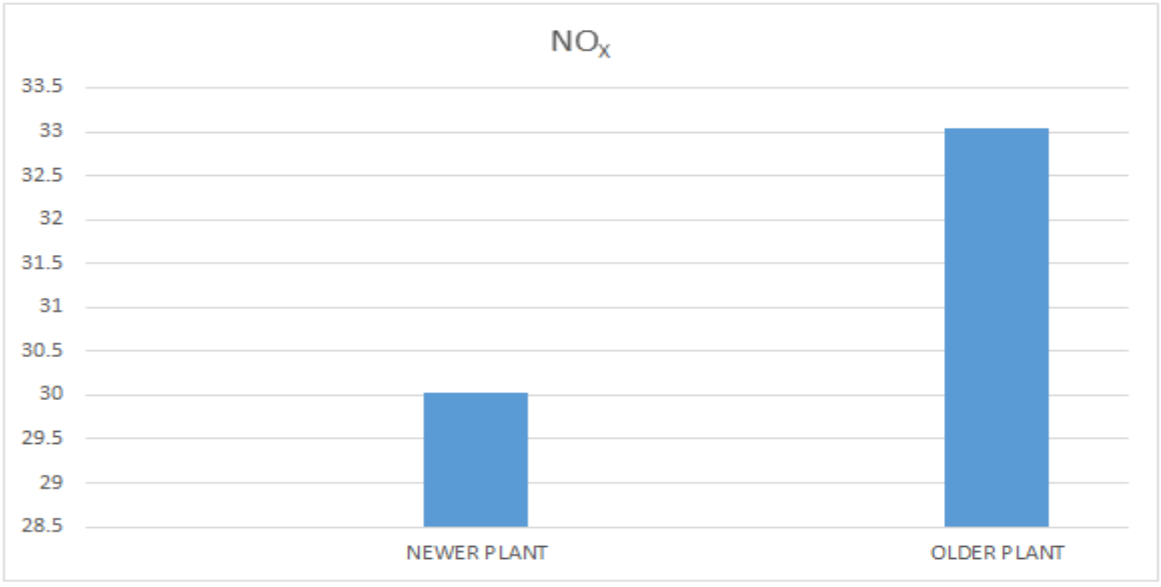

Fig 7. Comparison of mean values of emission of NO_X between new an old asphalt plants in rainy season

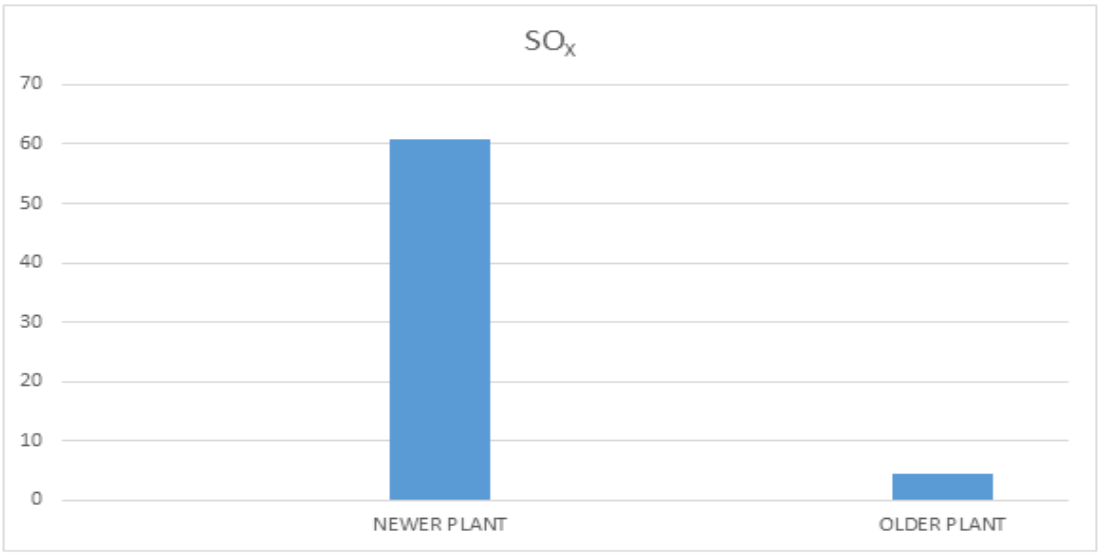

Fig 8. Comparison of mean values of emission of SO_X between new an old asphalt plants in rainy season

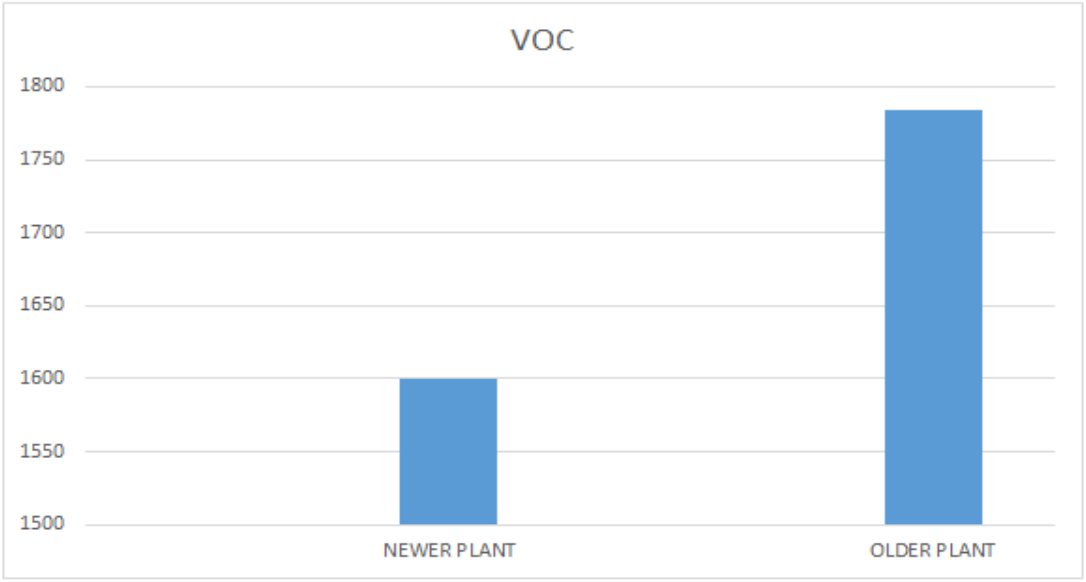

Fig 9. Comparison of mean values of emission of VOC between new an old asphalt plants in rainy season

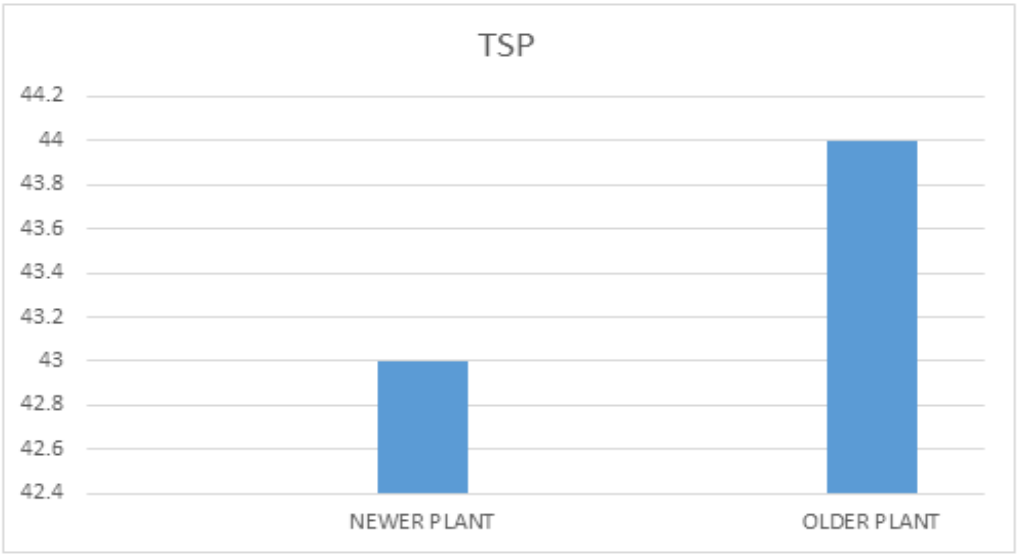

Fig 10. Comparison of mean values of emission of TSP between new an old asphalt plants in rainy season

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Table 3, shows the comparison between emission levels for both plants in the raining season .

Fig 6-10 presents the mean values obtained in the raining season for the newer plant and older plant. The mean value obtained in the raining season are slightly lower than the dry season mean values for both plants. The mean values were obtained from data in appendices 3 and 4.

V. TEST OF HYPOTHESIS

HYPOTHESIS 1.

ANALYSIS OF VARIANCE TABLE FOR AIR QUALITY DURING DRY SEASON USING THE NEW ASPHALT PLANT

STATEMENT OF HYPOTHESIS:
H0: On the average, the new asphalt plant emissions have no effect on the air quality during dry season
H1: On the average, the new asphalt emission have effect on the air quality during dry season

Table 4.
One-way ANOVA: NEW ASPHALT 1, NEW ASPHALT 2

SOURCE.	DF.	SS.	MS.	F.	F
FACTOR.	1.	99922.	99922.	0.01.	0.018
ERROR.	8.	126055944.	15756993.		
TOTAL.	9.	126155866			

S=3970. R-Sq=0.08% R-Sq(adj) = 0.00%

DECISION RULE: Reject the null hypothesis of the probability (significant value) is less than our confidence level (ALPHA value) otherwise accept the null hypothesis.

INTERPRETATION:
From the result shown above, the P-value=0.018, is less than our confidence level (ALPHA value=0.05) which shows that the test is significant.

CONCLUSION: since the probability (significant value =0.018) is less than our confidence level (ALPHA value=0.05), we shall reject the null hypothesis and conclude that the new asphalt plant emission have effect on the air quality.

HYPOTHESIS 2.

ANALYSIS OF VARIANCE TABLE FOR AIR QUALITY DURING THE RAINY SEASON USING THE OLD ASPHALT PLANT

STATEMENT OF HYPOTHESIS:
H0: On the average, the old asphalt plant emissions have no effect on the air quality during rainy season
H1: On the average, the old asphalt emission have effect on the air quality during rainy season

Table 5.
One-way ANOVA: NEW ASPHALT 1, NEW ASPHALT 2

SOURCE.	DF.	SS.	MS.	F.	F
FACTOR.	1.	284209.	284209.	0.01.	0.009
ERROR.	8.	159439841	19929980.		
TOTAL.	9.	159724050			

S=4464. R-Sq=0.18% R-Sq(adj) = 0.00%

DECISION RULE:
Reject the null hypothesis if the probability (significant value) is less than our confidence level (ALPHA value) otherwise accept the null hypothesis.

INTERPRETATION:
From the result shown above, the P-value=0.009, is less than our confidence level (ALPHA value=0.05) which shows that the test is significant.

CONCLUSION: since the probability (significant value =0.009) is less than our confidence level (ALPHA value=0.05), we shall reject the null hypothesis and conclude that old asphalt plant emission have effect on the air quality during rainy season.

VI. DISCUSION OF FINDINGS

The impact of asphalt plants on the air quality of the environment was carried out in this study.

Results obtained in the air quality assessment showed high values of CO, NO_X, SO_X, VOC and TSP at points nearest to the factory. These observations was reported in both the older and newer asphalt plants studied. A similar report had been made by El Kady (2011), NAPA (2014) and Bothma (2011) working on the effect of Hot-mix Asphalt production. The high TSP, SO_X, and NO_X reported near the plant could easily be attributed to the impact of the high temperature generated at the factory sites. The high temperature causes the reaction of the atmospheric nitrogen and Sulphur to form various oxides.

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Furthermore, the smokes released during heating and boiling of Tar caused the high TSP and associated acidic oxides reported in this study.

Observations show that the operation of the factory caused the abundance of the air quality parameters determined as they were higher in concentration around the various factories.

The emission loads formed a gradient that gradually decreases with distance away from the factory.

Analysis of the findings showed that the effects of the asphalt plant emission centered on its location and immediate surroundings. Further observations indicated that the age of the plant influenced the results, while the effect of the newer plant did not go beyond 200m from the factory.

The effect of the older plant extended up to 300m away. This could be attributed to accumulated effects and expansion, the operation of the older plant has generated a lot of waste which diffuse out with time and reached out more. This observation indicates that residents within 100-300m of the asphalt factory face the danger of inhaling these substances reported in the air. These findings contradict the report of NAPA (2014) which states that emission coming from asphalt stack is just steam, that is loss of vapour from the drying of aggregate at high temperature. The report further added, that odours from Asphalt plants do not indicate a health hazard.

Results obtained in the study indicate a significant seasonal influence, while higher values of emission were reported in the dry season, lower values were recorded during the raining season.

Two reasons could be adduced that influenced this situation, the rain could be said to have a wash down effect on the gases and particulate matter. As the rains fall to the earth surface, the drops carry particulate matter on its trail down thereby rendering the air clean of such substances. In addition, CO, NO_X and SO_X are highly soluble in water and will dissolve on coming in contact with the rain water which washes them off the air. On the other hand, asphalt plants are more operational and actively engaged in production during the dry when road construction is at its peak. Most construction companies lay off their workers during the rainy season as they cannot carry out much construction works during the rains.

This could also result in low production and hence lowered waste/gas product. Bawa (2008) and Ruiz etal (2014) has earlier reported a similar decrease in gaseous atmospheric pollutants in their studies in South Africa and Egypt respectively.

VII. CONCLUSION

From the foregoing analysis and findings, Hot-mix asphalt plant facilities in Owerri have the following impacts on the environment;

- Emission of gases, particularly nitrogen oxide, Sulphur dioxide, carbon monoxide, particulate matter and volatile organic carbons.
- The emission levels for the gases are higher for older plants than for newer plants.
- The effect of the asphalt plant is higher at the plant yard than at locations farther away from the plant yard.
- The emission levels for the gases are higher in dry season than for raining season
- Although these emissions occur, the mean effect in the quality of the air in the area is marginal but may become significant over a longer period.

RECOMMENDATIONS

The existing legal framework for environmental assistance in Nigeria is considered adequate detailed law, regulation and guidelines have been developed and serve as framework for conducting EIAs in both the public and private sectors. The implementation of these rules have been poor due to lack of adequate enforcement

- ENVIRONMENTAL MANAGEMENT PLAN (EMP)
- This is a document designed to ensure that sound environmental practices will be followed during the establishment, operation, rehabilitation, and after use of the facility, this will include inter alia.
- Regulatory agencies FMEH& UD to ensure mandatory environmental audit every ten years for every asphalt plant facility to ensure environmental cleanliness.
- Landscape management through planting of coniferous trees. Trees will act as air cleaners and also as noise barriers.
- Citing asphalt plants at least one (1) kilometer from the nearest human habitation.
- Encourage the use of small mobile asphalt plants in place of big plants located at one point, the use of mobile plants means the plant will be dismantled at the end of the project and this will reduce accumulation of pollutant elements in that area.
- Direct existing asphalt plant owners to install emission control devices like scrubbers and dust collectors.

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APPENDIX

Appendix 1: Air quality during the dry season (New asphalt plant)

	Air quality (ug/m^3)					
Component	**Edge**	**100m**	**200m**	**300m**	**control**	**FEPA**
CO	2100	1850	1500	1000	1000	1000
NOx	50.71	42.5	37.1	19.4	16.7	25
SOx	100.	86.3	66.4	56.3	29.2	40
VOC	3200	2500	1800	1200	1100	1500
TSP	83.0	76.0	70.0	38.0	25.0	60.0

Appendix 2.	; **Air quality during the rainy season (New asphalt) Distance** Edge 100m 200m 300m control					1 WHO
CO	1800	1850	1500	1230	1000	1000
NOx	40.5	38.5	30.6	25.0	15.5	20
Sox	85.6	70.5	60.4	50.0	38.0	20
VOC	3000	2200	1400	1300	100	250
TSP	65	55	40	35	20	60

Appendix 3	Air quality during the dry season (Old asphalt plant) (ug/m^3) Distance (m)					
CO	2400	2000	1700	950	950	1000
NOx	60.55	47.5	40.0	21.0	20.5	20
Sox	120	100	70.5	35.0	35.0	40
VOC	4000	3000	2000	1200	1200	1500
TSP	90	86.0	75.0	32.0	25.0	60.0

Appendix 4	**Air quality during the rainy season (old asphalt plant)** **Distance** **Edge 100m 200m 300m control**					
CO	1900	2000	1700	1200	1100	1000
NOx	40.2	39.5	35.0	30.0	20.5	20
SOx	130	120	65	62.0	45.0	20
VOC	3100	2500	1800	1400	120	250
TSP	70	60	45	45	20	