Evaluation of Atmospheric PM10 in the Southwest Region of Nigeria

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Abstract

Particulate matter (PM), according to World Health Organization (WHO), has caused several millions of deaths, and both the young and old have been affected. To mitigate this problem, the compositions of the elements that make up the PM and their sources must be determined. These can provide the necessary information needed by stakeholders to work on. To this end, the study determined the mass concentrations of the PM10 obtained from the Federal University of Technology, Akure (FUTA), National Museum and Monuments and Oba-Ile; for a period of ten months (January-October, 2018). A total of thirty samples was collected. The PM concentration was calculated gravimetrically and the data were subjected to statistical analyses. The results for PM in $\mu g/m^3$ were: FUTA (39.10±0.31-133.22±0.21), Museum (49.71±0.11-196.70±0.01), and Oba-Ile (34.50±0.31-161.30±0.42). The results were well above the WHO standard limits. Air Quality Index (AQI) was calculated for each location, and the results for the air quality in Akure showed that the locations were unhealthy for sensitive groups.

Keywords: particulate matter; AQI; anthropogenic activities; WHO; Akure; Nigeria
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1. Introduction

Air pollution is a major global issue due to its impact on human health and property [1-4]. Due to urbanization and industrial development, environmental quality has declined throughout the globe in recent times [5, 6]. It is thought that more than 2.4 million individuals die each year globally due to PM pollution issues [4, 7, 8]. According to Ilyas *et al*. [9] and Ndamitso *et al*. [4], PM moves into the lungs when inhaled, and thus has adverse effects that ultimately cause health-related problems such as cancer, asthma, and cardiovascular and respiratory diseases.

It has been confirmed that PM in Europe is a pollutant and has surpassed the recommended normal limits [10, 11]. Schweizer *et al*. [12] mention that PM is a complex mixture of chemical

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species from anthropogenic and natural emission sources and from secondary pollutants which form in the atmosphere. In particular, in developing nations, rapid urbanization and population growth are part of the causes of the world-wide PM issue. This statement was verified by Arnfield [13], who indicated that by 2025, more than 45% of the population will live in metropolitan towns around the globe. Balogun *et al*. [14] and Owoeye and Ibitoye [15] revealed that city migration could have risen to over 30 billion over the next 30 years. A town established in 1976, Akure is no exception. Its population has been estimated at 476,159 by the National Population Commission [16] since its founding, the population, business, industrial, farming and petroleum products (bitumen) have increased which may have an impact on particulate matter and other anthropogenic pollutants.

In Akure, Nigeria, several road constructions, farming, industrial activities, and heavy traffic have been on the increase during the past years. In these areas, no doubt, metals, gas particles, and dust are transported by wind or runoff waters. Often these particles can cause negative effects on man and buildings. To this effect, it is essential to characterize the distributions and concentrations of these metals and atmospheric deposits in the environment especially air and aquatic. This research evaluates the concentration of particulate matter (PM10) obtained in Akure, Ondo State, Nigeria.

2. Materials and Methods

Three different locations [National Museum and Monuments (005 11 40.2 E, 07 15 11.6 N), Oba-Ile (005 14 29.1 E, 07 16 04.4 N), and Federal University of Technology-FUTA (005 08 06.5 E, 07 18 07.6 N)] were selected for the sampling within the town (Figure 1). These locations represent commercial, residential, and educational settings respectively. Samplings took place once every month from 8 am to 4 pm (8 h) for 10 months (January to October 2018) using a "Gent" stacked filter unit. The PM10 were filtered through quartz filters (47mm) and kept in a desiccator at room temperature. By the end of the sampling period, thirty samples (ten per sampling area) were collected monthly. The filters were put in a chamber kept at 20ºC, and 35% relative humidity (RH) for 48 h to stabilize the weight. The particulate mass was determined gravimetrically (the difference of filter's weight before and after sampling) using an analytical balance (0.001mg) (Model Sartorius Microbalance ME 5 Balance).

The PM mass concentration was calculated based on these parameters:

The average flow rate = averaging flow rate at the beginning and end of 8 h sampling (1)

Average PM mass concentration ($\mu g/m^3$) = Mass/total volume (2)

The data obtained from the study data were extrapolated and scaled up to 24 h mean before computing the air quality index. The AQI (Air quality index) for the particulate matter was calculated by using the equation given by Osimobi *et al.* [17].

$$AQI = \left[\frac{AQI_{max} - AQI_{min}}{PM_{max} - PM_{min}}\ x\ (PM_{meas} - PM_{min})\right] + AQI_{min} \quad (3)$$

Where:

PM_{meas} is the 24 h measured average concentration of particulate matter ($\mu g/m^3$),
PM_{max} is the maximum concentration AQI color category containing PM_{meas}
PM_{min} is the minimum concentration of AQI color category containing PM_{meas}
AQI_{max} is the maximum AQI value for color category corresponding to PM_{meas}
AQI_{min} is the minimum AQI value for color category corresponding to PM_{meas}

The results were statistically analyzed using Minitab 16 Statistical Software.

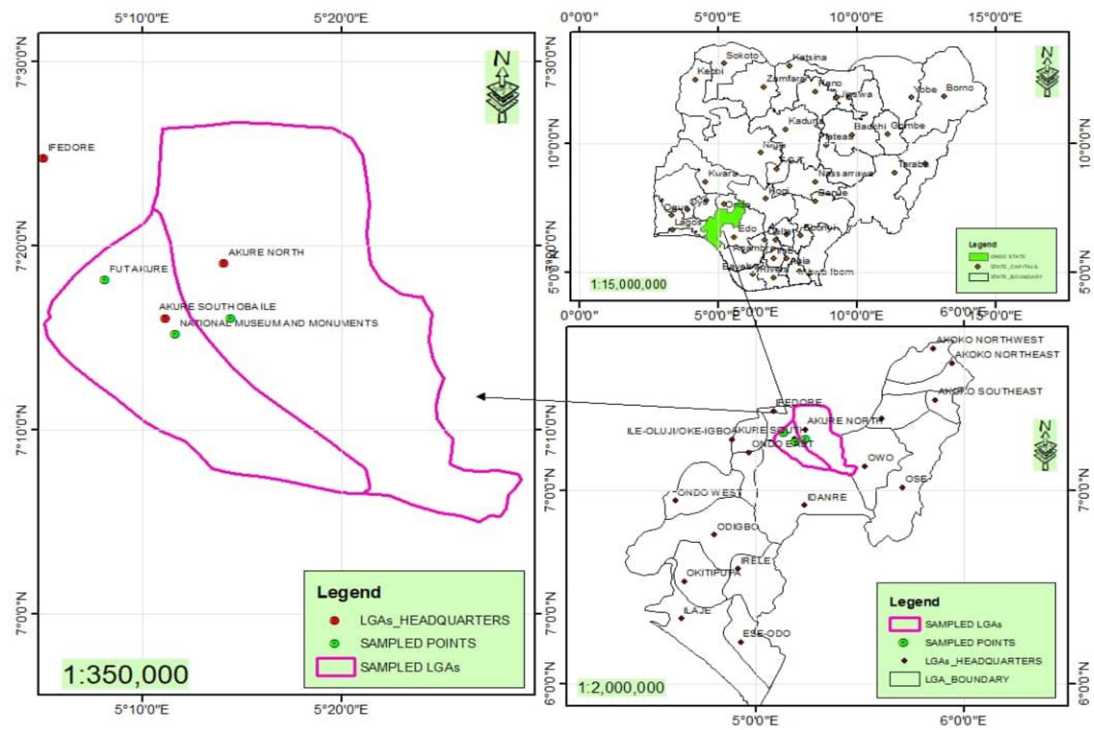

Figure 1. Map of the sampling points

3. Results and Discussion

Table 1 depicts a summary of the statistical results of the PM collected and analyzed in this study. The PM ranged between 39.10 and 133.20 (FUTA), 49.70 and 196.70 (Museum), and 34.50 and 161.30 (Oba-Ile) with mean values of 100.50, 125.20, and 112.80 µg/m^3 respectively. The Standard Error (SE) and Standard Deviation (SD) range were 10.9, 13.1 and 10.4 and 34.3, 41.3 and 33.0, while the Coefficient of Variation in percent (CV%) range was 34.17, 33.02, and 29.25, for FUTA, Museum, and Oba-Ile, respectively. The Skewness and Kurtosis gave -0.98, -0.01, -1.29 and -0.65, 0.68, and 3.80 for FUTA, Museum, and Oba-Ile, respectively. From Table 1, it could be deduced that the low standard error showed that the variability in the PM values was low during the sampling periods, while the CV (%) showed moderate variability. The variations could be due to the variations from the different months of sampling. The coefficients of variation of the PMs show that there was not much variation with locations, but the variance depicts high values due to the differences (variations) in the values obtained in each location as shown in the minimum and maximum values from each location.

The highest PM concentration occurred during the summer months when there was high temperature, solar radiation, low humidity and low wind speed. The most polluted months were April and October, which could have been due to the harsh weather conditions and high secondary transformations, as noted by Wang *et al*. [18]. The former could have been due to emissions from traffic and also agricultural burning during the April land as part of the preparation towards planting season, while the latter could have been due to the October harvest season [1]. The high PM values

Table 1. Summary of the statistical results of PM (particulate matter) (µg/m^3) measured during January to October 2018

	FUTA	Museum	Oba Ile
January	68.39	174.69	144.11
February	39.06	85.42	108.80
March	119.47	49.69	34.48
April	52.08	196.67	161.30
May	115.94	114.22	108.49
June	106.88	124.27	115.73
July	131.35	133.86	127.55
August	112.40	118.07	112.69
September	133.23	115.73	104.43
October	126.20	139.48	110.83
Mean	100.50	125.20	112.80
SE	10.90	13.10	10.40
SD	34.30	41.30	33.00
CV (%)	34.17	33.02	29.25
Min	39.10	49.70	34.50
Max.	133.20	196.70	161.30
Q1	64.30	107.00	107.50
Q3	127.50	148.30	131.70
Skewness	-0.98	-0.01	-1.29
Kurtosis	-0.65	0.68	3.80

obtained in the Museum area could have been a result of the accumulation of re-entrained and re-suspended dust resulting from vehicular emissions (low, medium and high) and unpaved terrain activities. The variations in the emissions, meteorological conditions, type of long-distance transport and secondary production are associated with the pollution levels in different seasons [19-21].

According to US. EPA [22], the air quality index of PM is categorized into good, moderate, unhealthy for sensitive groups, unhealthy, very healthy, and hazardous categories. The results were compared with this index and the results whose values were above 50 AQI range were grouped under the 'Moderate' and 'Unhealthy' groups while those with values less than this were classified as "Good" (Table 2). The average AQI in January through October of the three locations in Akure were 126.17, 131.34, and 138.96 (museum, Oba-Ile, and FUTA, respectively). All the locations were categorized as 'unhealthy for sensitive groups'. The health-related problem of PM is linked to particle sizes and particularly PM_{10} [21]. The PM deposits considered in this study were PM10, which was found in reasonable quantities in the sampling locations of this study and formed the basis of the classifications given in this study.

The values recorded in all the locations were more than 100 µg/m^3 recommended by India's Central Pollution Control Board [23], and more than three times greater than the European limit [24]. Our results (minimum-maximum values) were compared with other authors **-** Greilinger *et al*. [25] reported between10 and 45 µg/m^3 for Masemberg and from 20 to above 60 µg/m^3 for Bockberg, Austria; Mehta [26] gave 3.19 and 152.88 µg/m^3, for Ahmedabad, India; Abe and Miraglia [27] put that of São Paulo, Brazil to be 8 - 131 µg/m^3, and the Eastern part of Nigeria (14-504 µg/m^3) by Osimobi *et al*. [17]; Contini *et al*. [28] reported of South-Eastern Italy as 5.6 - 127.8 µg/m^3. It was observed that the minimum values from our study were higher than those reported by

Table 2. Air quality index of the selected sampling locations

Sampling Locations	**Air Quality Index Categories**					
	0-50 (Good)	**51-100 (Moderate)**	**101-150 (Unhealthy for sensitive groups)**	**151-200 (Unhealthy)**	**201-300 (Very Unhealthy)**	**>301 (Hazardous)**
FUTA	-	-	138.94	-	-	-
Museum	-	-	126.17	-	-	-
Oba-Ile	-	-	131.34	-	-	-

these authors. It is worthy of note that the maximum results obtained by Mehta [26] for Ahmedabad, India, and Osimobi *et al*. [17] were higher than ours. Also, the maximum results reported in this study, however, were lower than 109.60±10.83 - 453.45±62.92 µg/m^3 reported by Mandal *et al*. [29] for Delhi's industrial region and 584.8 µg/m^3 by Jain *et al*. [30] in Delhi, India. The variations between these results and those of others could be due to the climatic conditions of the areas, the methodology used and the natural and anthropogenic activities of the different locations. Also, the differences could be due to the differences in the weather conditions (temperature, humidity, and air exchange rates) [31].

The locational contributions of the PM to the total amount obtained in the study are shown in Figure 2. It could be noted that Oba-Ile, a residential area contributed 47% to the PM as against 36% (Museum) and 17% (FUTA) in February. The reason for the high contribution by Oba-Ile could have been the result of traffic diversion to this sampling location as a result of an accident that occurred on the Akure-Owo expressway during the sampling period. This increase in anthropogenic activities might have contributed immensely to the increase observed in the PM10 deposit of the said area during the said period (February). Likewise, the elevations in FUTA PM10 results could have been due to the waste dumps around the vicinity and also the on-going renovation activities of a lecture theater besides the sampling area [31].

4. Conclusions

To conclude, the evaluation of PM in this study shows that the concentrations were high. The results were well above the WHO standard limits. The highest value was obtained within the Museum vicinity, which could have been due to anthropogenic (dust, soil, traffic, and commercial) activities. The results, when compared with International Air Quality Index, indicate that the PM quality in Akure is unhealthy for sensitive groups. Constant monitoring of the vicinities is recommended.

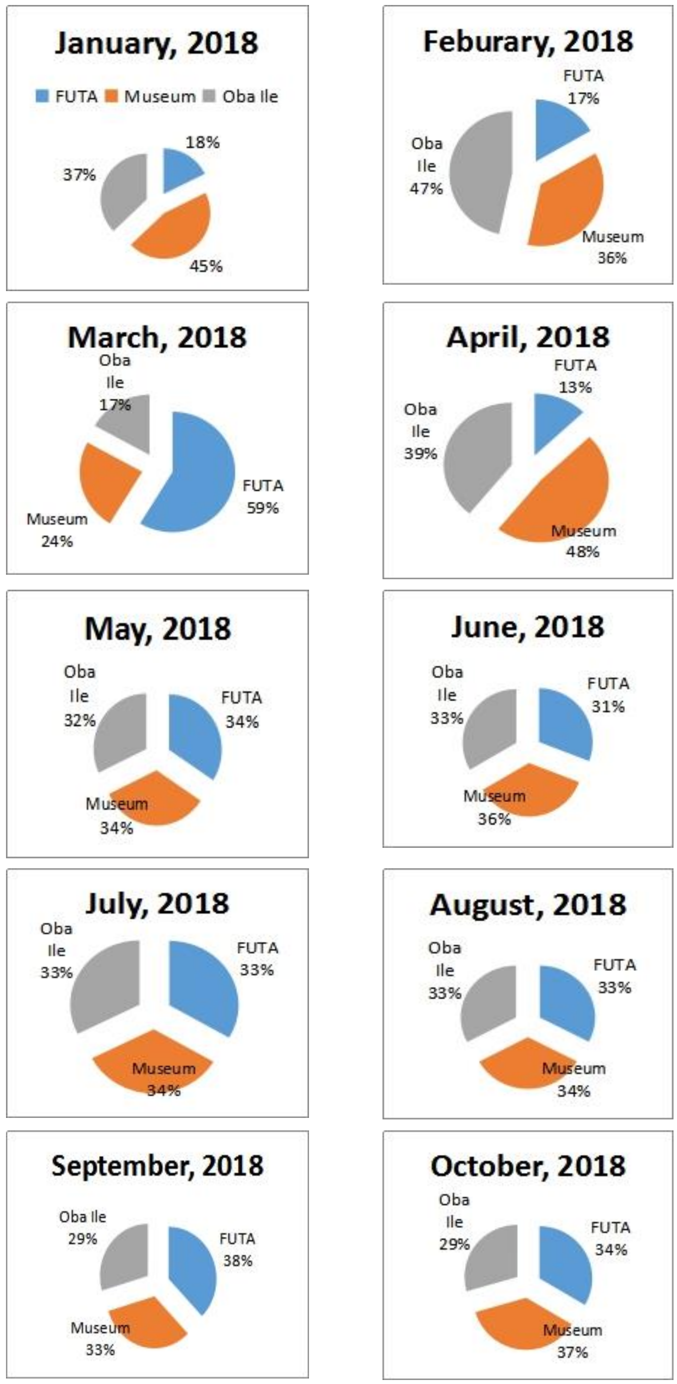

Figure 2. Distribution of PM_{10} in the locations (January-October, 2018)

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