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Comparative analysis of vehicular emissions in urban and rural milieus: A case study of Port Harcourt and Etche in Rivers State, Nigeria

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ABSTRACT

Vehicular emissions have emerged as one of the major sources of air pollution in urban centers. The increasing intensity of road traffic congestions as a result of many vehicles is a serious threat in Port Harcourt environment. Also, a plan by the Rivers State Government to extend the city Centre to Etche Local Government is a major concern. This study analyzed the concentrations of carbon monoxide, Nitrogen dioxide and sulphur dioxide respectively, in both Port Harcourt (urban milieu) and Etche (Rural Milieu). A simple random, sampling technique was adopted in selecting the sample locations in both milieus. From the analysis, carbon monoxide gave the highest concentration in the two peak periods (morning and evening), and for both milieus; sulphur dioxide was found to have the lowest concentration, for both Port Harcourt and Etche. Statistical package for social science (SPSS version 17.0) was used, and the statistical tools adopted in analyzing the three research hypothesis formulated were Analysis of variance (ANOVA), and Regression analysis. Findings, indicated that a significant difference exist between the concentration of pollutant in Port Harcourt, and Etche Areas. Secondly; the air pollution is higher during the peak periods in Port Harcourt Environment, and the meteorological parameters considered, significantly influence pollutant dispersion in Port Harcourt city is a serious threat to traffic wardens, and road side business operators.

Keywords: Vehicular Emissions, rural and urban, milieu, meteorology, dispersion: Air pollution, peak periods.

INTRODUCTION

Air pollution is gradually, becoming a serious menace in Nigeria cities. In urban area, inefficient energy utilization in the transportation sector generates high level of localized air pollution.

According to Fu, [1], and Goyal [2], Motor vehicles have remained the dominant sources of air pollution; especially as traffic congestion contribute about 50-80% of NO_2 and CO concentration in developing countries. Also, motor vehicles been a major sources of air pollution in urban cities is in the increase.

Port Harcourt city is an urban milieu located within latitude 6^0 58N to 7^0 6^1 N and longitude 4^0 40^1 E to 4^0 55¹E. it is characterized by residential, commercial, transportational, industrial, and institutional zones. The city is mostly a mixed zone, as various commercial activities takes place in residential and transportational route. As a result of the

industrial activities, Port Harcourt is overcrowded with people, population increases on a daily basis, and results to increase in the number of vehicles on the road.

Etche is one of the local government areas in Rivers State. It is over 100km kilometers away from the capital City. It is a rural environment that comprises of five clans, and numerous communities. Etche is peculiar, because Rivers State Government wants to extend the city centre to it.

This study looks at estimate of emissions only from land transportation i.e. cars, heavy duty trucks, buses etc. the emissions monitored are both from diesel and petrol vehicles. Two peak periods (morning and evening) were monitored for both milieus.

Three research hypothesis were tested, which includes

Ho: There is no significant difference between the concentration of pollutants in Port Harcourt and Etche milieusHo: The air pollution during the peak periods is not higher in Port Harcourt than in Etche.Ho: Meteorological factors do not significantly influence pollutant dispersion in both milieus.

Instrumentations and methods

The study was carried out in both Port Harcourt, and Etche in Rivers State, Nigeria. It was carried out over a period of two weeks in both milieus.

The variables collected include;

a. Three inorganic pollutants namely: CO₂, NO₂, and SO₂.

b. Meteorological parameters, namely: Wind velocity (M/S), Air temperature (⁰C), Relative Humidity (%)

Sample Frame

My sample frame consist of four nodes that were selected by simple random sampling out of eight to ten highly traffic density location that have been identified in Port Harcourt city as reported by Utang, P.E and Peterside K.S [4]; and densely populated areas of Etche.

The monitoring were carried out in two peak periods, which are: Morning peak 7am – 10am; Evening peak 4:30pm -7:30pm

Port Harcourt Locations monitored includes:

- Location A: Rumuokwuta Rumuola road (along Rivers State college of Science and Art)
- Location B: Waterlines Olu Obasanjo road (Evo Road Junction
- **Location C:** Agip junction (Along Rivers State University of Science and Technology)
- **Location D:** Artillery junction along Rumuodara road.
- Etche Locations monitored includes:-
- **Location A:** Chokocho community junction
- Location B: Odagwu junction
- **Location C:** Ulakwo junction
- **Location D:** Okehi Community Junction.

Instrument used:

Testo 350XL Emission Analyzer was used. This instrument was stationed in each of the locations sampled in both milieus, and was carried out between Monday to Thursday in each of the weeks.

Statistical tools involved the use of SPSS (version 17). It includes:-

- a. One way analysis of variance
- b. Two way analysis of variance
- c. Multiple Linear Regression

DATA PRESENTATION AND DISCUSSION

TABLE 1: AVERAGE EMISSION ESTIMATES AT MORNING PEAK FOR THE FOUR LOCATIONS IN ETCHE

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
А	4.3	0.0014	0.000024	1.13	36	45
В	3.5	0.00013	0.000015	1.12	34.2	50
С	2.6	0.0096	0.000015	1.39	34.0	51
D	2.6	0.017	0.000036	1.34	34.0	49

TABLE 2: AVERAGE EMISSION ESTIMATES AT EVENING PEAK FOR THE FOUR LOCATIONS IN ETCHE

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
А	4.3	0.00028	0.000014	1.10	34.4	47
В	2.7	0.0000095	0.000011	1.15	33.3	46
С	2.7	0.0095	0.000015	1.25	34.2	47
D	3.2	0.018	0.000032	1.34	32.8	46

TABLE 3: AVERAGE EMISSION ESTIMATES AT MORNING PEAK FOR THE FOUR LOCATIONS IN PORT HARCOURT

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
А	6.28	0.313	0.0003	1.35	32.2	49
В	5.93	1.65	0.00041	1.06	33.4	52
С	7.73	0.568	0.00033	1.30	32.4	51
D	3.23	0.575	0.00038	1.61	32.5	47

TABLE 4: AVERAGE EMISSION ESTIMATES AT EVENING PEAK FOR THE FOUR LOCATIONS IN PORT HARCOURT

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
А	8.3	0.69	0.000053	1.49	35	47
В	5.4	0.86	0.000045	1.39	35.6	47
С	6.9	1.09	0.00004	1.41	33.2	40
D	4.7	0.89	0.000043	1.51	32.5	43

TABLE 5: CONCENTRATION OF POLLUTANTS IN VARIOUS LOCATIONS FOR BOTH PORT HARCOURT AND ETCHE LOCATIONS

PORT HARCOURT					ETCHE			
Pollutants	Α	В	С	D	Α	В	С	D
CO	7.29	5.67	7.32	3.97	4.3	3.1	2.65	2.9
NO ₂	0.50	1.26	0.83	0.73	0.00084	0.00007	0.0096	0.018
SO_2	0.00018	0.00023	0.00019	0.00021	0.000019	0.000013	0.000015	0.000034

TABLE 6: COMPARISON OF CARBONMONOXIDE VALUES FOR THE AVERAGE ESTIMATE (BOTH PEAK PERIODS) IN FOUR LOCATIONS, FOR PORT HARCOURT AND ETCHE.

LOCATION	PORT HARCOURT	ETCHE
А	7.29	4.2
В	5.67	3.1
С	7.32	2.65
D	3.97	2.9

TABLE 7: COMPARISON OF NITROGEN DIOXIDE VALUES FOR THE AVERAGE ESTIMATE (BOTH PEAK PERIODS) IN FOUR LOCATIONS, FOR PORT HARCOURT AND ETCHE.

LOCATION	PORT HARCOURT	ETCHE
А	0.50	0.00084
В	1.26	0.00007
С	0.83	0.0096
D	0.73	0.018

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TABLE 8: COMPARISON OF SULPHUR DIOXIDE VALUES FOR THE AVERAGE ESTIMATE (BOTH PEAK PERIODS) IN FOUR LOCATIONS, FOR PORT HARCOURT AND ETCHE

LOCATION	PORT HARCOURT	ETCHE
А	0.00018	0.000019
В	0.00023	0.000013
С	0.00019	0.000015
D	0.00021	0.000034

TABLE 9: AVERAGE EMISSION ESTIMATES FOR EACH OF THE POLLUTANTS AND METEOROLOGY IN THE FOUR LOCATIONS IN PORT HARCOURT

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
Α	7.29	0.50	0.00018	1.42	33.6	48
В	5.67	1.26	0.00023	1.23	34.5	50
С	7.32	0.83	0.00019	1.36	32.8	46
D	3.97	0.73	0.00021	1.56	32.5	45

TABLE 10: AVERAGE EMISSION ESTIMATES FOR EACH OF THE POLLUTANTS AND METEOROLOGY IN THE FOUR LOCATIONS IN ETCHE

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
А	4.3	0.00084	0.000019	1.12	35.2	46
В	3.1	0.00007	0.000013	1.14	33.8	48
С	2.65	0.0096	0.000015	1.34	34.1	49
D	2.9	0.018	0.000034	1.34	33.4	48

TABLE 11: AVERAGE EMISSION ESTIMATES FOR EACH OF THE POLLUTANTS AND METEOROLOGY IN THE FOUR LOCATIONS IN PORT HARCOURT AND ETCHE

Location	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)	Wind speed (m/s)	Air temp (°C)	Relative Humidity (%)
А	5.795	0.25042	0.0000995	1.27	34.05	47
В	4.385	0.630035	0.0001215	1.185	34.15	49
C	4.985	0.4198	0.0001025	1.35	33.45	48
D	3.435	0.374	0.000122	1.45	32.95	47

DISCUSSION

There were slight variations in terms of concentration of the pollutants between the morning and evening peaks, in all the locations. The concentration of the pollutants was higher in the evening peak, and carbon monoxide (CO) was higher in concentration, as compared to other pollutants. Lower concentrations of SO_2 were detected in morning and evening peaks at Etche compared to Port Harcourt locations.

The mean Emission Estimates at morning peak in Port Harcourt, indicated that carbon monoxide (CO) has the highest concentration, and at location C (Agip junction along Rivers State University of Science and Technology). This may be due to influx of many vehicles, as the junction leads to Mile 3 market, University of Science and technology, which makes movement more in the morning peak.

For the mean estimate at Evening Peak, Carbon monoxide (CO), also recorded the highest concentration, and at location A (Rumuokwuta – Rumuola Road, along Rivers State College of Art and Science). The high concentration of carbon monoxide (CO) in the Location can be attributed to heavy traffic that is usually experienced between the hours of 4:30 pm to 7:30 pm. The mean estimate for both morning and evening peak at Etche, showed that carbon monoxide had the higher concentration, and at location A (Chokocho Community Junction).

Both Suphur dioxide (SO₂) and Nitrogen dioxide (NO₂) were very low at all the locations in Etche.

The meteorological parameters monitored (windspeed, Air temperature, and Relative Humidity) were relatively the same, as the monitoring was carried out at the same time for both milieus.

According to Utang and Peterside [3], operating characteristics involve the concentration of temperature, humidity, wind speed, and the degree of traffic congestion.

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The very low concentration of surplur dioxide (SO₂), can be attributed to few diesel powered vehicles that ply the selected locations.

Research hypothesis one

In testing the hypothesis which is "there is no significant difference between the concentration of pollutants in Port Harcourt and Etche Areas" table 5, was used, it was analysed using a two way ANOVA. The pollutants CO, SO₂ and NO₂ were dependent on locations (Port Harcourt and Etche). The result on the test between the subject effects shows that the concentration of pollutants (P<0.05) in Port Harcourt is different to that of Etche with F-ratio of 46.527. it therefore concludes that "there is a significant difference between the concentration of pollutant in Port Harcourt and Etche.

RESEARCH HYPOTHESIS TWO

In testing the Research Hypothesis two, which is "The Air pollution during the peak period is not higher in Port Harcourt".

Tables 7, 8, and 9 which indicate the comparison of carbon monoxide values, Nitrogen dioxide values, and sulphur dioxide values for the average estimates in Port Harcourt and Etche, were analyzed using One-way Analysis of variance (ANOVA). The result of the analysis in showed that P < 0.05 at a significance of 0.017 and F-ratio of 10.803. This means that the concentration of carbon monoxide (CO) is 99.98% higher in Port Harcourt locations as compared to Etche. In the second result, the P<0.05, at the significance of 0.002 and F-ratio of 26.726, means that the concentration of Nitrogen dioxide (NO2) is 99.99% higher in Port Harcourt to Etche Locations. In the third result, there was significance of 0.000, and F-ratio of 228.315. This means that the concentration of sulphur dioxide (SO₂) is 100% higher in Port Harcourt as compared to Etche areas.

The result therefore, concludes that "the Air pollution during the peak periods is higher in Port Harcourt. This means that the null hypothesis (Ho) is rejected.

RESEARCH HYPOTHESIS THREE

The third Hypothesis was tested using table 11, which is the average emission estimates for each of the pollutants and meteorological parameters in Port Harcourt and Etche. Regression model was used in analyzing it. From the result, sulphur dioxide concentration had a weak correlation with wind speed (0.084), Air temperature (-0.398) and Relative humidity (0.269).

From the result, Nitrogen dioxide concentration has a weak correlation with wind speed (-0.483), Air temperature (0.034), and a high correlation with Relative humidity (0.870).

For carbon monoxide, there was an average negative correlation with wind speed (-0.502), high correlation with Air temperature (0.765), and weak correlation with relative Humidity (0.076).

The coefficient of determination (R^2) for SO₂, CO and NO₂ on wind speed, Air temperature, and relative Humidity showed 1.00. This means that total dispersion of SO_2 , CO and NO_2 are completely (100%) explained by meteorological parameters (wind speed, Air temperature, and relative Humidity) Also, the result showed a Linear relationship between CO, SO₂ and NO₂ (dependent variables) on wind speed, Air temperature, and relative Humidity (independent variables).

The result therefore concludes that "meteorological factors influences pollutant dispersion in both milieus" The Null hypothesis was thereby rejected.

Predicti	ion Equa	tion
CO	=	$15.917X_1 + 10.961X_2 + 7.933X_3$
NO_2	=	$-4.745 X_1 - 3.516 \ X_2 - 1.347 \ X_3$
SO_2	=	$-21.946\ X_1-14.485\ X_2-10.879$

SO_2	=	-21.9	$-21.946 X_1 - 14.485 X_2 - 10.879 X_3$	
Where	X_1	=	Wind speed	
	X_2	=	Air temperature	
	X_3	=	Relative Humidity	

CONCLUSION

This study looked at the comparative analysis of vehicular emissions in urban and Rural Milieus; a case study of Port Harcourt, and Etche in Rivers state, Nigeria was examined. The Air pollution in the peak periods was seen to be higher in Port Harcourt. The meteorological factors were seen to influence significantly the pollutant dispersion in both milieus, as the coefficient of determination (R^2) was seen to be one (100%).

This is so, because total dispersion of the pollutant (CO, SO_2 and NO_2) was completely explained by meteorological factors (Wind speed, Air temperature, and Relative Humidity). The three null hypothesis formulated were rejected. There was low concentration of SO_2 , which is an indication that few diesel powered engine Vehicles ply such routes. The age limit of the vehicles cannot be left out of the scene, as it contributes to emissions. Finally, Traffic congestion in Port Harcourt cities, are serious threat to traffic wardens, police, hawkers, and business operators around the transportational routes.

Their continual exposure to such emissions from vehicles, can results to several ailments associated with such pollutants.

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