Assessment and Modeling of Particulate Matter at a Major Intersection in Minna, Nigeria.

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Abstract

Purpose: The intersection under investigation is a transit point for many people including students of various institutions and it is usually chaotic and dense at peak period with many vehicles exhausting various forms of gases called particulate matter (PM) at point of no movement and as they transit.
Design/Methodology/Approach: The traffic volume was determined manually and classified. SETRA systems 8000 series particle-counter was used to determine the level of PM and the obtained data was authenticated using various models.
Findings: The total traffic volume of 2,622 Vh/hr/day was obtained as the highest producing $PM_{2.5}$ and PM_{10} of 6.38 μg/m^3 and 208.67 μg/m^3 respectively, at temperature of 35.3 ºC and relative humidity of 75 %. The CO concentration of 19ppm - 44ppm was also obtained after sampling with gas detector.
Practical Implications: It was then concluded that traffic and PM production will exceed current levels if left unchecked, which will eventually lead to gradual loss of human life and environmental degradation.
Social Implication: Particulate matters impact the human body and the environment which also depends on factors such as their size, shape, concentration, composition, and how they are grouped together.
Originality and Value: These shows that human life is at risk because of constant assimilation of fossil fuel into the body system and is prevalent at high traffic volume points.
***Keywords**: Air Quality, Concentration, Particulate matter, Traffic Volume.*

1. Introduction

Transportation involves the transfer of people, commodities, and services from one place to another (O'Flaherty, et al., 2020; Gupta & Gupta, 2019); and played vital contribution to the economy of any nation and crucial role it plays on daily activities of both developed and developing countries cannot be overlooked. Nigeria like many other developing countries is witnessing sporadic rise in vehicular usage (Adebayo and Zubairu, 2020 & Ukpata, 2020). Minna the capital of Niger State in recent time has witness high volume of articulated vehicles owning to many insecurity problems of the nation, (abandoning of Kontangora-makwa road and Bida-Lambata Road due to kidnapping and bad road) which make the articulated vehicles to see Minna – Bida Road as alternative, unfortunately this road passes through the Federal University of Technology Minna as a result the road was categorized as high traffic volume according to the work carried out by Ajayi et al., (2020) and according to traffic count conducted by Niger state government (2021).

While road transportation offers the benefit of offering convenient door-to-door services for daily life, it demands more energy (in the form of fuel) for combustion and generates higher emissions compared to alternative modes of transportation. (Aziz et al., 2000 & Fuzz, 2021). This emissions and incomplete combustion is termed particulate matter.

Particulate matter is defined as a mixture of minuscule particles and liquid droplets found in the air, predominantly originating from the incomplete combustion of petroleum-based products. This presents notable concerns for both human well-being and the ecosystem, as underscored by Odekunle et al. (2021). It has gained prominence as a major contributor to air pollution, especially in heavily populated urban regions, with adverse consequences for human health, as highlighted by Dias (2020).

The extent to which these particulate matters impact the human body and the environment depends on factors such as their size, shape, concentration, composition, and how they group together (Barmparesos, 2020; Ngoc et al., 2021 & Morales et al., 2021). Health risks associated with these pollutants may encompass issues like respiratory difficulties and asthma, among other concerns.

2.0 Literature Review

Several research work has been done to established the effects of incomplete combustion in human health and environment like the work of Odekunle et al., (2021), it was concluded that high concentration of the fine mode particle in the study area was the result of contribution of vehicular activities to the ambient air quality and it was significant. Also the Hankey and Marshall (2020) try to find answer to what we breathe in while waiting at the bus park they discovered that it depend on how long a passenger stays at the park and its closeness to the exhaust, that determine the level of inhaled fresh particulate matter. Adeniran et al. (2022) focused on appraising the air quality and the release of pollutants from a well-recognized cement manufacturing facility in Nigeria. Their findings indicated that the workers in the factory might face potential risks, although the heavy nature of the particulate matter caused it to settle more rapidly within the cement factory's vicinity.

Adeniran additionally examined the levels of coarse and fine particulate matter exposure in the vicinity of critical intra-urban traffic junctions situated in the Ilorin metropolitan area of Nigeria. His research revealed that higher traffic volumes, especially during rush hours, correlated with increased concentrations of particulate matter. Other studies by Nkaro (2020), Garg (2021), and Tan (2020) have similarly demonstrated that road intersections tend to experience high traffic densities, leading to elevated levels of air pollutants. However, none of these studies have specifically examined the extent to which these factors affect the student population in and around FUTMinna and its surroundings.

The World Health Organization estimates the sources of PM production as follows:

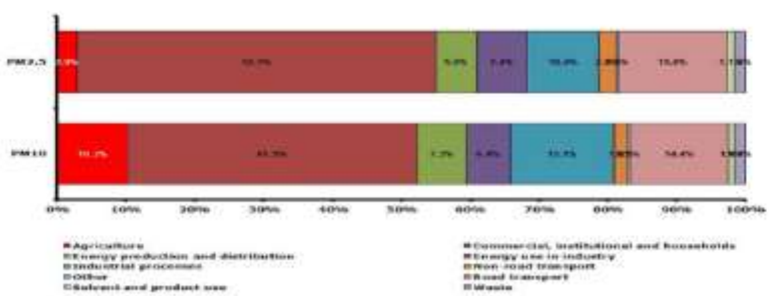

Plate I: The contribution of different sectors to emissions of primary $PM_{2.5}$ and PM_{10}

It categorized PM_{10} and $PM_{2.5}$, which represent the level of particle concentration released into the atmosphere due to various human activities within the European Union (EU). As per Suh (2021), the largest contributors to both PM_{10} and $PM_{2.5}$ emissions are Commercial, Institutional, and Household activities, accounting for 41.9% and 52.1% respectively. Following closely is Road transport, contributing to 15.8% of $PM_{2.5}$ emissions and Industrial processes, which contribute 15.1% to PM_{10} emissions.

In urban areas, such as Minna, road transport emerges as the primary source of both PM_{10} and $PM_{2.5}$ particles. It plays a significant role in the exposure of pedestrians to these particles (Hassan et al., 2022; Moore, 2019 & Levy et al., 2022).

Bus terminals present a specific challenge in relation to $PM_{2.5}$ pollutions, as individuals awaiting transportation at these terminals face a heightened risk of exposure to fine particulate matter produced during the combustion of various types of vehicles, encompassing motorcycles, tricycles, trucks, automobiles, buses, and heavy-duty vehicles (Kasuga, 2020). In accordance with a World Health Organization report on PM levels in Europe, the annual mean mass concentrations of both PM_{10} and $PM_{2.5}$ predominantly stem from substances such as sulfates, organic matter, nitrates, and black carbon, which originate from the combustion of fossil fuels (Geiss et al., 2021).

Recent studies indicate that the deterioration of vehicle parts, including tires and brakes, as well as the dispersion of road dust, constitute notable contributors to particulate matter (PM). In metropolitan centers across the globe, the rising demand for diverse transportation modes, encompassing automobiles, buses, and subways, has resulted in heightened air pollution originating from vehicular discharges (Zuurbier et al., 2021). This pattern remains consistent in the specific region under scrutiny. Given the variety of households within the studied area, it is crucial to investigate the cumulative influence of both household smoke emissions and traffic volume on air quality.

3.0 Material and Methods

3.1 Study Area

Minna is positioned in the northern region of Niger state, Nigeria. Niger state encompasses a total area of 96,363 square km² and is located between latitudes 8° 10' N and 10° 30' N, as well as longitudes 3° 30' E and 7° 30' E. Recent studies estimate its population at around 463,000 inhabitants. The region receives an annual precipitation ranging from 1,100mm to 1,600mm and undergoes distinct wet and dry seasons. The dry season typically spans from October to March, while April to October is characterized by consistently wet weather (see Fig 1). Average daily temperatures range from 28°C to 37°C.

Figure 1: Map of Nigeria Showing Niger State

Plate II: Aerial view of Kpakungu roundabout and its environs.

Plate II is a satellite image that highlights the busiest part of the corridor, the Kpakungu roundabout. It is an important intersection when entering Minna city or exiting the state while in transit

3.2 Traffic Study

Metro automatic traffic counter was used to conduct traffic count for 21 days of continuous counting, various categories of vehicle comprising of articulated vehicles, cars and motorcycles were done using metro traffic counter.

3.3 Air Quality Data Collection

The data was collected at location stated above and chosen because of its high traffic volume as proven by existing literatures, where the various researchers has adopted this sampling point as major congested areas (Oyetubo et al., 2022). SETRA systems 8000 series particle-counter was used for the air quality assessment (see Plate III).

Plate III: An overview of SETRA systems 8000 series particle-counter.

Air quality was assessed in terms of particulate matter (PM) concentrations utilizing the SETRA Model 8506, an Aerosol Particle Mass Monitor belonging to the SETRA systems 8000 series particle counter. This device is handheld, battery-powered, and portable, capable of measuring six different mass ranges of particulates: $PM_{0.3}$, $PM_{0.5}$, $PM_{1.0}$, $PM_{2.5}$, PM_5, and PM_{10}, spanning a range from 0.3µg/m³ to 10µg/m³. The sampling duration was set at 4 minutes and conducted for 12 hours on the initial day, employing a flow rate of 2.83 liters per minute. This sampling regimen was repeated for a total of 21 days at 4-minute intervals, commencing from 8:00 a.m. and concluding at 6:00 p.m

3.4 Particulate Matter Analysis

The methodology utilized for examining the association between traffic-related particulate matter exposures involves employing regression analysis through Microsoft Excel. Linear regression serves as a method to elucidate the connection between two variables. In this context, the variables under scrutiny in the linear regression are represented by Equation 1, formulated as Y = a + bX. Here, Y represents the dependent variable, X stands for the independent variable, b signifies the slope of the line, and a represents the y-intercept.

$$Y_i = f(X_i, ß) + e_i \qquad (1)$$

Where;

Yi = dependent variable

f = function

Xi= Independent variable

ß = unknown parameters

ei= errors terms

3.5 Artificial Neural Network

Li et al. (2019) introduced a recurrent neural network architecture based on the Multilayer Perceptron (MLP) model for the analysis and prediction of PM_{10} and $PM_{2.5}$ levels. In this model, the input layer was configured to represent the activation states of nodes within the intermediate layers. The processed signal was subsequently looped back to the input layer, with the neurons in the second layer containing condensed information derived from meteorological and chemical parameters from the previous time step. As a result, this architecture demonstrated a dynamic memory of the event types presented as inputs to the network. Meteorological conditions, real-time PM_{10} and $PM_{2.5}$ concentrations from the training data, along with CO concentrations, were utilized as inputs to model PM_{10} and $PM_{2.5}$ concentrations using the recurrent neural network. This study established the potential of this model as a valuable tool for obtaining real-time information concerning PM_{10} and $PM_{2.5}$ concentrations.

3.6 Health Data

A total of 350 questionnaires were distributed to individuals who use the route and reside in the area, and 327 of them were returned, constituting a response rate of 93.42%. These responses were subjected to analysis utilizing straightforward percentages and fundamental statistical methods to gain insights into response trends.

4.0 RESULTS AND DISCUSSION

4.1 Air Quality Data Collection

The summary of the data collected for the duration of research is presented in Table 1. The data collected represents the active traffic section of the selected route along the Federal University of Technology, Minna (FUT Minna) corridor. Presented is the maximum, minimum and average of the obtained data for Temperature, Relative Humidity, Particulate Matter, Particulate matter Ratio, Passenger cars and Trucks

Table 1: Air Quality Data.

	Time (3-hour interval)	Temp (ºC)	RH (%)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}/PM_{10}$	PCU	Trucks
Average	8 a.m.	30.9	68.08	2.48	34.84	0.0809	912.3	329.7
Max	To	35.3	75	6.38	208.67	0.1858	2400	222
Min	6 p.m.	28.6	55	1.00	7.16	0.0306	429.8	219.8

During the data collection, the highest temperature recorded was 35.3ºC and a minimum of 28.6 ºC does confirming a volatile situation at the study area, according to Kingham *et al.*,(2011)). see Figure 2.

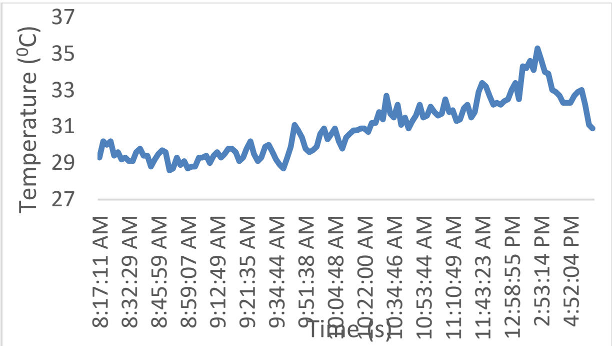

Figure 2: Temperature Range

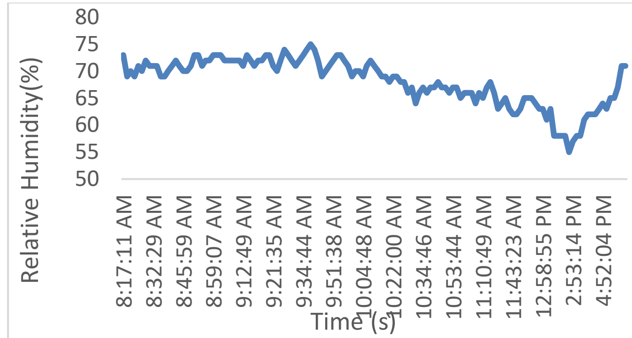

Figure 3: **Relative humidity**

In Figure 3, the relative humidity ranges from 75% to 55% and had an average of 68.1% during the data collection at the route, also showing a situation that the environment is volatile it easy for the particulate matter to travel a wide range. Suh, (2009).

In Figure 4, the data collection at the selected route, the $PM_{2.5}$ ranged from 1.0 µg/m^3 to 6.38 µg/m^3 and had an average of 2.48µg/m^3. This implies volatility of the sample material.

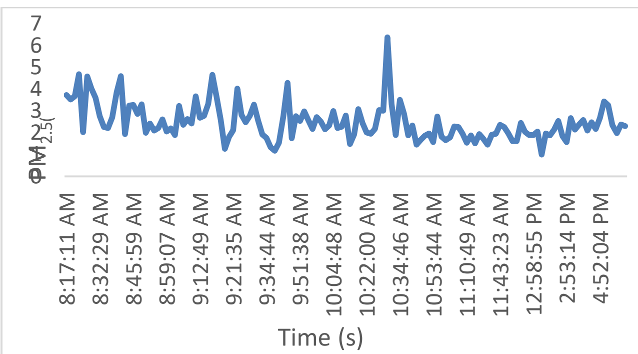

Figure 4: Particulate Matter ($PM_{2.5}$)

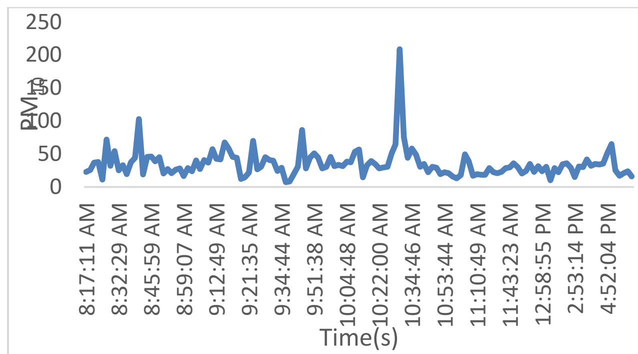

Figure 5: Particulate Matter (PM_{10})

During the 21 days of data collection at Kpakungu roundabout, the PM_{10} ranged from 7.16 µg/m^3 to 208.67 µg/m^3 and had an average of 34.84µg/m^3 as in Figure 5 and visibly showed that articulated vehicles are responsible for PM and this occurred mostly at 9:00 am to 10:00 am.

4.2 Regression Analysis of $PM_{2.5}$

The Regression Statistics presented in Table 2 offer statistical metrics for evaluating the model's data fit. Typically, higher R-squared values are indicative of a better fit. The R-squared value of 0.927 suggests that, during the sampled period, the model accounts for approximately 92.7% of the variance in the dependent variable. The adjusted R-squared value stands at 0.913301. R-squared is valuable for comparing regression models with varying numbers of independent variables.

The standard error of the regression provides insight into the typical size of residuals, showing the model's overall accuracy. Smaller values indicate a closer alignment between data points and fitted values. Notably, this metric utilizes the same units as the dependent variable. Based on the results, the standard deviation between predicted and observed values is 0.679963 µg/m³.

Table 2: Regression statistics of $PM_{2.5}$ for 21 days.

Regression Statistics	
Multiple R	0.962576
R Square	0.926554
Adjusted R Square	0.913301
Standard Error	0.679963
Observations	83

In the ANOVA analysis conducted in Microsoft Excel, the key statistic of significance is denoted as Significance F. This represents the p-value for the F-test, which assesses the overall significance of the model. The p-value for this F-test is extremely small, measuring 2.75E-46, and is expressed in scientific notation due to its minuscule magnitude. The notation "E-46" signifies that we would need to shift the decimal point 46 positions to the left to express the value. This exceptionally low p-value is smaller than any reasonable significance level, affirming the strong statistical significance of the regression model.

Table 3: Analysis of Variance (ANOVA) of $PM_{2.5}$.

	Df	**SS**	**MS**	**F**	**Significance F**
Regression	2	472.4496	236.2248	510.9219	2.75E-46
Residual	81	37.45036	0.46235		
Total	83	509.9			

Trucks and Passenger cars (PC) are two independent variables. The coefficient for passenger cars and trucks are 0.042428 and 0.016569 respectively, this implies a positive relationship as passenger cars increases, $PM_{2.5}$ also tends to increase by 0.042428 µg/m^3 and 0.016569 µg/m^3 respectively. (Table 4)

Table 4: Coefficients table of $PM_{2.5}$

	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	0	0	0	0	0	0
PC	0.042428	0.018086	2.345855	0.021429	0.006442	0.078414
Trucks	0.016569	0.008739	1.896099	0.061513	-0.00082	0.033956

The confidence interval for Passenger cars and Trucks is [0.006442, 0.078414] and that of relative humidity [-0.00082, 0.033956]. Hence, there is 95% confidence that the actual population parameter for $PM_{2.5}$ falls within this range.

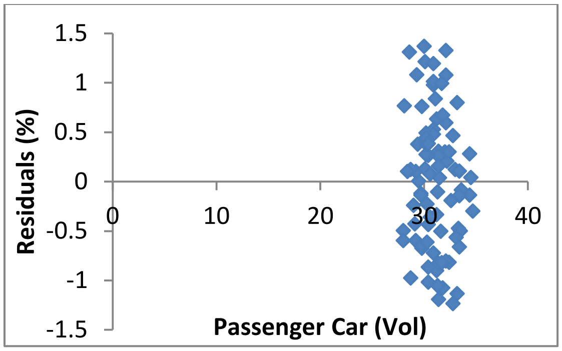

Figure 6: Residual plot for Passenger car $PM_{2.5}$

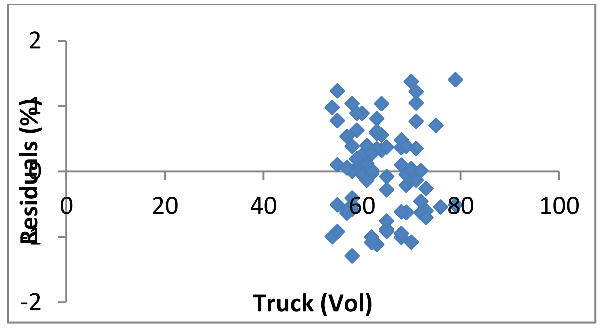

Figure 7: Residual plot for Truck $PM_{2.5}$

Residuals exhibit a random distribution centered around zero, indicating that the model effectively aligns with the data, as illustrated in both Figure 6 and Figure 7.

4.3 Regression Analysis of PM_{10}

Table 5, containing Regression Statistics, offers statistical metrics to assess the adequacy of the sample collection for particulate matter (PM_{10})

Table 5: Regression statistics

Regression Statistics	
Multiple R	0.437798
R Square	0.916675
Adjusted R Square	0.904593
Standard Error	8.83402
Observations	83

Both the R-squared value and the adjusted R-squared value are notably high, approximately at 0.917 and 0.904593, respectively. An R-squared value of around 0.917 suggests that our model explains approximately 91.7% of the variance in the dependent variable.

Table 6: Analysis of Variance (ANOVA) of PM_{10}.

	df	**SS**	**MS**	**F**	**Significance F**
Regression	2	6728.739	3364.37	9.484574	0.000201
Residual	80	28377.61	354.7201		
Total	82	35106.35			

Within Table 6's ANOVA analysis, the crucial statistic is Significance F. This represents the p-value for the overall F-test, assessing the model's overall significance. The p-value for the comprehensive F-test is 0.000201, an exceedingly small value. This value is significantly smaller than any reasonable significance threshold. Therefore, it can be inferred that the regression model holds strong statistical significance.

Table 7: Coefficients table for the multiple regression analysis for PM_{10}.

	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	151.2624	68.20076	2.217899	0.029398	15.53857	286.9862
PC	4.40946	1.586324	2.77967	0.00678	-1.56635	7.25258

Truck	0.455561	0.410562	1.109604	0.270494	-0.36148	1.272605

Trucks and Passenger cars (PC) are two independent variables. The coefficient for passenger cars and trucks are 4.40946 and 0.455561 respectively, this implies a positive relationship as passenger cars increases, PM_{10} also tends to increase by 4.40946 $\mu g/m^3$ and 0.455561 $\mu g/m^3$ respectively. It is concluded according to Table 7 that the regression model is statistically significant.
The confidence interval for Passenger cars is [-1.56635, 7.25258] and that of relative humidity [-0.36148 and 1.272605]. We can express a 95% confidence that the true population parameter for PM10 lies within this interval.

Analyzing the residual plots is essential. Figure 8 displays the residual plot related to temperature, while Figure 9 presents the residual plot for trucks.

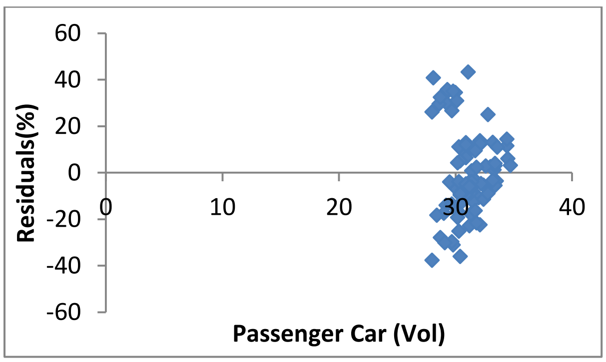

Figure 8: Residual plot for Passenger car PM_{10}

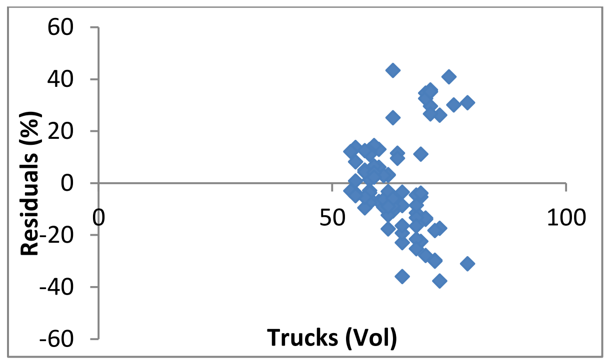

Figure 9: Residual plot for Truck PM_{10}

Residuals are randomly scattered around zero which means the model fits the data.

4.4 Result Validation using Thomas-Fierring Model

4.4.1 Results for Passenger Car Equivalent

The synthetic data was generated using Thomas-Fierring Model and it was tested by comparing the mean, standard deviation, maximum and minimum values with the observed data that were not used in generating the data. Table 8 shows the summary of the generated data for 7 days recorded for the corresponding 7 days for PCE. Figure 10 shows the graphical representation of PCE values for the synthetic and observed values of PCE.

Table 8: Summary of observed PCE and synthetic PCE.

	Observed	Synthetic	% Reliability	% Difference
Mean	1487.9	1553.4	96%	4%
std dev	717.4	865.5	83%	21%
Max	2908.8	4241.6	69%	46%
Min	619.0	616.8	100%	0%

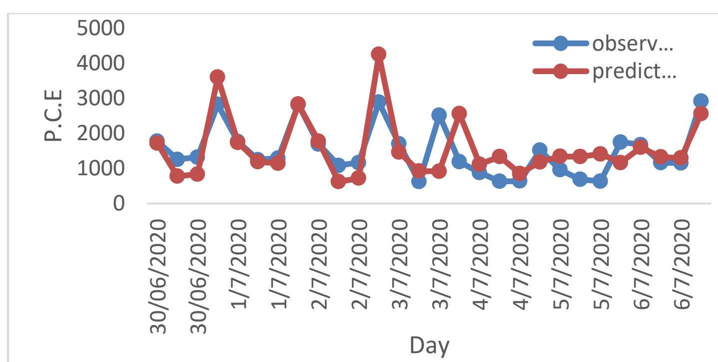

Figure 10: Observed and synthetic PCE for traffic at Kpakungu intersection.

The result of the reliability assessment of Thomas-Fierring's Model in the prediction of future traffic trends at Kpakungu shows consistency. Comparison of the mean, standard deviation, the maximum and minimum value for the observed data and the synthetic data generated as presented in Table 8 shows reliability of 96% and a minimal observable difference of 8% between the mean of the observed data and the synthetic data can be observed. 83% reliability and 21% difference were observed. Although this descriptive presentation, is not a sufficient basis for deciding the reliability of this method, but serves as pointer in the right direction. The minimum generated PCE was almost equal to the observed while a maximum value predicted of 4241.6 is 46% higher than the observed. This indicates that the traffic at the intersection will grow to higher figures in the future if the trend is not checked.

4.4.2 Results for $PM_{2.5}$

The synthetic data for $PM_{2.5}$ generated using Thomas-Fierring Model was tested by comparing the mean, standard deviation, maximum and minimum values with those of the observed that were not used in generating the observed data.

Table 9: Summary of observed $PM_{2.5}$ and synthetic $PM_{2.5}$

	Observed	Synesthetic	% Reliability	% Difference
Mean	2.22	2.71	82%	22%
Std dev	0.64	0.53	83%	-17%
Max	3.5	4.52	77%	29%
Min	0.64	0.53	83%	-17%

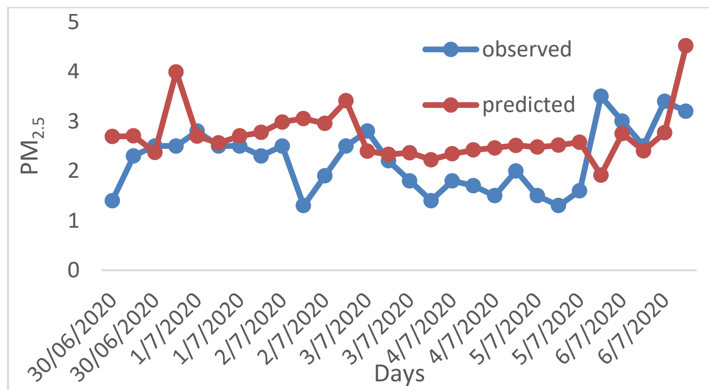

Figure 11: Observed and synthetic PM_{10} at Kpakungu intersection.

The results of the reliability assessment of Thomas-Fierring's Model in the prediction of future $PM_{2.5}$ trends at Kpakungu show consistency. Comparison of the mean, standard deviation, Maximum and minimum value for the observed data and the synthetic data generated.

The mean has 82% reliability and observed difference of 22% between the mean of the observed data and the synthetic data observed. The standard deviation has an 83% reliability and a -17% difference was observed for the standard deviation. Although these descriptive presentations are not sufficient basis for deciding the reliability of this method, it serves as pointer in the right direction.

The minimum generated $PM_{2.5}$ was 0.53µg/m^3 was -17%. This indicates that the minimum observed value is higher than the synthesized. A maximum value predicted of 4.52µg/m^3 is 29% higher than the observed. This supports the finding that the trends for PM_{10} continue upward as the traffic and other human activities at the intersection continues to grow at the intersection. Figure 11 shows the graphical representation of $PM_{2.5}$ values for the synthetic and observed values of $PM_{2.5}$

The test carried out on the synthesized values for PCE, PM_{10} and $PM_{2.5}$ all indicate the possibility of significant reliability of the Thomas Fiering model. It is not expected that the means, standard deviation, minimum and maximum be 100%.

The test has demonstrated that the generated synthetic data is concerning the various unbiased statistical properties of each data set. The reliability implies that it could be used for making estimates and policies that affect PM production or reduction concerning traffic flow at Kpakungu roundabout.

4.4.3 Results for PM_{10}

The synthetic data for PM_{10} generated using Thomas-Fierring Model was tested by comparing the mean, standard deviation, maximum and minimum values with those of the observed that were not used in generating the observed data.

The mean and standard deviation are principally the determinants of unbiased statistics which needs to also be preserved for the generated data to be reliable. Table 10 shows the summary of the generated data for 7 days and observed data recorded for the corresponding 7 days for PM_{10}.

Table 10 Summary of observed PM_{10} and synthetic PM_{10}.

	Observed	Synthetic	% Reliability	% Difference
Mean	40.71071	50.8911	80%	25%
Std dev	21.06029	18.47719	88%	12%
Max	90.2	101.9	89%	13%
Min	10.8	18.3	59%	70%

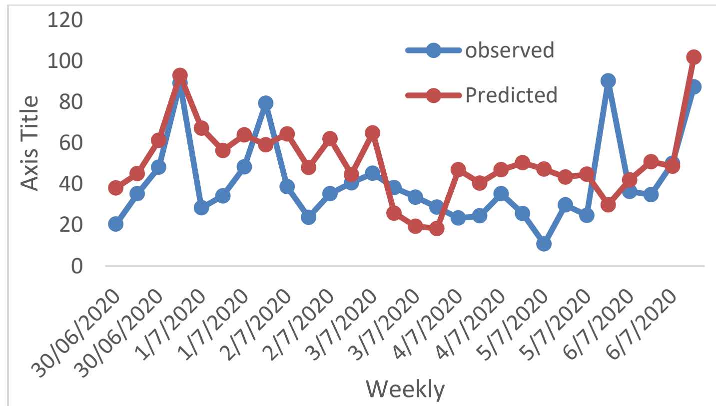

Figure 12: Observed and Synthetic PM_{10} at Selected Route.

The result of the reliability assessment of Thomas-Fierring's Model in the prediction of future PM_{10} trends at Kpakungu shows consistency. Comparison of the mean, standard deviation, the maximum and minimum value for the observed data and the synthetic data generated. 80% reliability for the mean and an observed difference of 25% between the mean of the observed data and the synthetic data can be observed while 88% reliability with 12% difference was observed for the standard deviation. Although these descriptive presentations are not a sufficient basis for deciding the reliability of this method, it serves as pointers in the right direction.

The minimum generated PM_{10} was 18.3µg/m^3 was 18% above the observed while a maximum value predicted of 101.9µg/m^3 is 13% higher than the observed. This supports the finding that the trends for PM_{10} continue upward as the traffic at the intersection continues to grow at the intersection.

4.5 Health Implication of Particulate Matters

(i) On short-term Exposure

90% of questionnaire respondent confirmed that, they are usually been exposed to PM while passing/seeking commercial vehicles. This shows that almost all passengers and drivers plying the Kpakungu intersection road experiences short-term exposure as most of the respondent says they spend within 5-10 minutes before get means of transportation to their destination shown in Figure 13.

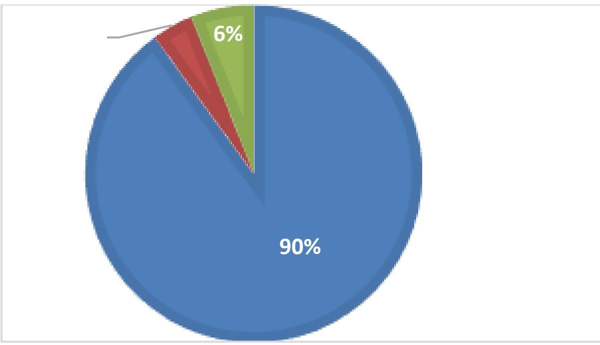

Figure 13: PM exposure for short term

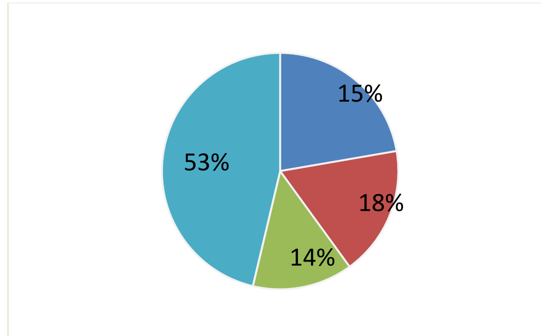

Figure 14: Short-term effect of PM on commuters.

The Figure 14, shows that 53% of the respondent both drivers and commuters confirmed that due to the delay while moving through the intersection, they experienced headaches, chest pain and fatigue which is as a result of exposure to particulate matter within time spent on this axis/route.

(ii) On Long-term exposure

Figure 15 show that a large proportion, 59% of the respondent confirmed that, they use the intersection multiple times a day. This shows that most of them are likely susceptible to the long-term effects of exposure. The respondents revealed that long-term exposure causes some adverse effects such as cardiovascular diseases (CVD). However, this effect is not frequently noticeable as the effect in most commuters varies from short to long term.

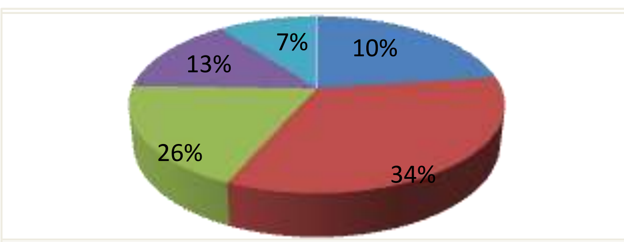

Figure 15: Frequency of Passing Kpakungu Intersection

5.0 Conclusion

This study delves into the examination of particulate matter (PM) levels and their sources within bus stations, with a specific emphasis on the impact of such exposure on passengers while waiting at Kpakungu bus stop. Furthermore, the research investigates the associated health implications. PM concentrations at Kpakungu bus stop predominantly emanate from a variety of sources, including vehicle fuel combustion, the wear and tear of vehicle components such as tires and brakes, the dispersion of road dust, tobacco smoking, and industrial emissions. In addition, meteorological factors such as temperature, relative humidity, atmospheric pressure, and rainfall volume, in conjunction with the design and orientation of the bus station, contribute to shaping the distribution of PM at this location. The study has demonstrated that bus stops have the potential to accumulate elevated levels of PM, resulting in heightened individual exposure and potential health consequences, including cardiovascular diseases (CVD), respiratory ailments, and diabetes.

The relationship between the peak traffic occurrence, time and concentration of PM was carried out using regression analysis using MS Excel. $PM_{2.5}$ and PM_{10} showed a positive correlation. There is no significant relationship between PM production and temperature or relative humidity. Commuters at the Kpakungu roundabout are exposed to an average of 2.3ug/m^3 $PM_{2.5}$ while they are exposed to an average of 38.5ug/m^3 of PM_{10}.
Thomas-Fiering model was used to stimulate a synthetic occurrence of traffic, $PM_{2.5}$ and PM_{10} at the intersection. It showed that traffic and PM production will exceed current levels if left unchecked. The need for government and its agencies to start working on other means of transportation in the country so as to continue to have a healthy society.

5 Recommendation

i Creating air quality prediction systems at bus stops, with the potential to minimize health risks, is not only achievable but also imperative.

ii Reduction of the volume of automobiles plying the corridor especially at the Kpakungu roundabout by introducing big buses that carry more people with less PM production per capita.

iii Periodic data collection and analysis to ascertain the efficiency of the policy being implemented.

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