PARTICULATE CONCENTRATION AROUND BUSY TRAFFIC LOCATIONS IN OGBOMOSO, NIGERIA

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ABSTRACT
This research work reported the results of the investigation of air pollution from automobiles and other anthropogenic sources at intersections of ten (10) selected busy junctions in Ogbomoso, South-western, Nigeria. Ten (10) sampling sites were considered with the sampler, aerosol mass monitor (831) placed 1-1.5m above the ground level and 1m away from the edge of the road. Particulate matter less than 1.0, 2.5, 4.0, and 10µm were monitored in rush hour (RH) and non-rush Hour (NRH) period. The results of $PM_{1.0}$, $PM_{2.5}$, $PM_{4.0}$, PM_{10}were in the range of 1.03 - 4.35µg/m^3, 5.71– 70.15µg/m^3, 13.96- 476.88µg/m^3, 36.35– 1013.34µg/m^3, respectively. The particulate concentration of PM_{10} was highest at TakieJunction.with a value of 1013.34 µg/m^{3}while that of $PM_{1.0}$ was found to be highest at Federal Government College (FGC) junction with a value of 4.35µg/m^3. $PM_{2.5}$ was also found to be highest at FGC junction with a value of 70.15µg/m^{3}and finally, $PM_{4.0}$ was found to be highest at Takie junction with a value of 132.76 µg/m^3. The highest value of PM_{10} with a value of 1013.34µg/m^3 was due to traffic congestion, traffic intersection and dust from the untarred roads. $PM_{2.5}$and $PM_{10}$when compared with the standard provided by WHO (2006) showed that out of all the ten locations, Takie and FGC junction were above the standard for $PM_{2.5}$ while Agbowo, Ojagbo, FGC, Arowomole, Takie, Arada, Orita Naira, Oke-Anu were above the standard for PM_{10}.

Keywords: Particulate Matter, Traffic, Mass concentration, Microclimatic parameters

INTRODUCTION

Ambient air quality is defined as the surrounding air quality or open space situation, that the condition/situation of the air in the outdoor environment, directly affects the health of humans and ecosystems (Ali and Abd-Rahman, 2013). The rising air pollution in the environment degraded the ambient quality of the air thus, various standards and regulations were established in the light of addressing this air pollution. According to Vellero (2008), ambient air pollution is divided into anthropogenic pollution or non - anthropogenic, stationary or mobile sources and indoor or outdoor pollution. The main cause of ambient air pollution varies from industrial effluents, open burnings, agricultural activities to emissions from vehicles (Talib*et al*., 2002).

On the other hand, the indoor air quality refers to the enclosed environment spread from smoking, vapour of building materials, cooking, heating and hobby activities (Colome*et al*., 1992). Equally, outdoor air quality refers to the outside condition that is widespread based on meteorological condition, location and surrounding development (Peavy*et al*., 1985). Pollution on the other hand could be the act of polluting or the state of being polluted, especially contamination of the environment by harmful substances. Pollution can occur in various forms which include water pollution, air pollution and land pollution.

Air pollution can be defined as the presence of contaminants or pollutant substances in the air that interfere with human health or welfare, or produce other harmful environmental effects (USEPA, 2007). In most developing countries of the world vehicular growth has not been checked properly by environmental regulating authorities leading to increased levels of pollution (Han and Naeher, 2006).Particulate air pollution has been widely investigated in many parts of the world (Zakey*et al.,* 2008; Efe, 2008; Oluyemi and Asubiojo, 2001). The level of suspended particulate matter pollution has an influence on human health (Sufian, 2011). Suspended particulate matter is a nearly widespread urban pollutant. It is a complex mixture of small and large particles of varying sources and chemical composition. The effects on the health caused by particulate matter depend on the size of the particles.

There is good evidence of the effects of short-term exposure to PM_{10} on respiratory health, but for mortality, and especially as a consequence of long-term exposure, $PM_{2.5}$ is a stronger risk factor than the coarse part of PM_{10} (particles in the 2.5–10 µm range). All-cause daily mortality is estimated to increase by 0.2–0.6% per 10 $\mu g/m^3$ of PM_{10} (Samoli*et al*., 2008). Long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary mortality by 6–13% per 10 $\mu g/m^3$ of $PM_{2.5}$ (Beelen*et al*., 2008). Susceptible groups with pre-existing lung or heart disease, as well as elderly people and children, are particularly vulnerable. For example, exposure to particulate matter affects lung development in children, including reversible deficits in lung function as well as chronically reduced lung growth rate and a deficit in long-term lung function (WHO, 2011).

In general, smaller particles are more toxic because of their ability to penetrate deep into the respiratory tract, particles with diameter of 10 µm or more are filtered when inhaled through the nose. While bigger particles remain in the throat, the smaller ones ($PM_{2.5}$ or $PM_{1.0}$) get in the trachea and in the respiratory system. Besides, they are also more toxic since they often consist of heavy metals and cancer causing organic compounds (Hörmann*et al*., 2005). It is of great deal to look into the issue of this particulate concentration around busy traffic location in Ogbomoso. The particulate are sampled at various locations and are assessed based on health organisation standard.

MATERIALS AND METHODS

Sampling Area

This study was conducted in ten (10) different busy traffic locations in both North and south of Ogbomoso metropolis. Ogbomoso is a city in Oyo state, southwestern Nigeria. It was founded in mid-17 century with about a population of 1.1million. It is a pre-colonial urban centre and is considered one of the largest cities, in Oyo State, Nigeria. The city is located at a distance of about 100 km north of Ibadan, the Oyo state capital and about 80 km south of Ilorin. It is one of the main gateways to the northern part of Nigeria from the Yoruba (i.e. the majority of people are members of the Yoruba ethnic group). Ten busy traffic locations are selected for the study. The map of Nigeria showing Ogbomoso metropolis is represented in Figure 1 while the map showing selected locations is represented by Figure 2.

Figure 1: Map of Nigeria Showing Ogbomoso Town

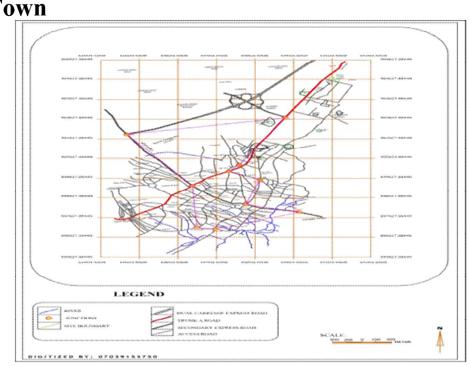


Figure 2: Map Showing the 10 Sampling Locations in Ogbomoso Metropolis

Sampling Methodology

This study was conducted in February 2015, that is, around the hot and dry season of the year. Concentrations of Particulate matter data, $PM_{1.0}$, $PM_{2.5}$, $PM_{4.0}$ and PM_{10} were detected by using Aerosol Mass Monitor (Aerocet - 831) manufactured by Met One Instruments Inc., USA. The Aerocet 831 is a mass monitor that simultaneously provides data of four important mass ranges in approximately one minute. This portable device records particulate matter ranges, PM_1, $PM_{2.5}$, $PM_{4.0}$ and PM_{10} with the ability to take concentration range of 0 – 1000 $\mu g/m^3$. Its operating principle is based on particle count to mass conversion.

The monitor was exposed to outdoor air of the selected locations at a height of 1–1.5m above the ground level. Weather Tracker Kestrel 4500 andHumidity and Temperature Meter (Vaisala HM 34)were used for the measurements of microclimatic parameters. These were used to measure the wind speed, wind direction, relative humidity, pressure and temperatureduring the study. Traffic counts were done manually by recording the population of vehicles per hour.

Statistical Analysis

The extrapolated values of concentration, 'i' at time,'t' were calculated using an atmospheric stability formula proposed by Bashar *et al*.(2009). It is given as:

$$C_2 = C_1 \times F \quad (1)$$

Where C_2 is the concentration at the averaging period t_2

C_1 the concentration at the averaging period t_1

F is the Conversion factor from the averaging period t_1 to t_2

$$t_2 = (t_1/t_2) \quad 2$$

$n = 0.28$, the stability Dependent Exponent.

The raw data obtained was analysed using descriptive statistic while the 24-hours extrapolated data was used to create box and whisker plot. The box plot shows from its graphic interpretation the maximum, the median and minimum value which was used in analysing the raw data gotten from each location. In addition, a standard on particulate matter was also used with the data collected in order to know the health effect of the particulate from each location.

Table 1: Statutory Limit of Particulates

	$PM_{2.5}$	PM_{10}
24 – Hour Primary Standard	25 µg/m^3	50 µg/m^3
Annual Primary Standard	10 µg/m^3	20 µg/m^3

Source: WHO(2006).

Results and Discussion

Results of Average Values of Ambient Air Measurement in the Selected Locations

The 24 – hour extrapolated values are plotted on a box and whisker plot showing the distribution of the dataset of the rush hour (RH) and the non – rush hour (NRH) obtained from each location (Figure 3a – Figure 3j). The average variation of $PM_{1.0}$, $PM_{2.5}$, $PM_{4.0}$ and PM_{10} concentrations across the locations are shown in Figures. The results showed that the concentrations for $PM_{1.0}$ (RH) from all the selected locations range from 1.23-9.39µg/m^3 with Agbowo having the highest concentration of 9.39 µ/m^3. For $PM_{1.0}$ (NRH) the concentrations ranged from 1.06– 3.25 µg/m^{3}with Takie having the highest concentration. For $PM_{2.5}$ (RH), the concentrations ranged from 6.52– 91.51 µg/m^3 with FGC having the highest concentration.

For $PM_{2.5}$ (NRH), the concentrations range from 6.41– 65.25 µg/m^3 with Takie having the highest concentration. For $PM_{4.0}$ (RH), the concentrations ranged from 15.86– 152.65 µg/m^3 with FGC having the highest concentration; for $PM_{4.0}$ (NRH), the concentrations range from 15.74– 184.43 µg/m^{3}with Takie having the highest concentration. For PM_{10} (RH), the concentrations ranged from 38.19– 704.59 µg/m^{3}with Takie having the highest concentration. For PM_{10} (NRH), the concentrations ranged from 42.10– 1110.33 µg/m^3 with Takie having the highest concentration. Comparing these results with the standard of air quality in Table 1, Takie and FGC are out of range for $PM_{2.5}$while Agbowo, Ojagbo, FGC, Arowomole, Takie, Arada, Orita Naira, Oke-Anu and Starlight showed a result which is above the WHO recommended standard for PM_{10}.

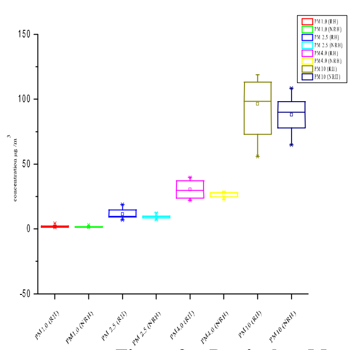


Figure 3a: Particulate Matter Concentration in Starlight Area

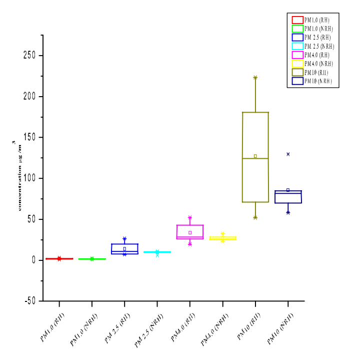


Figure 3b: Particulate Matter Concentrationin Oke-Anu Area

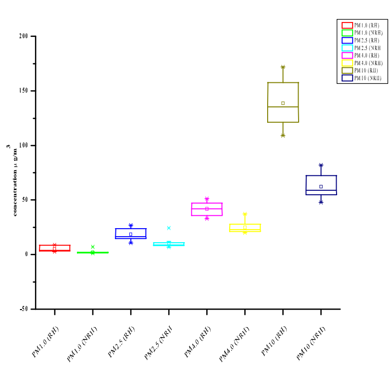
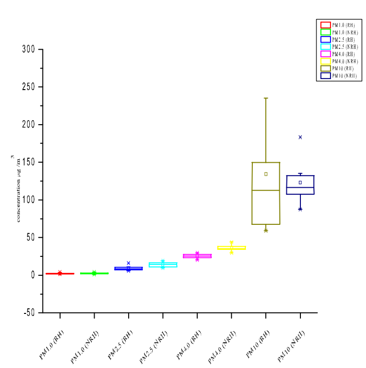


Figure 3c: Particulate MatterConcentration in Orita Naira Area Figure



3d: Particulate Matter Concentrationin Arada Area

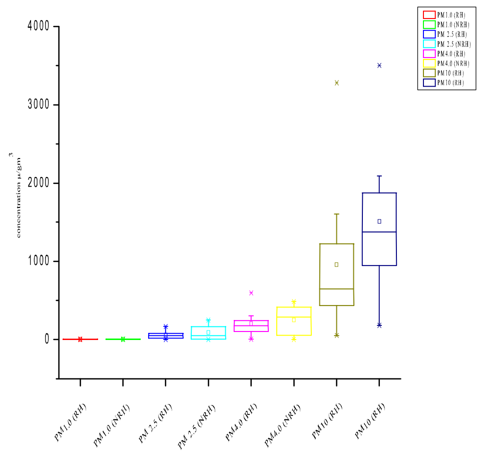


Figure 3e: Particulate Matter Concentration in Takie Area

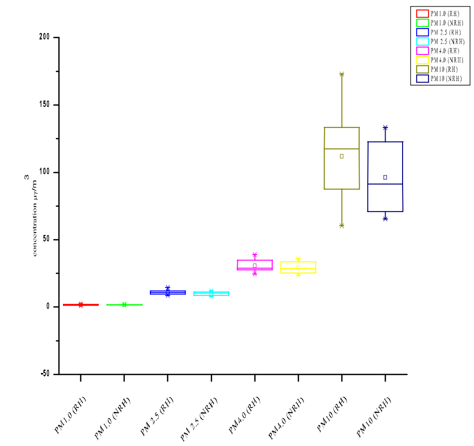


Figure 3f: Particulate Matter Concentration in Arowomole Area

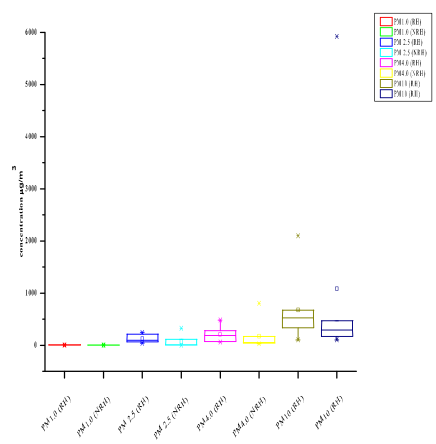


Figure 3g: Particulate Matter Concentrationin FGC Area

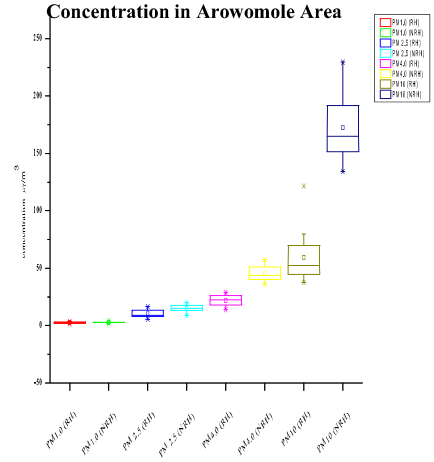


Figure 3h: Particulate Matter Concentration in Ojagbo Area

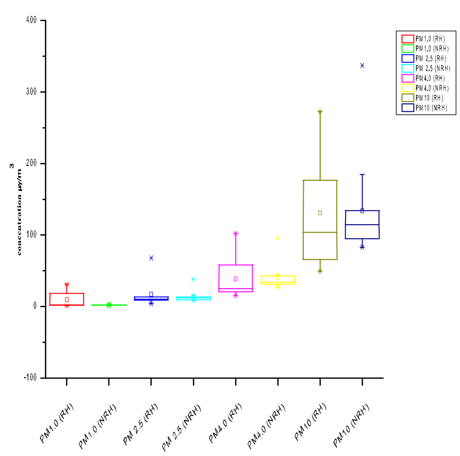


Figure 3i: Particulate Matter Concentration in Agbowo Area

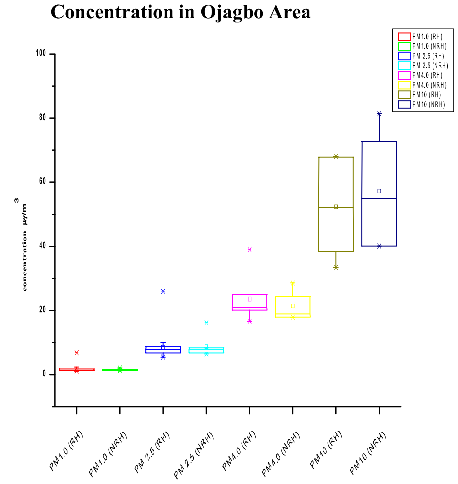


Figure 3j: Particulate Matter Cncentrationin Kinnira Area

Results of Meteorological Parameters

Measurement of the outdoor meteorological parameters showed that temperature and relative humidity were in the range of 24.9 – 33.2 °Cand 48.9 – 71.2%. The temperature and relative humidity values agree to the range predicted for south-western Nigeria in recent studies (Lawal, 2013; Emmanuel *et al.*, 2013; NIMETS, 2011).

Table 2: Average, Maximum and Minimum Meteorological Data of the Study Area

Locations	levels	Temperature	Relative Humidity	Wind speed	Wind direction
STARLIGHT	Avg.	34.9	35.1	0.4	SW
	Max.	36.4	39.4	1.1	
	Min.	33.1	30.8	0.2	
OKE ANU	Avg.	33.1	43.0	0.4	SW
	Max.	36.9	50.6	1.8	
	Min.	28.4	39.5	0.1	
ORITA NAIRA	Avg.	24.7	72.1	0.7	NE
	Max.	27.3	74.8	2.6	
	Min.	23.8	69.4	0.1	
ARADA	Avg.	29.8	56.4	0.4	SW
	Max.	31.0	59.0	0.9	
	Min.	28.5	53.2	0.1	
TAKIE	Avg.	28.3	61.2	0.6	SW
	Max.	29.2	64.2	1.5	
	Min.	27.4	57.8	0.2	
AROWOMOLE	Avg.	34.9	34.8	0.3	SW
	Max.	36.4	39.4	0.5	
	Min.	33.1	30.8	0.2	
FGC	Avg.	30.6	36.3	0.6	NE
	Max.	36.0	38.9	2.1	
	Min.	28.0	33.6	0.2	
OJAGBO	Avg.	26.4	64.9	0.3	SE
	Max.	28.2	69.7	0.7	
	Min.	24.7	59.8	0.1	
AGBOWO	Avg.	29.7	50.0	0.3	NW
	Max.	32.0	58.3	0.7	
	Min.	27.1	43.4	0.1	
KINNIRA	Avg.	31.1	53.5	0.4	NW
	Max.	33.9	61.1	1.1	
	Min.	29.7	49.5	0.1	

Results of Vehicular Counts

Table 3 presents the result of the average vehicular counts for both RH and NRH. In all the lcations, the minimum vehicular counts ranged from 3 – 7 per min; while the minimum motorcycle counts ranged from 7 – 15 per min. The maximum vehicular counts ranged from 17 – 18 per min; while the maximum motorcycle counts ranged from 36 – 51 per min.

Table 3: Average Traffic in the Selected Locations

Locations	No of vehicles/min		No of motorcycles/min	
	RH	NRH	RH	NRH
STARLIGHT	15	15	51	28
OKE ANU	7	3	15	14
ORITA NAIRA	13	8	51	17
ARADA	8	9	49	36
TAKIE	18	12	38	18
AROWOMOLE	10	9	20	18
FGC	8	17	16	7
OJAGBO	12	9	49	31
AGBOWO	12	10	35	25
KINNIRA	12	9	30	27

CONCLUSION

Particulate concentration distributions were measured over a period of seven days (1- week) for four different particulate sizes ($PM_{1.0}$, $PM_{2.5}$, $PM_{4.0}$ and PM_{10}) in ten different traffic locations. The data measured at these 10 traffic locations reasonably represent the ambient air quality in the environment. Considering the fine particulates ($PM_{2.5}$) which is more harmful than the coarse particulates (PM_{10}), it can be deduced from the results that at some locations the emission values are within the WHO ambient air quality standards while some are out of range. Out of ten locations, Takie and FGC area seemed to be the locations with emission values higher than the normal WHO standard for the fine particulates ($PM_{2.5}$) while Starlight, Oke-Anu, Orita Naira, Arada, Takie, Arowomole, FGC, Ojagbo and Agbowo showed a result that is more than the normal standard for the coarse particulates (PM_{10}). The reason for this high values were due to traffic congestion and majorly some of these roads are not tarred while some are bad already. Dust from these untarred roads added to the high emission of particulates from these locations. However, contribution of natural sources is minimal compared to the anthropogenic sources. There are less of natural emissions compared to anthropogenic emissions which are due to the handiwork of man. Based on the results and other factors mentioned above, it will be good if all untarred roads and bad roads are reconstructed in order to reduce the emission of particulate matter from these locations.

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