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OCCUPATIONAL AIR POLLUTION INDEX (API) ASSESSMENT AND MEASURED ATMOSPHERIC VARIABLES AT SELECTED CONSTRUCTION SITES

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Abstract: **This study considered occupational air pollution index (API) and the effects of meteorological variables for two seasons at selected construction sites in the cities of Owerri and Port-Harcourt. Suspended microscopic particles of the size range 2.5µm and 10 µm generated at the construction sites were collected on filter papers and their concentrations were determined on a monthly basis for 2 seasons (wet and dry seasons). The results showed that air pollution of the selected construction sites were relatively poor. The highest API values recorded during the study for $PM_{2.5}$ and PM_{10} at Owerri construction site were 314 and 155, while that of Port-Harcourt were 216 and 106 respectively. Comparing the values of API between Owerri and Port-Harcourt construction sites for the period under study, air pollution index at Owerri construction site was higher than that of Port-Harcourt. This difference in API could be attributed to the volume of work and meteorological conditions of the selected construction sites. Occupational exposure to poor air quality has been identified as the cause of increased ischemic heart disease, respiratory problems, and even death among construction workers and workers in other industries, hence the need to ensure air quality monitoring and improvement in our environment and industries.**

Keywords: **Occupational, air pollution index, Assessment, Atmospheric variables**

I. INTRODUCTION

The monitoring of air quality in any given environment is very important, especially environment where certain occupational activities like construction activities which promote poor air quality due to the release of microscopic particles into the ambient air. Research has shown that the major cause of occupational related diseases emanate from air pollution in the work environment.What constitutes the major causes of air pollution during construction activity include fumes from vehicles, emission of dust, as well as acoustic pollution from vehicular movements [1]. Investigation of the impact of construction activity on the ambient air quality revealed that during construction activity, the concentration of airborne particles of 10micrometres increased by 15µgm^{-3} compared to when there was no construction activity [2]. More so,85% of PM_{10} generated during construction comes from "storage, transit on unpaved road, and aggregate crushing while (15%) comes from construction equipment and trucks"[3]. The risk of increased ischemic heart disease among construction workers is due to the occupational exposure to airborne particle pollution[4]. About one million workers die every year from occupational exposure to ambient air contaminated with dust, carcinogenic, and pathogenic particles [5]. The health effects from dust particles are dependent upon their size distribution and chemical constituents[6]. A study has revealed that "outdoor workers in Almaty during the cold season are at high risk of respiratory diseases." Poor air quality has a negative impact on economy[7]. For instance, in 2014, poor air quality caused the United States America to lose about $790 billion in damages[8]. A number of studies have shown that "exposure to air pollution can lead to neuro developmental and neuropsychiatric disorders" [9]

II. EFFECTS OF ATMOSPHERIC VARIABLES ON AIR QUALITY

The University Corporation for Atmospheric Research (UCAR) reported that atmospheric variables such as temperature, air pressure, and humidity influence both weather and air quality [10]. "Air quality is strongly dependent on weather and is therefore sensitive to climate change[11]. "Intense human activities and adverse atmospheric conditions aggravates poor air quality and harm human health"[12]. Some of these meteorological conditions include wind speed, humidity, rainfall and temperature. Findings from "statistical analysis of meteorological factors and air pollution at winter months in

Elaziğ" has shown that the relationship between meteorological variables and air pollutant concentrations are both moderate and weak [13].

Air movements (wind) determine whether air pollutants will built up or dispersed. A series of thermal and photochemical reactions taking place in the atmosphere are promoted by humidity[14]. Rainfall plays important role in the improvement of air quality and visibility because of its scavenging effects on airborne particles and dissolution of gaseous pollutants [14]). Temperature also affects the concentration of atmospheric pollutant. "The impact of temperature on the concentration of air pollutants becomes more obvious, as the latitude increases" [12].

III. AIR QUALITY COLOURS

The essence of air quality colours is to make it possible to identify when the ambient air is becoming unhealthy. The Environmental Protection Agency (EPA) deemed it necessary to give specific colour to each API category[5].These colours are green, yellow, orange, red, purple, and maroon.

IV. EQUATION OF AIR QUALITY INDEX

Air quality index is given by equation (1). This equation is used to convert mass concentration to air quality index (AQI)

$$\mathbf{I} = \frac{\mathbf{I}_{\mathbf{high}} - \mathbf{I}_{\mathbf{low}}}{\mathbf{C}_{\mathbf{high}} - \mathbf{C}_{\mathbf{low}}} (\mathbf{C} - \mathbf{C}_{\mathbf{low}}) + \mathbf{I}_{\mathbf{low}} \quad (1)$$

Where;

I= the (Air Quality) index,
C= the pollutant concentration,
$\mathbf{C}_{low}$= the concentration break-point that is $\leq$ C,
$\mathbf{C}_{high}$ = the concentration break-point that is $\geq$ C,
$\mathbf{I}_{low}$= the index break-point corresponding to C_{low}
$\mathbf{I}_{high}$= the index break-point corresponding to C_{high}

Table 1 is extracted from EPA's table of breakpoints for the calculation of air quality index of $PM_{2.5}$ and PM_{10} respectively.

Table 1: The EPA's table of breakpoints for $PM_{2.5}$ and PM_{10}

$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	AQI	AQI
C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	I_{low} - I_{high}	Category
0.0-12.0 (24-hr)	0-54 (24-hr)	0-50	Good
12.1-35.4 (24-hr)	55-154 (24-hr)	51-100	Moderate
35.5-55.4 (24-hr)	1 55-254 (24-hr)	101-150	Unhealthy for Sensitive Groups
55.5-150.4 (24-hr)	255-354 (24-hr)	151-200	Unhealthy
150.5-250.4 (24-hr)	355-424 (24-hr)	201-300	Very Unhealthy
250.5-350.4 (24-hr)	425-504 (24-hr)	301-400	Hazardous
350.5500.4 (24-hr)	**505-604 (24-hr)**	**401-500**	**Hazardous**

V. MATERIALS AND METHOD

The following materials/Instruments; namely microprocessor Am-4832 digital anemometer, hygrometer-digital thermometer, rain gauge, digital electronic balance, funnel and What-man filter papers were employed in the measurement of some atmospheric variables (temperature, relative humidity (RH), wind speed and amount of rainfall) and collection of samples of particulate matter (PM).

VI. METHOD

Suspended microscopic particle of the size range 2.5µm and 10 µm generated at the construction sites were collected on filter papers and their concentrations were determined on a monthly basis for 2 seasons (wet and dry seasons). The concentration values of these airborne microscopic particles were used to calculate the air quality index, using equation (1).

VII. RESULTS AND DISCUSSION

Figures 1, 2, 3, and 4areplots of the values for the measured meteorological variables (temperature, relative humidity, wind speed and amount of rainfall) for Owerri construction site, while figures 5, 6, 7, and 8 are plots of the values for the measured meteorological variables (temperature, relative humidity, wind speed and amount of rainfall) for Port Harcourt construction site respectively.

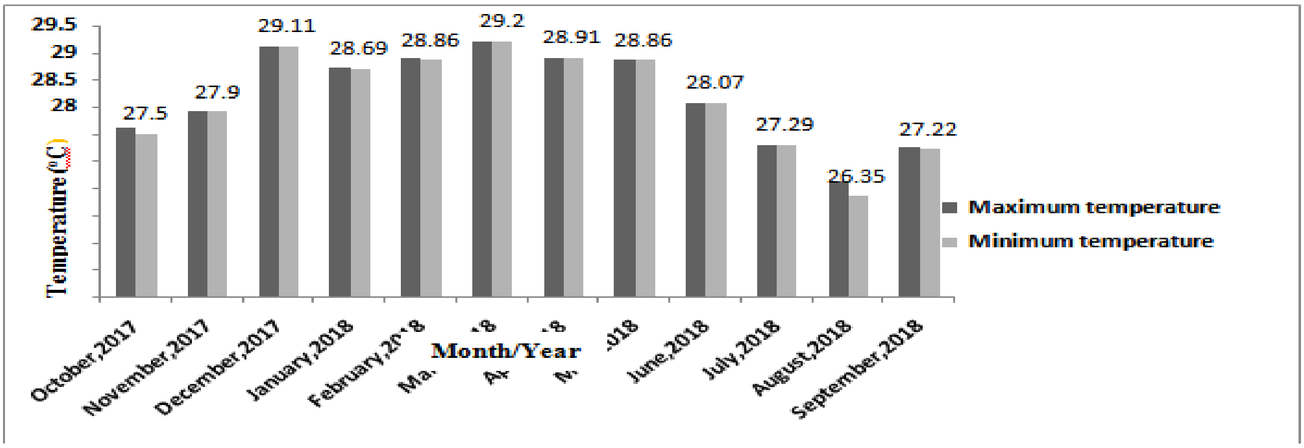

Fig.1: Monthly Average Maximum and Minimum Temperature for Owerri

In Figure 1, the month of March has the highest monthly average temperature of 29.20°C for both maximum and minimum temperatures, while the month of August has the lowest monthly average temperature of 26.62°C and 26.35°C for maximum and minimum temperatures respectively. Again, the month of August has the highest temperature difference of 0.27°C between maximum and minimum temperatures followed by the month of October with a difference 0.10°C. More so, most of the months, both maximum and minimum monthly average temperatures are the same. The plot also shows that both maximum and minimum temperatures for wet seasons are relatively lower than the temperatures of the short dry season. This could be attributed to the difference in the weather conditions between the two seasons.

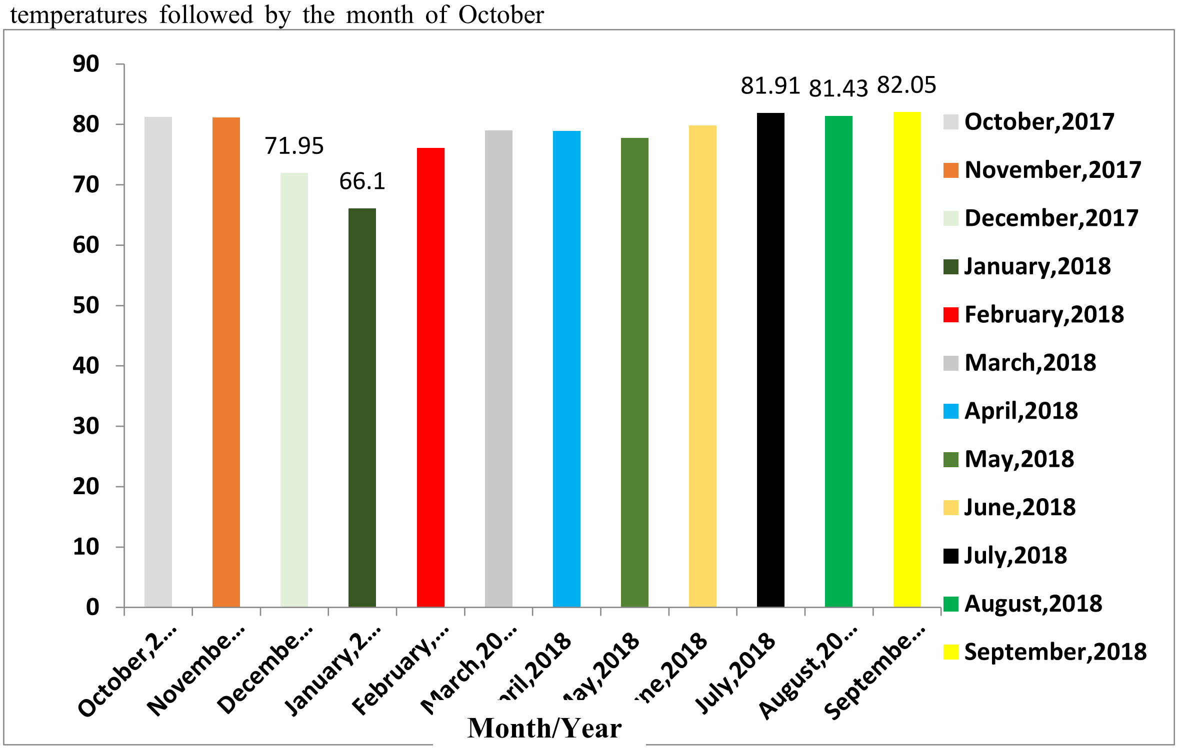

Figure 2:Monthly Average Relative Humidity for Owerri

Figure 2 is a plot of monthly average relative humidity for Owerri. The month of September has the highest humidity with a numerical value of 82.05% followed by July with a value 81.91%. The month of January has the least humidity with a value of 66.1% followed by December with a numerical value of 71.95%. This drop in relative humidity could be attributed to the dry weather condition due to the harmattan. More so, one can observe from the graph that the relative humidity of the wet season are generally higher than the dry season.

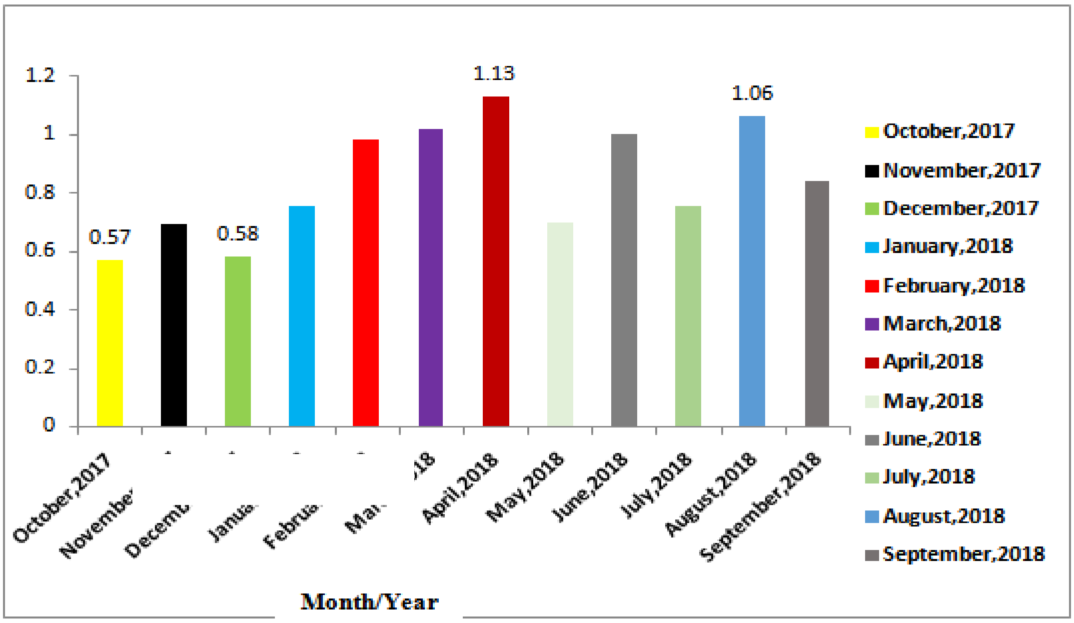

Figure 3: Monthly Average Wind Speed for Owerri

Figure 3 is a chart showing monthly average wind speed for Owerri. The monthly average wind speed varies throughout the period except the months of January and July where both months have a constant value of 0.75 m/s. The monthly average wind speed reaches its peak in the month of April with a value of 1.13 m/s, while the month of October has the lowest average wind speed with a numerical value of 0.57 m/s followed by the month of December with a value of 0.58 m/s.

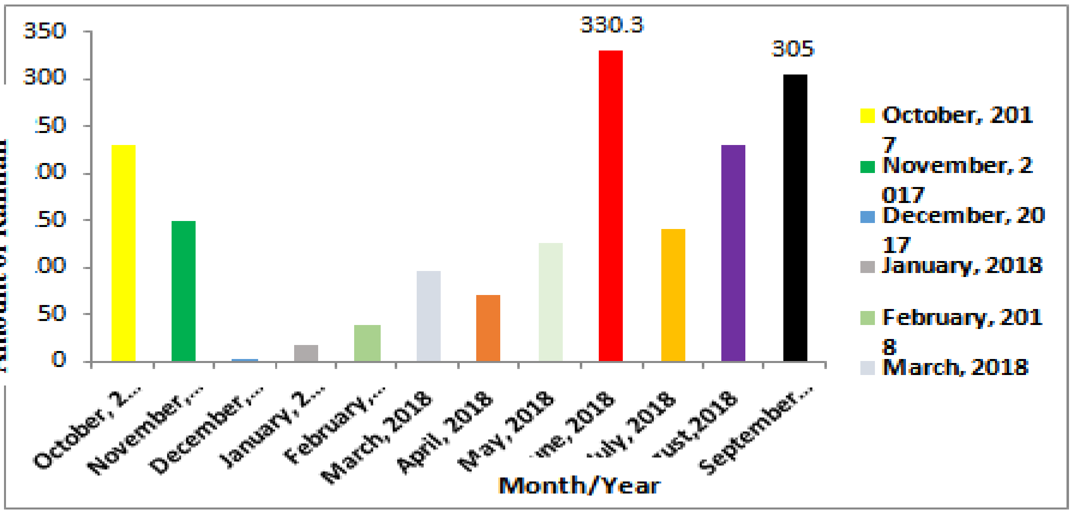

Figure **4: Monthly Average Rainfall for Owerri**

Figure 4 is a chart showing monthly average rainfall. Each bar height represents average rainfall for a particular month. The monthly average rainfall varies throughout the period. The month of June has the highest rainfall with a value of 330.30cm followed by September with a numerical value of 305 cm while the least rainfall was recorded in the month of December with a value 1.5 cm followed by January with a numerical value of 17.7cm. This low rainfall in the month of December, 2017 was due to dry season and harmattan.

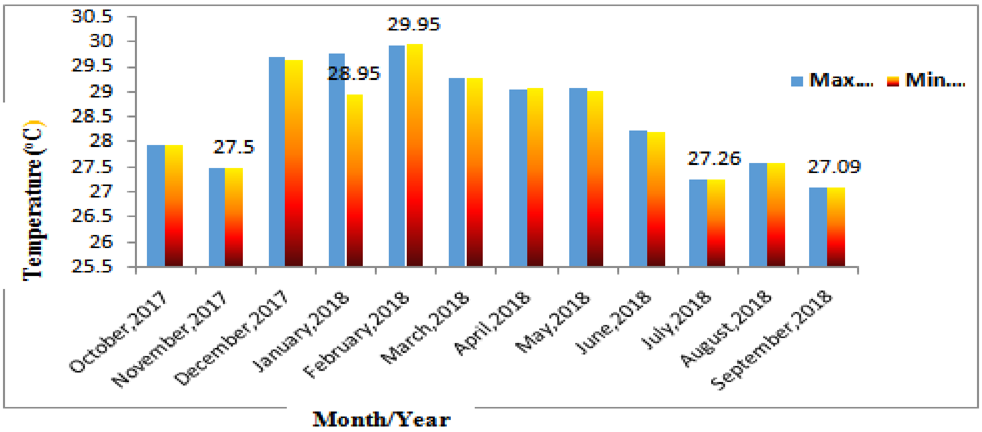

Fig. 5: Monthly Average Maximum and Minimum Temperatures for Port-Harcourt

In Figure 5, the month of February has the highest monthly average temperature of 29.95°C for both maximum and minimum temperatures, while the month of September has the lowest monthly average temperature of 27.09°C. Looking at the plot, only the month of January has the highest separation between the points of maximum and minimum temperatures. Most of the months, both maximum and minimum monthly average temperatures are equal. The plot also shows that both maximum and minimum temperatures for wet seasons are relatively lower than the temperatures of the short dry season, except the month of January, 2018 where minimum temperature drops below 29°c.

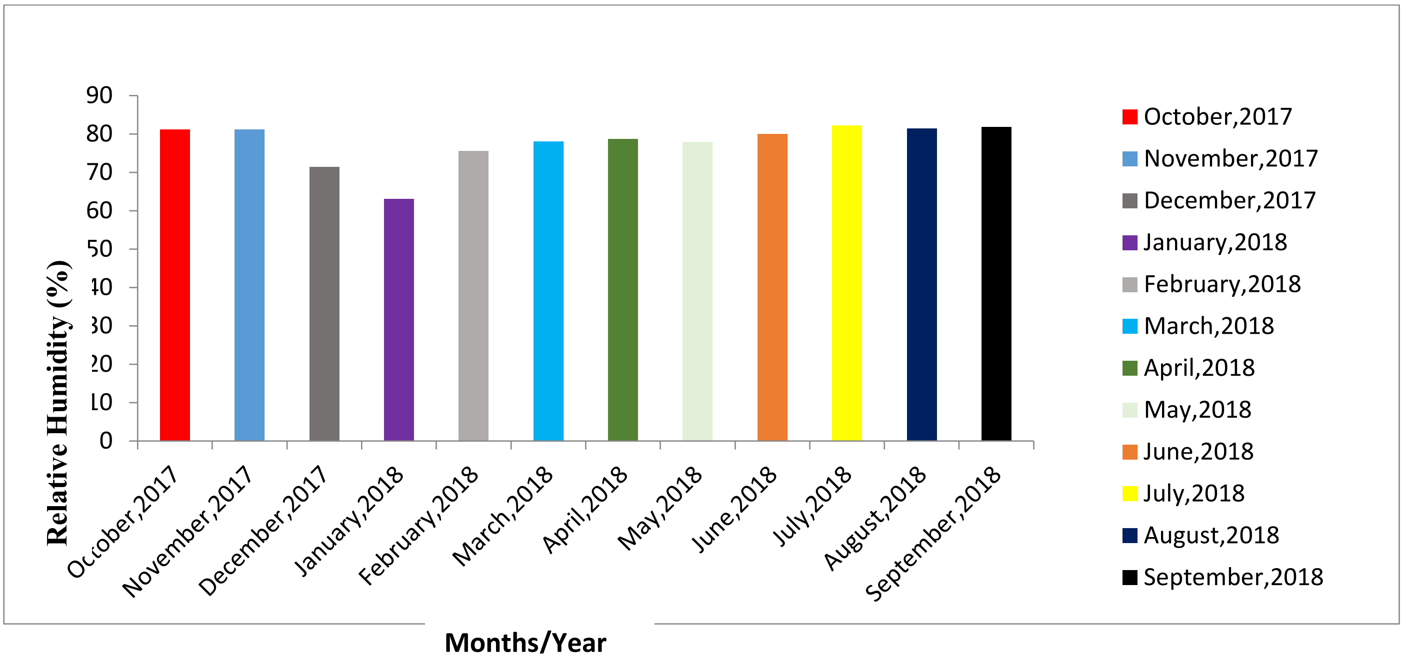

Fig.6: Monthly Average Relative Humidity for Port Harcourt

Figure 6 is a plot of monthly average relative humidity for Port Harcourt. The month of July has the highest humidity with a numerical value of 18.16%. In the months of October and November, 2017 the bar indicates a constant value of 81.22% in relative humidity, and a sharply fall to 63.02% in January. This sharp fall in relative humidity could be attributed to the dry weather condition due to harmattan. In the month of February, the relative humidity rises to 75.61% and then varies slightly from March to September. This rise in humidity was due to the wet season which brought about an increase in relative humidity.

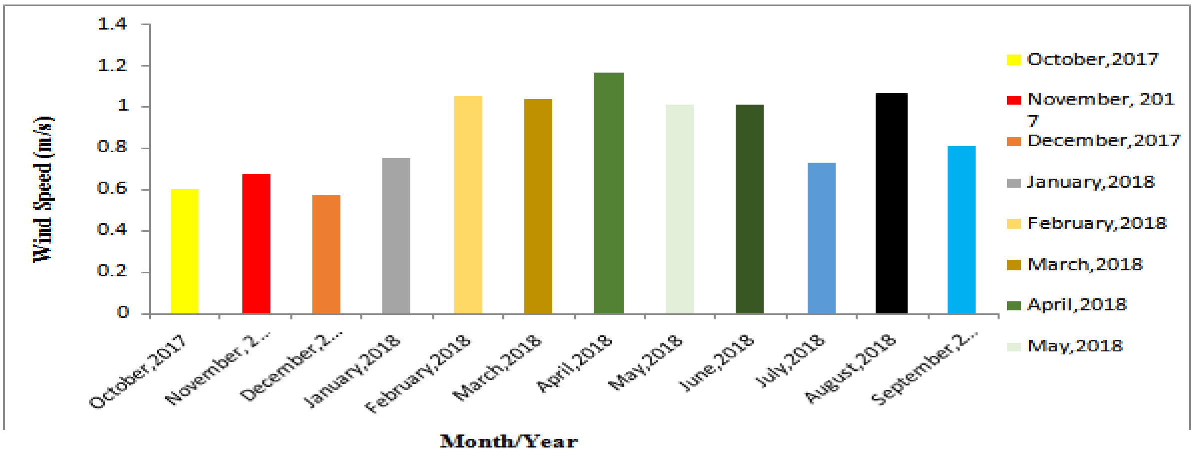

Fig.7: Monthly Average Wind Speed for PortHarcourt

Figure 7 is a chart showing monthly average wind speed. The monthly average wind speed varies throughout the period except May and June having a constant value of 1.01 m/s. The monthly average wind speed reaches peak in the month of April with a value of 1.17 m/s while the month of December has the lowest average wind speed with a numerical value of 0.57 m/s. This smallest wind speed recorded in month of December, 2017 could be attributed to the influence of harmattan.

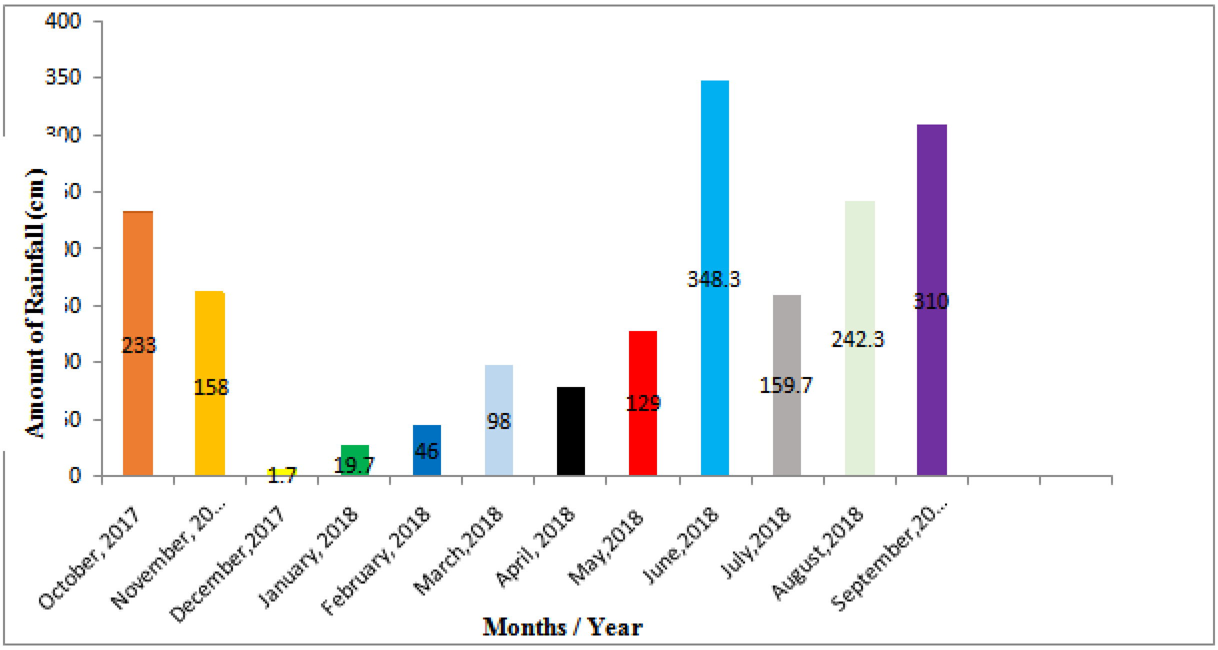

Fig.8: Monthly Average Rainfall Port Harcourt

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Figure 8 is a chart showing monthly average rainfall. Each bar height represents average rainfall for a particular month. The monthly average rainfall varies throughout the period. The month of June has the highest rainfall followed by September while the lowest rainfall was recorded in the month of December followed by January. The lowest rainfall recorded in the months of December, 2017 and January, 2018 was due to dry season and harmattan.

VIII. AIR QUALITY INDICES OF PORT-HARCOURT AND OWERRI CITIES

Air quality index for the construction sites of the two cities are calculated using equation (1) and EPA's values for $PM_{2.5}$ and PM_{10} given in Table 1.

Based on 24 hour average, AQI for the construction sites is calculated as follows:

I_{high} = **200**
I_{low} = 151
C_{high} = 150.4
C_{low} = 55.5

For $PM_{2.5}$ and C =78.20 we have;

$$I = \frac{200-151}{150.4-55.5}(78.20 - 55.5) + 151 = 163$$

Similarly, for PM_{10} and C = 78.20 we have;

I_{high} = **100**
I_{low} = 51
C_{high} = 154
C_{low} = 55

$$I = \frac{100-51}{154-55}(78.20 - 55) + 51 = 63$$

The calculated values of AQI for other mass concentrations are shown in Tables 2 and 3 respectively.

Table 2: Monthly Air Quality Index (AQI) for Owerri Construction Site

Month/Year	PM mass Conc. (µg/m³)	AQI ($PM_{2.5}$)	AQI Category	Status	AQI (PM_{10})	AQI Category	Status
October, 2017	68.43	158		Unhealthy	57		Moderate
November,2017	127.08	188		Unhealthy	87		Moderate
December, 2017	185.73	235		Very Unhealthy	116		Unhealthy for sensitive group
January,2018	263.93	314		Hazardous	155		Unhealthy
February, 2018	146.63	198		Unhealthy	96		Moderate
March, 2028	107.53	178		Unhealthy	77		Moderate
April, 2018	107.53	178		Unhealthy	77		Moderate
May, 2018	146.63	198		Unhealthy	96		Moderate
June, 2018	127.08	188		Unhealthy	87		Moderate
July, 2018	107.53	178		Unhealthy	77		Moderate
August, 2018	136.85	193		Unhealthy	91		Moderate
September,2018	97.75	173		Unhealthy	72		Moderate

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Table 3: Monthly Construction Site Air Quality Index (AQI) for Port-Harcourt Sampling Location

Month/Year	PM mass Conc. (µg/m³)	AQI ($PM_{2.5}$)	AQI Category	Status	(AQI) (PM_{10})	AQI Category	Status
October, 2017	78.20	163		Unhealthy	62		Moderate
November, 2017	78.20	163		Unhealthy	62		Moderate
December, 2017	58.65	153		Unhealthy	52		Moderate
January,2018	146.63	198		Unhealthy	96		Moderate
February, 2018	166.18	216		Very Unhealthy	106		Moderate
March, 2028	68.43	158		Unhealthy	57		Moderate
April, 2018	87.98	168		Unhealthy	67		Moderate
May, 2018	107.53	178		Unhealthy	77		Moderate
June, 2018	68.43	158		Unhealthy	57		Moderate
July, 2018	97.75	173		Unhealthy	72		Moderate
August, 2018	58.65	153		Unhealthy	52		Moderate
September,2018	58.65	153		Unhealthy	52		Moderate

Considering Tables 2 and 3, it shows that air pollution index of the selected construction sites were relatively poor. The highest API values recorded during the study for $PM_{2.5}$ and PM_{10} at Owerri construction site were 314 and 155, while that of Port-Harcourt were 216 and 106 respectively. Comparing the values of API between Owerri and Port-Harcourt construction sites for the period under study, air pollution index at Owerri construction site was higher than that of Port-Harcourt. This difference in API values could be attributed to the volume of work and meteorological conditions of the selected construction sites. For instance, in the month of June, 2018, the amount of rainfall recorded at Port-Harcourt construction site during the period was higher than that of Owerri. Port Harcourt has a value of 348.3cm while Owerri has 330.3cm.

IX. CONCLUSION

Air pollution index of the selected construction sites were relatively poor. Occupational exposure to poor air quality has been identified as the cause of increased ischemic heart disease, respiratory problems, and even death among construction workers and workers in other industries where their activities generate air pollution, hence the need to ensure air quality monitoring and improvement in our environment and industries.

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