SPATIO-TEMPORAL ANALYSIS OF ATMOSPHERIC POLLUTANT CONCENTRATIONS AT BUS TERMINALS ALONG MAJOR TRAFFIC CORRIDORS IN PORT HARCOURT URBAN AREAS

Vincent Ezikornwor Weli[1] and Sadiq Ize[2]
[1,2] Department of Geography and Environmental Management, University of Port Harcourt, Nigeria.

ABSTRACT: *This study empirically analyzed atmospheric pollutants concentration especially its relationship to meteorological parameters in the vicinity of bus terminals in the city of Port Harcourt. Data on both atmospheric pollutants ((*PM_1*,* $PM_{2.5,}$ PM_7*, TSP,* SO_2*,* NO_2*, CO, VOC and CO) with their meteorological variables were collected with the aid of Aeroqual 300 series multi-Gas Meter and Extech weather station Gavin UID respectively; in Mile 1, Mile 3, Garrison, Rumuola and Lagos park bus terminals which were selected based on their high level of socio-economic activities and high frequency of buses alighting. Data were analysed using the Pearson's Product Moment Correlation Coefficient, Step-Wise Multiple Regression and Analysis of Variance (ANOVA). Findings indicates that that Relative humidity (RH) had a direct relationship but low correlation with* PM_1 PM_7*, TSP and CO of correlation values (r) of 0.343, 0.229, 0.271 and 0.146 respectively but inversely correlated with* SO_2 *(r = -0.476). However, RH had a direct significant relationship with* $PM_{2.5}$*,* SO_2*, and VOC (r = 0.548, 0.629 and 0.595 respectively at p = 0.05). Temperature had a significant but inverse relationship with* $PM_{2.5}$*,* SO_2*, and VOC (r = -0.524, -0.641 and -0.6 12 at p = 0.05) and a direct significant relationship with* NO_2 *(r = 0.712) and* CO_2 *(r = 0.553. Wind speed showed a weak relationship with* PM_1 *and* CO_2 *(r = 0.010 and 0.205) but inversely and significantly correlated to* PM_7*,* PM_{10}*, TSP, CO,* $PM_{2.5}$*,* SO_2 *and VOC (r = -0.398, -0.398, -0.436, -432, -0.575, -0.864 and respectively) which means that as wind speed reduces the concentration of these pollutants increases at the bus terminals. Result showed that there were elevated spatial and temporal concentrations of these pollutants because of calm atmospheric condition prevailing at the bus terminal. Enforcement of stricter laws and regulations to control emissions of these obnoxious air pollutants because of their health implications for commuters is strongly recommended.*

KEYWORDS: air pollution, carbon monoxide, emission concentration, vehicular emissions, bus terminals.

INTRODUCTION

Traffic-related sources of air pollution are drawing increasing concern for interested exposure assessors, air pollution meteorologist, epidemiologist as well as toxicologist. Clean air is considered to be a basic requirement for human health and wellbeing. Various chemicals are emitted into the air from both, natural and anthropogenic sources. In spite of the introduction of cleaner technologies in industry, energy production and transport, air pollution remains a major health risk (Tasic et al; 2009). The

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economic development of entire regions depends on the easy access to people and goods ensured by contemporary transport technology. Owing to its flexibility, road transport is a major transport mode, and cars are objects of desire and pride in many societies (WHO, 2005). Unfortunately, these positive aspects are closely associated with the hazards to the environment and human health caused by transport, particularly road transport (Dora & Phillips, 2000 cited in WHO, 2005). Today, motor vehicles are responsible for nearly one half of smog-forming Volatile Organic Compounds (VOCs), more than half of the nitrogen oxide (NOx) emissions, and about half of the toxic air pollutant emissions in the United States. The rapid increase in the number of cars has led to traffic congestion especially in the city of Port Harcourt which is a major hydrocarbon industrial hub of Nigeria. The decrease in average car speed due to traffic congestion has led to an increase in the total vehicle exhaust emissions. Congested traffic corridors in dense urban areas are key contributors to the degradation of urban air quality. According to monitoring data, vehicle exhaust has become one of the main factors affecting Beijing's air quality. It produces 50 percent of the airborne pollutants (Beijing International, 2014). The United Nations estimated that over 600 million people in urban areas worldwide were exposed to dangerous levels of traffic- generated air pollutants (Cacciola et al., 2002). Air pollution and its public health impacts are drawing increasing concern from the environmental health research community, environmental regulatory agencies, industries, as well as the public. Particulate matter pollution for instance is nowadays one of the problems of the most concern in great cities, not only because of the adverse health effects, but also for the reducing atmospheric visibility and affect to the state of conservation of various cultural heritages (Van Grieken & Delalieux, 2004). The avalanche of literature suggests that air pollutants could contribute to increase in hospital admission, lead to absence from work and school, increase in mortality rate (see Giri et al ; 2006; Wang and Zhao, 2008; Hopke, 2009 and Weli 2014) For animals, there are the problems of mottled teeth and condition of the joints known as exostosis leading to lameness and ultimate death (Han and Naeher; 2006). In the case of atmospheric properties, air pollutants causes visibility reduction which may lead to safety hazards, fog formation and precipitation, solar radiation reduction and alteration in temperatures and wind distribution (see Jacobson, 2001; Rosenfeld, 2002; Chow et al .,2002; Watson 2002a,b; Cao et al 2004). Utang and Peterside (2011) estimated emission levels at road intersections experiencing recurrent traffic congestion at certain periods, identified as peaks, and comparing the values with less congested periods known as off peak periods in Port Harcourt.

From the available literature, it is obvious that there is dearth of empirical analysis of atmospheric pollutants concentration especially its relationship to meteorological parameters in the vicinity of bus terminals which houses a great number of passengers waiting to get buses in the city of Port Harcourt. Therefore, this study attempts to assess the atmospheric loading of pollutants at bus terminal where passengers alight and wait for buses. It seeks to unravel what type(s) of atmospheric pollutants that are predominant and their level of concentrations at the bus terminals; the relationship between meteorological variables and pollutant concentration in the vicinity of the bus terminals with a view to recommending appropriate measures aimed at reducing pollutants at the terminals.

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METHODOLOGY

Studied sites and sample collection

The present study was performed in Port Harcourt which is the capital of Rivers State in Nigeria. It lies along the Bonny River and is located in the Niger Delta. According to the 2006 Nigerian census Port Harcourt has a population of 1,382,592. It features a tropical monsoon climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualifies as dry season months in the city. The harmattan, which climatically influences many cities in West Africa, is less pronounced in Port Harcourt. Its heaviest precipitation occurs during September with an average of 370 mm of rain. December on average is the driest month of the year; with an average rainfall of 20. mm. Temperatures throughout the year in the city are relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25°C-28°C in the city. In the dry season, severe air pollution in the form of aerosol smog occurs frequently in the urban area of Port Harcourt, particularly during meteorologically calm (wind speed < 2 ms-^{1}) and stable conditions. Heavy automobile traffic is characteristic for Port Harcourt urban area. The average age of passenger cars is more than 15 years, which means that leaded gasoline (0.4 g l-1 Pb) is still widely used

Data on both atmospheric pollutants with their meteorological variables were collected with the aid of Aeroqual 300 series multi-Gas Meter and Extech weather station Gavin UID respectively in five (5) major bus terminals which were selected based on high level of socio-economic activities and high frequency of buses alighting at these identified bus terminals (table 1and fig.1). The total number of buses alighting at each selected bus terminals was counted in order to determine its relationship to pollutants concentration. The selected bus terminals include; Mile 1, Mile 3, Garrison, Rumuola and Lagos park. Data were analysed using the Pearson's Product Moment Correlation Coefficient, Step-Wise Multiple Regression and Analysis of Variance (ANOVA) .

Table 1: Spatial distribution of Sampled Stations

S/No	Stations	X and Y Coordinates
1	AQ1 Mile 3	NO4^{O}, 48^{1} 5^{11}, E006^{O}, 59^{1}, 22.7^{11}
2	AQ2 Mile 1	NO4^{O}, 47^{1} 36^{11}, E006^{O}, 59^{1}, 44.2^{11}
3	AQ3 Lagos Town	NO4^{O}, 45^{1} 43.1^{11}, E006^{O}, 01^{1}, 08.1^{11}
4	AQ4 Garrison	NO4^{O}, 48^{1} 21^{11}, E006^{O}, 00^{1}, 33.0^{11}
5	AQ5 Rumuola	NO4^{O}, 49^{1} 54^{11}, E007^{O}, 00^{1}, 17.2^{11}

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RESULT AND DISCUSSION OF FINDINGS

Findings showed that the mean values of total Suspended Particulate Matter (SPM) sizes of (PM_{11}, $PM_{2.5}$, PM_7 and PM_{10}) in the morning hours in Mile 3 bus terminal is 0.046 µg/m^3. In mile I, the mean value was 0.064 µg/m^3. The measurement for Lagos and garrison bus terminals indicates a mean value of 0.029µg/m^3 and 0.041 µg/m^3 respectively. While Rumuola has a mean value of 0.048 µg/m^3. Mile 1 had the highest concentration of the suspended particulate matter with a value of 0.232 µg/m^3. The least PM size (0.029 µg/m^3) was obtained at the Lagos bus terminal. Similarly, the value of total suspended particles (TSP), showed that the distribution among the bus terminals differs significantly. However, mile 3 bus terminal had a mean value of 0.137mg/rn3, mile I had 0.424mg/m^3, while Rumuola obtained a value 0.123mg/rn^3. Furthermore, the mean concentration of nitrogen oxide (NO_2)

varied very slightly among the sampled locations. Mile 3 had a mean value of 0.185mg/m^3. Mile 1 and Rumuola had mean values of 0.238mg/m^3 and 0.234mg/m^3 respectively.

Table 2: Spatial variation of atmospheric pollutants and meteorological variables at the Bus Terminals

Stations	**Time**	**RH%**	**Temp. °C**	**Wind speed m/s**	**Suspended particulate matter (µg/m^3)**					**Concentration in (mg/m^3)**					**Wind directIon**
					PM_1	$PM_{2.5}$	PM_7	PM_{10}		NO_2	$S0_3$	VOC	$C0_3$	Co	
Mile3	830am 902am	82.8 82.6 82.5	28.6 28.7 28.6	0.8 0.9 0.7	0.004 0,005 0.006	0.012 0.012 0.019	0.057 0.059 0.042	0.078 0.095 0.090	0.105 0.136 0.170	0.183 0.183 0.189	1.41 1.41 1.42	241.2 223.8 196.8	0.03 0.03 0.04	27.84 27.84 27.84	South- west
Mean		**82.6**	**28.6**	**0.8**	**0.005**	**0.014**	**0.053**	**0.088**	**0.137**	**0.185**	**141**	**220,4**	**0.033**	**27.84**	
Mile1	915am 935am	81.3 81.4 81.5	28.8 28.9 28.9	0.5 0.7 0.6	0.006 0.003 0.004	0.020 0.037 0.036	0.046 0.127 0.390	0.069 0.153 0.152	0.095 0.184 0.994	0.223 0.223 0.223	2.52 2.53 2.52	288.4 296.0 296.0	0.04 0.04 0.04	1545 15.45 15.45	South
Mean		**81.4**	**28.8**	**0.6**	**0.004**	**0.021**	**0.187**	**0.125**	**0.424**	**0.223**	**2.52**	**293.4:**	**0.04**	**15.45**	
Lagos	950am 1039am	74.6 74.5 74.7	29.7 29.7 29.8	1.2 1.3 1.4	0.009 0.010 0.010	0.019 0.018 0.018	0.040 0.034 0.037	0.059 0.040 0.046	0.087 0.046 0.054	0.221 0.221 0.223	0.12 0.12 0.13	63.3 60.5 60.5	0.05 0,05 0.05	10.55 10.54 10.57	South- west
Mean		**74.6**	**29.7**	**1.3**	**0.010**	**0.018**	**0.047**	**0.048**	**0.062**	**0.222**	**0.12**	**61.4**	**0.05**	**10.55**	
Garrison	1049am 1101am	69.1 69.2 69.4	30.0 30.1 30.1	1.6 1.4 1.6	0.005 0.006 0.004	0.013 0.019 0.014	0.049 0.063 0.060	0.078 0.083 0.071	0.102 0.102 0.084	0.238 0.238 0.238	0.68 0.68 0.58	119.0 110.0’ 94.9	0.03 0.03 0.03	4.77 4.78 4.79	South- west
Mean		**69.2**	**30.1**	**1.5**	**0.005**	**0.015**	**0.057**	**0.077**	**0.096**	**0.238**	**0.65**	**108.37**	**0.03**	**4.78**	
Runujola	1129am 1220pm	59.4 59.5 59.7	31.2 31.3 31.4	1.5 1.5 1.4	0.002 0.002 0.002	0.017 0.003 0.008	0.057 0.100 0.045	0.095 0.126 0.061	0.132 0.157 0.081	0.230 0.233 0.239	0.50 0.58 0.59	136.5 136.5 121.5	0.05 (J.05 0.06	22.76 22.76 22.76	South- west
Mean		**59.5**	**31.3**	**1.5**	**0.002**	**0.009**	**0.067**	**0.094**	**0.123**	**0.234**	**0.56**	**131.4**	**0.05**	**22.76**	
WHO										**0.4**	**0.35**				

Table 2 presents data analysis on atmospheric pollutants, nitrogen oxide (NO_2), $S0_2$, VOC, CO_2 and CO in the sampled stations, with meteorological variations. The table revealed the time of sampling and the mean values for each sampled locations. The concentration of Nitrogen Oxide (NO_2) varied very slightly among the sampled locations. Mile 3 recorded 0.185mg/m^3 (measured in the morning between 8.3Oam and 9.O2am), with RH of 82.6%, mean temperature 28.6°C, while mean wind speed was 0.8m/s, and wind direction was south-west. At mile 1 recorded 0.223 mg/rn3 (measured between 9. l5am and 9.35am. RH was 81.4%, mean temperature recorded 28.8, wind speed 0.6m/s and the direction of flow was southward lagos , Garrison and Rumuola had mean values of 0.222 mg/m^3, 0.238 mg/m^3 and 0.234 mg/m^3 NO_2 concentration respectively (recorded between 9.50am and 10.39am).

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Table 3: Correlation Matrix Analysis of Atmospheric Pollutants and Meteorological Parameters

Atmospheric pollutants	Meteorological parameters		
	RH(%)	Temp (°C)	Wind speed (m/s)
PM_1	0.343	- 0.297	0.010
$PM_{2.5}$	0.548	- 0.524*	- 0.575
PM_7	0.229	- 0.0209	- 0.398
PM_{10}	0.146	- 0.158	- 0.398
TSP	0.271	- 0.256	- 0.436
NO_2	- 0.706**	0.712**	0.610*
SO_2	- 0.629*	0.641*	- 0.864**
VOC	0.595*	- 0.612*	- 0.857**
CO_2	-0.476	0.553*	0.205
CO	0.146	-0.144	-0.432

* Correlation is significant at the 0.01 level (2-tailed) ** Correlation is significant at the 0.05 level (2-tailed)

Result indicates that (table 3) Relative humidity (RH) had a direct relationship but low correlation with PM_1 PM_7, TSP and CO of correlation coefficient r 0.343, 0.229, 0.271 and 0.146 respectively but inversely correlated with SO_2 of correlation coefficient (r) of -0.476. However, RH had a direct significant relationship with PM2.5, SO_2, and VOC of correlation Coefficient (r) = 0.548, 0.629 and 0.595 at p = 0.05 (2- tailed). While it was inversely proportional with a high relationship of correlation coefficient of (r) = -0.706 at p = 0.01 (2-tailed). Temperature (°C) was inversely proportional to PM_1 PM_7, PM_{10}, TSP, and CO, of correlation coefficient -0.297, -0.209,-0. 158, -0.256, and -0.144 with a low relationship while temperature (°C) had a significant relationship with $PM_{2.5}$, SO_2, and VOC but inversely proportional, of correlation coefficient (r) -0.524, -0.641 and -0.6 12 at p = 0.05 (2-tailed). Furthermore, temperature had a direct significant relationship with No2 of correlation coefficient (r) = 0.712 at p = 0.01 (2-tailed) and also with CO_2 of correlation coefficient (r) = 0.553 at p = 0.05 (2-tailed).The analysis obtained on wind speed showed a low relationship with PM_1 and CO_2 of correlation coefficient (r) = 0.010 (PM_1) and 0.205 (CO_2) but inversely correlated to PM_7, PM_{10}, TSP and CO. The correlation coefficient (r) recorded PM_7 -0.398, PM_{10} -0.398, TSP = -0.436, and (= -432 which means the relationship was low. However, wind speed also had an inversely proportional correlation with $PM_{2.5}$, SO_2 and VOC which was significantly high. The correlation coefficient recorded for $PM_{2.5}$ (r) = -0.575, at p = 0.05 (2-tailed), SO_2 (r) = 0.864 at p = 0.01 (2-tailed) and VOC (r) = -0.857 at p = 0.01 (2-tailed). But a direct correlation relationship exist between wind speed and nitrogen oxide (NO_2), and this recorded a correlation coefficient of (r) = 0.610 at p = 0.05 (2- tailed), which means that the relationship was high.

Table 4: Correlation Statistics of pollutants and relative humidity and their Significance Level

Atmospheric pollutants	Correlation coefficient (r)	R^2	Correlation Determination (%)	t-test for t- calculated	Table value at 14 of P = 0.05	Significance
TSP	0.271	0.0734	7.34	1.02	2.14	NS
NO_2	-0.706	0.4984	49.84	3.59	2.14	S
SO_2	0.629	0.3956	39.56	2.92	2.14	S
VOC	0.595	0.3540	35.4	2.67	2.14	S
CO_2	-0.476	0.2266	22.66	1.95	2.14	NS
CO	0.146	0.0213	2.13	0.53	2.14	NS

S - Significant; NS — Not Significant
P - Probability Level
DF -Degree of Freedom

Pearson's Correlation Statistics was used to test this hypothesis and the analysis was done using table 4.2 and table 4.5. The dependent variable (Y) is each of the atmospheric pollutant while the independent variable (X) is the meteorological variables. Since our calculated (t) from the distribution were 1.02, -3.59, 2.92, 2.67, -1.95 and 0.53, however, 3.59, 2.92 and 2.67 are higher than the critical t- value of 2.14 at DF' 14, p = 0.05, for the distribution. Thus, the relationship between meteorological variable RH (%) SO_2, NO_2 and VOC are significant. But the relationship between RH and other pollutants (TSP, CO_2, and CO) is not significant. Thus may be due other factors which may have influenced the relationship.

Table 5: Correlation Statistics for Atmospheric Pollutants and Temperature (°C) and Significance Level

Atmospheric pollutants	Correlation coefficient (r)	R^2	Correlation Determination (%)	t-test for t- calculated	Table value at 14 of p=o.05	Significance
TSP	-0.256	0.0656	6.56	0.95	2.14	NS
NO_2	0.712	0.5069	50.69	3.655	2.14	S
SO2	-0.641	0.4109	41.09	3.011	2.14	S
VOC	-0.612	0.3745	37.45	2.79	2.14	S
CO_2	0.553	0.3058	30.58	2.39	2.14	NS
CO	-0.144	0.0207	2.07	0.59	2.14	NS

Note: S - Significant; NS - Not Significant

Table 4 shows the correlation statistics which used to test this relationship. Temperature (°C) is the independent variable (X) while the atmospheric pollutants are the dependent variables (Y). The results showed that the relationship between temperature (°C) and atmospheric pollutant (TSP and CO). From the analysis in table 5 there is no significant relationship between temperature and total suspended particulate and carbon monoxide. However, the relationship between temperature (°C) and NO_2, CO_2, VOC were significant at p= 0.05.

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Table 6**:** Pearson's Correlation Statistics for Atmospheric Pollutants and Wind Speed (m/s) and their Significance Level

Atmospheric pollutants	Correlation coefficient (r)	R^2	Correlation Determination (%)	t-test for t- calculated	Table value at 14 of p=o.05	Significance
TSP	-0.436	0.1901	19.01	1.75	2.14	NS
NO_2	0.610	0.3721	37.21	2.78	2.14	S
SO_2	-0.864	0.7464	0.7544	6.13	2.14	S
VOC	-0.857	74.64	73.44	5.99	2.14	S
CO_2	0.205	0.042	4.2	0.75	2.14	NS
CO	-0.432	0.1866	18.66	1.73	2.14	NS

Note: S — Significant; NS - Not Significant.

Table 6 shows the correlation statistics and significance level of atmospheric pollutant and wind speed (m/s). The table distribution, showed that TSP, CO and CO_2 of t-test calculated values 1.75, 0.75, and 1.73 had lower values when compared to the table value of 2.14 at p = 0.05. The relationship is not significant (NS). Therefore, we accept null hypothesis for TSP, CO_2 and CO. On the other hand, calculated (t) values for NO_2, SO_2 and VOC are 2.78, 6.13 and 5.19. These values are higher than table value 2.14 at p = 0.05. This implies that there is no statistical significant spatial difference in the levels of pollutant among the bus terminals in Port Harcourt.

Table 7**:** Analysis of Variance and the Significant Level of Pollutants at each Bus Terminal
Note: Df = 4 under 10 at P = 0.05 from the F-distribution Table = 3.48. NS = Not Significant; S = Significant.

Furthermore, the analysis conducted on particulate matter (PM_1— to) matter showed that the particle sizes position may have been affected by time; location which a result may be as human's activities in the area. It was observed that, most particulate matter, approximately 10mm or less in diameter, are of smoke and are produced by incomplete combustion of fossil fuel (Smith 1975; Miller 1994). The urban environment of Nigeria, are characterized with increased particulate matter (PM_{10}) (Efe, 2008).
Air pollution trends are strongly affected by atmospheric conditions such as temperature, pressure and humidity (RH); and by global circulation patterns. For instance, the study revealed that RH had a direct relationship but low correlation with PM_1, PM_7 TSP and carbon monoxide. The result also showed that temperature (°C) had a significant relationship with NO_2, CO_2, VOC and CO_2. Since Port Harcourt, is usually characterized by high temperature, high pressure and high humidity; the oxides of sulphur and nitrogen combined with water vapour in the atmosphere cause acid rain cities (Efe, 2008). Wind speed (m/s) also showed a significant relationship with NO_2, SO_2 and VOC in We study area. In addition, the level of concentration of these pollutants (No_2, So_2 and VOC) varies with time which could also be attributed to time, location and type of human activities. For instance, levels of concentration of SO2 was higher in mile III; VOC and CO were higher in mile I. These findings supports the works of Mkoma, et al (2010) and Weli, 2014 which affirmed that the temporal and spatial variability of the atmospheric particles and its components are influenced by meteorological parameters such as rainfall, temperature, relative humidity and air flow patterns.

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Atmospheric pollutant	**ANOVA**	**Sum of squares**	**(df) degree of freedom**	**Mean square**	**F-ratio**	**Table value at p= 0.05**	**Significance**
PM_1	Between groups within groups Total	0.000 0.000 0.000	4 10 14	0.000 0.000	2 1.733	3.48	S
$PM_{2.5}$	Between groups within groups Total	0.001 0.000 0.001	4 10 14	0.000 0.000	5.886	3.48	S
PM_7	Between groups within groups Total	0.045 0.067 0.111	4 10 14	0.011 0.007	1.672	3.48	NS
PM_{10}	Between groups within groups Total	0.009 0.007 0.0 16	4 10 14	0.002 0.001	3.193	3.48	NS
TSP	Between groups within groups Total	0.255 0.492 0.752	4 10 14	0.064 0.050	1.283	3.48	NS
NO_2	Between groups within groups Total	0.005 0.000 0.005	4 10 14	0.001 0.000	191.260	3.48	S
SO_2	Between groups within groups Total	10.702 0.012 10.714	4 10 14	2.676 0.001	2280.332	3.48	S
VOC	Between groups within groups Total	103840.057 1534.127 105374.184	4 10 14	25960.014 153.413	169.217	3.48	S
CO_2	Between groups within groups Total	0.001 0.000 0.001	4 10 14	0.000 0.000	23.250	3.48	S
CO	Between groups within groups Total	1024.073 .001 1024.073	4 10 14	256.018 0.000	3840272.50 0	3.48	S

CONCLUSION

The study revealed the types of atmospheric pollutants were found in the vicinity of the bus terminals and that meteorological variables such as RH, Temperature and Windspeed can influence the spatial distribution of pollutants. $S0_2$ concentration was higher than WHO standards of air quality which has the potential for causing acid rain.

Recommendations

1) There should be an improvement in air quality management for the benefit of the environment and the health of commuters.
2) Ambient air and air-related measurement should be conducted occasionally, to ensure proper monitoring and air quality assessment in the city.
3) Assessment of the data quality for ambient air toxics should be employed which will promote accuracy, completeness and promptness in all instruments used for air quality collection.

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4) Enforcement of stricter laws and regulations should be enforced for the reduction of activities that pollutes and reduces air quality.

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