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IMPACT ASSESSMENT OF PARTICULATE POLLUTANTS IN SELECTED TRAFFIC CONGESTED AREAS IN ZARIA METROPOLIS, KADUNA STATE, NIGERIA.

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Abstract

It has been noticed that the concentration of particle pollutants in major nodal points in Zaria metropolis has continued to grow as the traffic volume increases. The concentration of particulate matter and meteorological data was measured within the Zaria metropolis and was limited to major ways within the town which include Kwangila, PZ, Kasua Mata, Agoro and Kofar Doka. The concentrations of the Particulate Matter in different particle sizes ($P_{0.3}$, $P_{0.5}$.$P_{1.0}$, $P_{2.5}$ and $P_{5.0}$) were measured using particle counter, at each sampling point for 3hrs during the morning peak hours (7:00am to 10.00am), for 3hrs during the afternoon off peak hours (11.00am to 2:00pm) and for 3hrs for the evening peak hours (4:00 to 7:00pm) after a comprehensive traffic volume of vehicles plying the sampling points had been done for one month. The average traffic volume for the peak period (morning) across the five sampling points ranged from 2701-3060 while that of the evening peak hours ranged from 2676-3651. The average traffic volume for the off peak (afternoon) ranged from 1777-2255 with kwangila recording the highest traffic volume for both peak and off peak periods. The impact of traffic density on the concentration of particulate matter measured showed that increase in traffic led to a corresponding increase in the concentration of particulate matter recorded for both peak and off- peak periods. The $P_{2.5}$ was used as bases for comparison with the AQI standard for peak and off peak periods. For peak hour session, the air quality at Kwangila, Kasua Mata and Agoro was classified as unhealthy and hazardous while that of PZ and Kofar Doka was classified unhealthy to people with heart and lungs diseases. The concentration of PM obtained for off-peak period for all the sampling points was classified moderate and safe when compared with AQI standard. In this regard, there is a need to not only promote public transportation with larger capacity of passengers but to also improve the public transportation system. This will reduce greenhouse gas emissions by providing a convenient option to reduce unnecessary driving and by lowering emissions per passenger kilometer travelled. The use of non-motorized means of transportation would also help in curbing excessive release of pollutants into the atmosphere. Planting of Trees along major ways to trap and absorb pollutants is another option of reducing the amount of pollutants in the atmosphere. The use of older vehicles should be discouraged. The older a vehicle is the more the tendency to emit more pollutants.

Key words: Particulate Matter, Traffic congestion, Metrological parameters, Standards

1. INTRODUCTION

In recent times/ Recently, environmental pollution has become one among major challenges facing big cities in Nigeria and worldwide. This is not unconnected to the increase in number of vehicles plying our roads as a result of urbanization, industrialization, in addition to other human activities such as bush burning, mining, gas flaring etc. One common feature of the issues relating to the environment in Nigeria is that it is fast becoming unfriendly, unsustainable and that it endangers species, which if left untracked can destroy the universe.

Human activities and the environment are inter-related. This is because any activity of man is done in the environment and the resultant effect is either positive or negative to humankind. Human activities are however diverse. Negative effects lead to the discharge ofharmful pollutants like particulate matter (PM), sulphur dioxide ($SO_)$, carbon monoxide (CO), hydrocarbon (HC), etc. that cause acid rain, global warming, and the malfunctioning of human hemoglobin (WHO, 2015) etc. The emittance of such gases into the atmosphere is known as air pollution. (IPCC, 2011)

The growing concerns about the health implications of air, water, and soil pollution toecosystems have led to the establishment of agencies which are saddled with the responsibility of combating the adverse effects. Examples of these organizations, agencies and departments are World Health Organization (WHO), United State Environmental Protection Agency (USEPA), United Nations (UN), Central Pollution Control Board (CPCB) from India, Federal Environmental Protection Agency (FEPA), National Environmental Standards and Regulations Enforcement Agency (NASREA). The local, national and international agencies are working and concentrating on pollution of the environment and publishing and issuing documents to improve the air quality. The Air Quality Index (AQI) is a pointer that determines the degree of pollution in an area. Each of these pollutants has an air quality standard which is used to calculate the overall AQI for the city.

Particulate Matter (PM) is the sum of all microscopic solid and liquid particles, of human and natural origin, that remain suspended in a medium such as air for some time. These particles vary greatly in size, composition, and origin, and may be harmful. (AQEG, 2016)

Ambient Particulate Matter (PM) is a mix of heterogeneous components that varies greatly by season and by region. It consists of various components, which include Organic Carbon (OC), Elemental Carbon (EC), nitrate, sulfate and

trace elements (e.g., iron, vanadium, nickel). These chemical components are derived from various anthropogenic and natural sources, such as soil or road dust, vehicle exhaust, biomass combustion, sea salt, forest fires, and may have great spatio-temporal variations associated with particular regional and local sources.(APEG, 1999)

Particulate Matter consists of a complex mixture of air-borne materials, such as elemental carbon, organic matter, trace elements, inorganic salts, mineral dust and water suspended in air. Other by-products such as Nitrogen Oxides (NOx), Volatile Organic Compounds (VOCs) and Sulfur-dioxide (SO_2) are also contained in the PM aerosols that form the atmospheric gaseous combustion. The composition of this mixture of atmospheric PM can be changed dramatically due to changes in emission sources, chemical atmospheric processes, meteorological parameters, time and season. (Preradovic et el/al 2011.)

The sources of these particles originate mainly from a number of different immobile and portable mission sources as well as from natural sources. The particles from combustion sources are thought to be more harmful to human health than particles generated from other sources. (Sabiomi et el/al, 2011)

Zaria has for long attracted people from other places due to the variety of functions that it performs. Consequently, the pressure of population has led to increase in demand for economic growth and sustainability. The size of the shore of the city has been opened up in terms of dimension and capacity, thus leading to a rise in the number of vehicles on the roads as well as in the vibrancy in the socio-economic market. The city has become polycentric, growing from having one center to eight and many sub-centers. As a result of the increase in technological, industrial, economical, socio and agricultural advancement coupled with increases in population growth, it is expected that the composition of the natural air within the metropolis, especially in areas where economic activities are prevalent must have been altered and polluted in no small measures, thereby leading to the deterioration of environmental quality.

This Research work therefore was set out to assessing the level of hazardous particulate pollutants in some selected traffic congested areas within the Zaria Metropolis. The areas in question are Kwangila flyover, PZ, Kasua Mata, Agoro and Kofar Doka.

Review of Related Studies

The growing risk of increased pollution from mobile transportation sources is alarming. Congestion on Nigeria roads and increase in the concentration of pollutants in the air has consequently increased the health risk on human population. In specific studies relating to Nigeria experience, mobile source of

emissions have tended to the largest contributor to urban emission inventories in many locations.

Table 1: Particulate Matter Results obtained from different locations in Nigeria

S/NO	Location	$PM_{2.5}$ (µg/m3)	References
1	Lagos	887-988	Owoade et al, 2013
2	Calabar	109-269	IKamaise et al, 2013
3	Benin	173-520	Ediagbony et al, 2013
4	Ile-Ife	233-379.	Owoade et al, 2016
5	Ile-Ife	298-421	Fawole et al 2016
6	Lagos	983-1021	Ezeh et al 2014
7	Abuja	312-422	Attah et al 2017
8	Portharcourt	472-531	Johnson et al 2016
9	Aba	298-376	Moses et al 2015
10	Kano	417-462	Onabowale et al 2015

(Amodio et al., 2017)

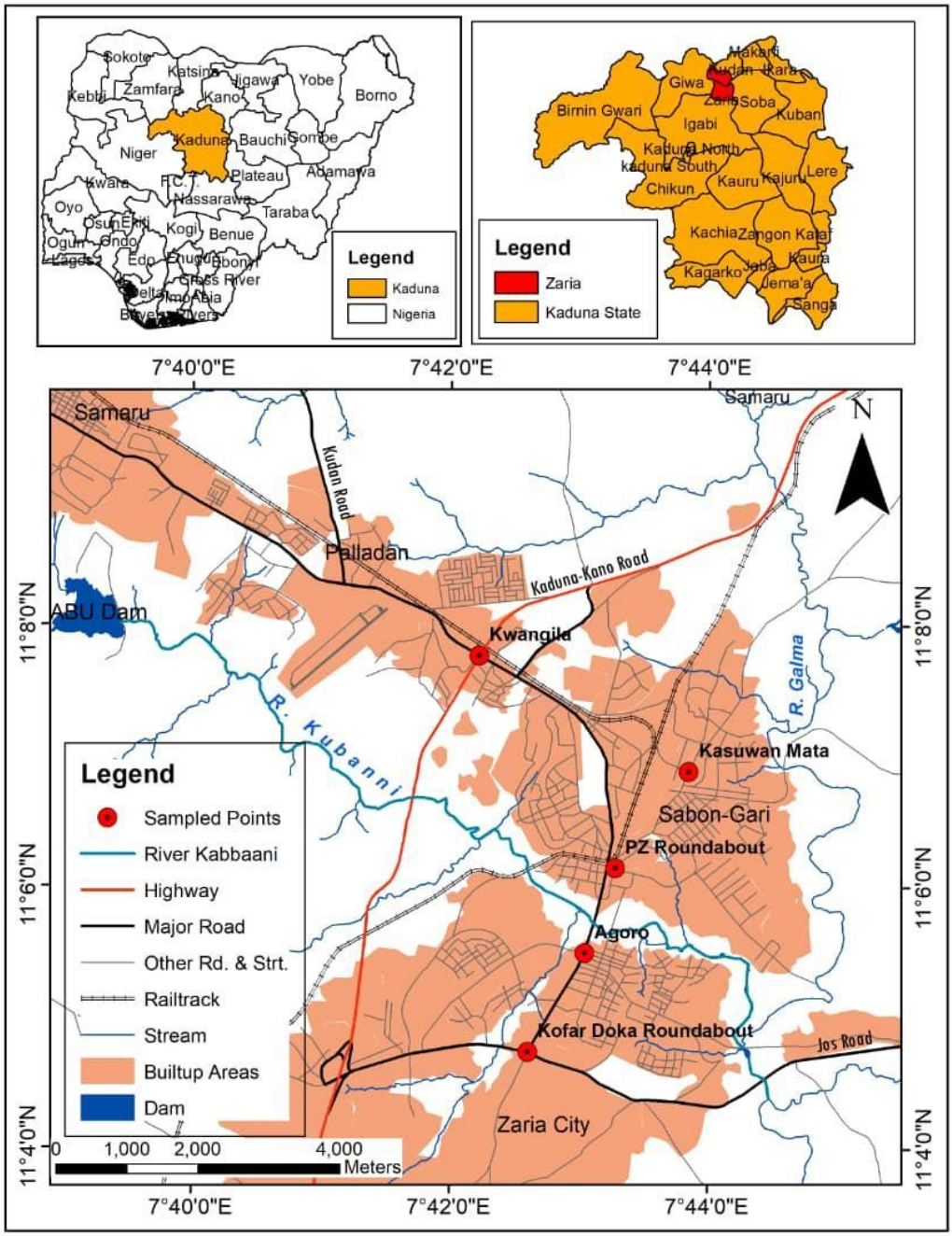
2. LITERATURE GAP

Researchers in this topic area have been focusing on the monitoring, on the evaluation and on the assessment of gaseous pollutant such as Carbon monoxide, Carbon dioxide, Oxides of Nitrogen, Hydrocarbons, Oxides of Sulphur etc in traffic congested areas. Not much work has been done on particle pollution especially as it relates to inhalable coarse particles such as $P_{0.3}$, $P_{0.5}$, $P_{1.0}$, $P_{2.5}$ and $P_{5.0}$ which this study addressed. The contributions of this study to the science of particulate pollutants in Zaria include profiling the average mass concentrations of pollutants $PM_{5.0}$, $PM_{2.5}$, $PM_{1.0}$, $PM_{0.5}$ and $PM_{0.3}$ including the interaction between these pollutants in Zaria. This has not been recently undertaken in Zaria. Particulate matter measurements are rarely determined for a considerable length of time as done in this study. This is one of the very few studies that have determined the concentration as well as particle sizes of Particulate matter in Zaria in relation to metrological parameters.

3. STUDY AREA

The study area is Zaria, Kaduna State, North-Western part of Nigeria. It is located at 11.11 latitude and 7.72 longitude and it is situated at elevation 644 meters above sea level. Zaria has a population of about 1 million people, making it the 2nd biggest city in Kaduna State. It operates on the WAT time zone, which means that it follows the same time zone as Kaduna.

It is important to note that Zaria houses more than 100 corporate establishments belonging to Federal, State and private organizations, this singular act in addition to various economic activities such as buying, selling and transporting have brought about increase in population and number of vehicles that ply the roads on a daily basis. The increase in the number of vehicles also causes traffic to flow more slowly, leading to more time spent in traffic jam and consequently, to increasing fossil fuel burning and pollution.



MAP OF ZARIA SHOWING THE STUDY AREAS AND SAMPLING POINTS

4. METHODOLOGY

(a) Identification of Traffic Congested areas within Zaria metropolis**.**

This was done by carrying out a reconcealed survey, which entails reaching out to relevant stake holders in the field who are familiar with the traffic patterns across the nooks and crannies of Zaria metropolis. They include but are limited to drivers, passengers, transport researchers, road transport unions such as National union of road transport workers, National union of road transport owners etc. Five major traffic hotspots were identified, which include: Kwangila-Flyover, PZ Round about, Agoro Round about, Kofa Doka Round about and Kasuwa Mata Junction.

(b) Determination of Trafffic level: A traffic count is a count of vehicular or pedestrian traffic, which is conducted along a particular road, path, or intersection (Middleton et al., 2007). A traffic count is commonly undertaken either automatically (with the installation of a temporary or permanent electronic traffic recording device), or manually by observers who visually count and record traffic on a hand-held electronic device or tally sheet. The volume of vechicle plying the roads along the sampling points were manually counted. The traffic counts exercise was carried out daily (Monday to Sunday) for a period of four weeks for peak and off- peak periods. The peak period was divided into two; Morning hours peak (7:00am-10:00am) and the Evening hours peak (4:00pm-7:00pm) and the off-peak period, (afternoon) (11.00am-2.00pm) in the month of July, 2020. The average volumes of traffic at each site per hour were calculated and recorded. All the traffic counted were categorized by the type of vehicle.The categories are: Motorcycles/Tricyles, Cars/Buses, and Trucks/Lorries.

(c) Determination of Particle Concentrations: The subjects that were studied specifically were PM $_{0.3}$um, PM $_{0.5}$um, PM $_{1.0}$um, PM $_{2.5}$um and PM $_{5.0}$um at ground level in relation to traffic. The ground level was defined as five (5) feet above the ground at road intersections. The height of five feet was chosen because it best represents the breathing height of people when standing or seating. Particle concentrations were determined using a mechanical device called the particle counter.

(d) The impact and relationship of traffic density on the concentration of pollutants from vehicular emissions was determined using the Pearson

Product Moment correlation Statistical tool to find out the strength of relationship between traffic density and the concentration of each of the particle pollutants. The effect of particle concentration on metrological Parameters such as relative humidity, dew point temperature, atmospheric temperature and web temperature were also considered.

(e) The AQI standard was used to classified the sampling points based on the concentration of $P_{2.5}$



PARTICLE COUNTER

Mode of Operation

Particle counters are used to determine the air quality by counting and sizing the number of particles in the air. This information is useful in determining the quantity of particles inside a building or in the ambient air. It also is useful in understanding the cleanliness level in a controlled environment. The nature of particle counting is based upon light scattering, light obscuration, or direct imaging (USEPA, 2011)

A high intensity light source is used to illuminate the particle as it passes through the detection chamber. The particle passes through the light source (typically a laser or halogen light) and if light scattering is used, then the redirected light is detected by a photo detector. If direct imaging is used, a halogen light illuminates particles from the back within a cell while a high definition; high magnification camera records passing particles. Recorded video is then analyzed by computer software to measure particle attributes. If light blocking (obscuration) is used the loss of light is detected. The amplitude of the light

scattered or light blocked is measured and the particle is counted and tabulated into standardized counting bins. (EA, 2016)

5. RESULTS AND DISCUSSION

Table 2: shows the average traffic volume per hour at the selected sites for morning session at peak period between the hours of 7.00am to 10.00am.

Table 2: Average traffic volume per hour for Morning Peak

Sampling sites	Tricycles/ Bikes	Cars/Buses	Trucks/Lorries	TOTAL
Kwangilla	1654	1261	145	3060
Pz Round About	1439	1137	125	2701
Agoro Round About	1287	1163	243	2693
Kasua Mata Junction	1394	1295	137	2826
Kofa Doka Round About	1237	1032	11	2380

Sourced: Field survey, 2020

As can be seen from the table, Kwangilla recorded the highest traffic volume per hour with average total traffic volume of 3060, followed by Kasua Mata with average total traffic volume of 2826. The average total traffic volume recorded at Agoro Round about and Kofa Doka recorded respectively were 2693 and 2380.

Table 3: Average traffic volume per hour for Evening Peak

Sampling sites	Tricycles/ Bikes	Cars/Buses	Trucks/Lorries	TOTAL
Kwangilla	1860	1486	305	3651
Pz Round About	1615	1403	191	3002
Agoro Round About	1774	1007	206	2987
Kasua Mata Junction	1812	1433	152	3397
Kofa Doka Round About	1462	1075	139	2676

Sourced: Field survey, 2020

Table 3 shows the average traffic volume per hour at the selected sites for evening peak between the hours of 4.00pm to 7.00pm.

As shown from table 3, just like in the case of morning peak, Kwangilla also recorded the highest average total traffic volume of 3651 followed by Kasua Mata with average total traffic volume of 3397. 2987 and 2676 were obtained respectively as the average total traffic volume for Agoro Round About and Kofan Doka.

It can also be deduced from the results of the traffic count conducted for morning and evening peak that tricycles and bikes dominated the vehicle type followed by car/buses while trucks and lorries carried the least across all the sampling points. The results also showed that evening peak recorded more vehicles than morning peak across all the sampling points with kwangila taking the lead, followed by Kasua Mata, Agoro round about and Kofa Doka in that order.

Table 5: Average traffic volume per hour for Afternoon off-peak

Sampling sites	**Tricycles/ Bikes**	**Cars/Buses**	**Trucks/Lorries**	**TOTAL**
Kwangilla	1372	827	56	2255
Pz Round About	915	692	69	1076
Agoro Round About	977	893	112	1982
Kasua Mata Junction	1061	820	129	2010
Kofa Doka RoundAbout	904	769	104	1777

Sourced: Field survey, 2020

Table 5 shows the average traffic volume per hour at the selected sites for afternoon off-peak between the hours of 11.00am to 2.00pm. The traffic pattern was in agreement with the peak periods as Kwangilla recorded the highest average total traffic volume of 2255 followed by Kasua Mata with a record value of 2010. Agoro Round about and Kofa Doka had respectively the values of 1982 and 1777 as their average total traffic volume for the offpeak period. Tricycles and bikes dominated the vehicle type followed by car/buses while trucks and Lorries carried the least across all the sampling points.

Average Concentrations of Particulate Matter during the Morning Peak

Sampling Points	P 0.3 µg/m3	P 0.5 µg/m3	P1.0 µg/m3	P2.5 µg/m3	P 5.0 µg/m3	RH (%)	AT (^{O}C)	DP (^{O}C)	WP (^{O}C)
Kwangila Junction	194651	16743	2981	188	102	66.9	30.6	35.9	30.1
PZ Round About	158925	12987	2213	148	69	68.3	32.9	36.6	29.4
Kasua Mata Junction	169876	14324	2876	164	75	71.5	31.9	32.5	28.9
Agoro Round About	176234	13123	2314	158	85	69.7	33.5	33.5	27.6
Kofa Doka Round About	135893	11123	2321	141	84	69.5	32.7	34.7	25.7

Kwangila recorded the highest particle concentrations across the sizes of the matter. These results when compared with the average traffic volume recorded at kwangilla showed a regular or linear relationship. It indicated that the higher the traffic volume the higher the concentrations of the particulate matter recorded. Kofa Doka recorded the lowest particle concentration across the sizes of the matter as can be seen from the table and when these results are put side by side with that obtained for the average traffic volume at Kofa Doka, a linear relationship was also observed. That is, the lower the traffic density, the lower the concentration of particulate matter recorded.

Correlation between Traffic Volume and concentrations of particulate matters for Morning session (Peak Period)

	TD	***P0.3***	***P0.5***	***P1.0***	***P2.5***	***P5.0***	***AT***	***RH***	***DP***	***WP***
TD	1.00									
P0.3	0.67	1.00								
P0.5	0.88	0.94	1.00							
P1.0	0.75	0.89	0.88	1.00						
P2.5	0.58	0.90	0.85	0.67	1.00					
P5.0	0.68	0.73	0.81	0.44	0.85	1.00				
AT	-0.53	-0.71	-0.71	-0.58	-0.45	-0.59	1.00			
RH	-0.52	-0.24	-0.44	0.03	-0.40	-0.82	0.41	1.00		
DP	0.54	-0.09	0.22	-0.12	-0.04	0.46	-0.26	-0.83	1.00	
WP	0.81	0.30	0.55	0.49	0.05	0.32	-0.58	-0.41	0.69	1.00

(Generated from Pearson Product Moment Correlation of TD and Particle Concentration).

Particulate matter concentrations showed a very strong correlation with traffic density at r = 0.67, 0.88, 0.75, 0.58 and 0.68 for $P_{0.3}$, $P_{0.5}$, $P_{1.0}$, $P_{2.5}$ and $P_{5.0}$ respectively. Metrological factors like relative humidity, atmospheric temperature showed a negative correlation with traffic density at r = -0.53 and -052 respectively. This showed that traffic density is not in any relationship with the relative humidity and atmospheric temperature. Other external factors such as wind flow, human activities such as burning, mining, construction etc. might be responsible for this variation. Another very important point to note from the results obtained is the fact that there a strong correlation between and among each of these particle sizes which is an indication that they all come from the same sources as shown from the correlation.

Average Concentrations of Particulate Matter during the Evening Peak

Sampling Points	P 0.3 µg/m3	P 0.5 µg/m3	P1.0 µg/m3	P2.5 µg/m3	P 5.0 µg/m3	RH (%)	AT (^{O}C)	Dp (^{O}C)	Wp (^{O}C)
Kwangila Junction	220123	18574	3103	216	98	69.5	29.6	33.6	31.4
PZ Round About	165321	12987	2431	151	76	68.5	29.5	32.1	28.5
Kasua Mata	174321	15098	2932	172	82	71.7	28.6	30.6	27.6
Agoro Round about	186675	15123	2654	190	89	67.9	30.5	31.3	28.8
Kofa Doka	176540	14983	2765	141	83	70.8	31.4	31.9	31.5

The result obtained for evening session as can be seen from table 4.2 also indicated that a linear relationship exist between the traffic volume and concentrations of particulate matter recorded as earlier observed and ascertained for the morning session. That is, increase in traffic volume is directly proportional to a corresponding increase in the concentration of particulate matter and decrease in the volume of traffic is brought about a corresponding decrease in the concentration of the particulate matter recorded.

Correlation between Traffic Volume and concentrations of particulate matters for Evening session (Peak Period)

	TD	***P0.3***	***P0.5***	***P1.0***	***P2.5***	***P5.0***	***AT***	***RH***	***DP***	***WP***
TD	1.00									
P0.3	0.82	1.00								

P0.5	0.69	0.96	1.00							
P1.0	0.71	0.91	0.90	1.00						
P2.5	0.72	0.34	0.24	0.08	1.00					
P5.0	0.57	0.71	0.62	0.39	0.43	1.00				
AT	-0.27	0.00	-0.04	0.25	-0.81	-0.15	1.00			
RH	-0.50	-0.13	0.13	-0.12	-0.33	-0.20	-0.22	1.00		
DP	0.52	0.72	0.61	0.48	0.21	0.95	0.16	-0.30	1.00	
WP	-0.28	0.20	0.22	0.32	-0.79	0.19	0.87	0.09	0.44	1.00

(Generated from Pearson Product Moment Correlation of TD and Particle Concentration).

Particulate matter concentrations showed a very strong correlation with traffic density at r = 0.82, 0.69, 0.71, 0.72 and 0.57 for $P_{0.3}$, $P_{0.5}$,$P_{1.0}$, $P_{2.5}$ and $P_{5.0}$ respectively. Metrological factors like relative humidity, atmospheric temperature showed a negative correlation with traffic density at r = -0.27 and -050 respectively. This showed that traffic density is not in any relationship with the relative humidity and atmospheric temperature. Other external factors such as wind flow, human activities such as burning, mining, construction etc. might be responsible for this variation. Another very important point be revealed from the results obtained is the fact that there a strong correlation between and among each of these particle sizes which is an indication that they all come from the same sources as shown from the correlation.

Average Concentrations of Particulate Matter during the Afternoon Off-Peak

Sampling Points	P 0.3 µg/m3	P 0.5 µg/m3	P1.0 µg/m3	P2.5 µg/m3	P 5.0 µg/m3	RH (%)	AT (^{O}C)	Dp (^{O}C)	Wp (^{O}C)
Kwangila	142031	100009	1874	96	63	65.9	34.7	36.7	34.3
PZ	92901	7895	1212	55	46	64.2	33.2	35.3	32.9
Kasua Mata	10003	8832	1423	83	57	66.8	35.3	32.5	33.7
Agoro Round about	109823	10023	1762	91	49	66.3	34.8	31.7	31.7
Kofa Doka	112045	11203	2190	62	45	65.4	33.6	32.5	31.5

For the afternoon session (off–peak period) as shown from table 4.7, Kwangila recorded the highest particle concentrations across the sizes of the matter. $P_{0.3}$ had a value of 142031um, $P_{0.5}$ with 10009um, $P_{1.0}$ with 1874um, $P_{2.5}$

with 96um and $P_{5.0}$ with 63um at a relative density of 65.9%, atmospheric temperature of 34.7^{0}C, dew temperature of 36.7^{o}C and web dew temperature of 34.3^{o}C.

PZ recorded the lowest particle concentrations across the sizes of the matter. $P_{0.3}$ had a value of 92901um, $P_{0.5}$ with 7895um, $P_{1.0}$ with 1212um, $P_{2.5}$ with 55um and $P_{5.0}$ with 46um at a relative density of 64.2%, atmospheric temperature of 33.2^{0}C, dew temperature of 35.3^{o}C and web dew temperature of 32.9^{o}C

Correlation between Traffic Volume and concentrations of particulate matters for Afternoon session (off-Peak Period)

	TD	***P0.3***	***P0.5***	***P1.0***	***P2.5***	***P5.0***	***AT***	***RH***	***DP***	***WP***
TD	1.00									
P0.3	0.82	1.00								
P0.5	0.78	0.93	1.00							
P1.0	0.79	0.93	0.99	1.00						
P2.5	0.63	0.32	0.20	0.15	1.00					
P5.0	0.54	0.09	0.13	0.08	0.89	1.00				
AT	0.77	0.30	0.38	0.37	0.75	0.90	1.00			
RH	0.67	0.27	0.43	0.40	0.67	0.89	0.95	1.00		
DP	0.27	0.49	0.15	0.18	0.17	-0.28	-0.25	-0.46	1.00	
WP	0.73	0.65	0.50	0.45	0.90	0.66	0.57	0.51	0.42	1

(Generated from Pearson Product Moment Correlation of TD and Particle Concentration).

The (off peak period), particulate matter concentrations showed a very strong correlation with traffic density at r = 0.82, 0.78, 0.79, 0.63 and 0.54 for $P_{0.3}$, $P_{0.5}$,$P_{1.0}$, $P_{2.5}$ and $P_{5.0}$ respectively. Unlike for the peak period, metrological factors like relative humidity, atmospheric temperature, dew temperature, web dew temperature showed a positive correlation with traffic density at r = 0.75, 0.67, 0.77 and 0.75respectively. This showed that traffic density is in a linear relationship with the relative humidity, atmospheric temperature, dew temperature and web dew temperature during the off peak period. This linear relationship cannot be unconnected to the fact that the environment is calmer during the off peak period and less of human activities presumed to occupy the atmosphere during that period in time. It can also be observed from the results obtained that there a strong correlation between and among each of these particle sizes which is an indication that they all come from the same sources as shown from the correlation.

The positive correlation agrees with Wallington *et al*., (2015) that increase in traffic density can increase the air pollutants load resulting from vehicular emissions. The negative and low correlation of metrological factors such as relative humidity, atmospheric temperature etc. with traffic volume at all peak traffic periods could be attributed to the fact that apart from traffic volume, other factors like vehicle speed, engine condition, age of vehicle, vehicle technology among others could influence the concentration of pollutants coming out from the tail pipe (Abbaspour and Soltaninejad, 2014).

Comparison of concentration of $P_{2.5}$ µg/m3 data of Zaria with the standard AQI value

Air quality index is an index for reporting daily air quality in the developed world. It gives information on how clean or polluted the air is and what associated health effects might be a concern for individuals. The air quality data of Zaria metropolis for both peak (morning and evening) and off peak (afternoon) was therefore compared with the air quality index value for proper analyses.

AQI RANGE (P 2.5 µg/m3)	**AIR QUALITY CONDITION**	**COLOR**	**Actions to protect your health from particle pollution**
0-50	Good	Green	None
51-100	moderate	Yellow	Unusually sensitive people should consider reducing prolonged presence
101-150	Unhealthy For sensitive group	Orange	The following groups should reduce prolonged presence 1. People with heart and lung diseases 2. Children and older adults
151-200	unhealthy	Red	The following groups should reduce prolonged presence 1. People with heart and lung diseases **2.** Children and older adults
201-300	unhealthy	Purple	Everyone should reduce prolonged presence.
301-500	Hazardous	Maroon	Everyone should reduce prolonged presence.

(Air now, 2016)

The $P_{2.5}$ was used as bases for comparison with the AQI standard for peak and off peak periods. For peak hours session, the air quality at Kwangila, Kasua Mata and Agoro was classified as unhealthy and hazardous while that of PZ and

Kofar Doka was classified unhealthy to people with heart and lungs diseases. The concentration of PM obtained for off-peak period for all the sampling points was classified moderate and safe when compared with AQI standard.

6. CONCLUSION

In order to diminish the consequences that air pollution has on people's health, pollution awareness should be of high priority to both government and individuals. One possible approach is to establish channels of communication to enlighten the general public on the danger associated with vehicular emissions. This will help protect individuals particularly road users from possible harm. There is epidemiological evidence that short-term exposure to particulate matter is positively correlated with mortality of exposed group, therefore PM pollution is a public health concern. The government should respond rapidly by setting up environmental investigations into other sources of particulate pollution and ways of mitigation using multiagency kind of intervention.

Recommendation

PM is a global problem. Developing countries too like the developed ones should see this as a joint task to tackle therefore collaborative efforts should be put in place with stakeholders throughout the world. In setting standards to protect public health from the effect of air pollutants, the concept of threshold may not be useful because certain population groups are very sensitive and the effects of these pollutants are detected even at low levels. To enable the development of effective risk reduction strategies based on qualitative knowledge, further data analysis and more comprehensive monitoring are recommended.

In addition to the pollutants discussed in this study, other aspects of air pollution should also be addressed in the development of air pollution policy for Nigeria. These include air pollutants such as carbon monoxide (CO) sulphur dioxide (SO_2), persistent organic pollutants, (POP), certain metals, certain volatile organic compounds and nitrogen trichloride. The combine effects of the urban air pollution mix is also an important issue that remains unresolved.

In order to mitigate the problems/challenges posed by vehicular traffic emissions in Zaria metropolis, the following strategies have been recommended:

1. Funding for research borne by government
2. Improvement in public transport operation
3. Promoting public awareness and education
4. Legislation on the age of vehicles imported into the country.
5. Continued Air quality monitoring along major routes
6. Urban planning

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