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Research Paper

Preliminary Results of Air Pollution Status in Selected Roadsides in Jalingo, Taraba State Nigeria

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Abstract
The rapid increase in vehicular activities in the past two centuries contributes vastly to air pollution levels. In as much as Social interactions and economic growth are well enhanced by vehicular transportation in many developing countries, it is unfortunate that exhausts from vehicles contribute immensely to ambient air quality especially in the urban areas. The concentrations of carbon monoxides (CO) and carbon dioxide (CO_2) emissions in selected roadsides in Jalingo have been assessed. Four roads were used as sample locations where the concentration of CO_2 and CO were measured using an air quality meter for four weeks. The mean concentration of CO_2 and CO obtained were respectively as follows: 542.25 ppm and 7.49 ppm for the roadblock, 540.05 ppm and 5.55 ppm for Hammaruwa way, 598.81 ppm and 17.42 ppm for market road, and 463.80 ppm and 1.08 ppm for Nigerian Labour Congress (NLC) road (control). Based on the acceptable limit of CO_2 (600 ppm), the Roadblock road, Hammaruwa way, and the NLC/control road are safe. Only the market road had value that exceeded the acceptable limit, and it may be attributed to high vehicular activities on the roadsides. Therefore, more alternative roads should be constructed in other to minimize traffic congestion and also, the use of nose masks should be encouraged. For the CO, all the sites are safe because they fall within the acceptable level of CO (1-70 ppm).

Keywords
Carbon Monoxide, Carbon Dioxide, Pollution, Jalingo, Environment

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1. INTRODUCTION

Transportation now and then plays a vital role in our day-day activities and has been crucial to the accessibility of systems. Social interactions and the economic growth experienced in the past two centuries are well enhanced by vehicular transportation (Zhou et al., 2018; Lozhkin et al., 2018). Individuals, families, entrepreneurs, firms, and so forth, exchange goods and services on daily basis through transportation to improve their economic lives and the standard of living. As such, there is a huge increase in traffic roads, especially in urban areas. Consequently, the human population and human activities are promoted thereby putting an incredible strain on our environment (Mittal and Mittal, 2013; Ipeaiyeda and Adegboyega, 2017).

Vehicles are the major cause of air pollution in urban areas, Anthropogenic CO_2 and other greenhouse gases are well known to come from their exhausts (Orisaleye et al., 2018). The spontaneous increase in the number of vehicles is the cause of poor traffic flow congestion in many cities (Ugbebor and John, 2018). Atmospheric pollutions from motor vehicles can either be of the exhaust or non-exhaust type. Pollutants such as NO_x, SO_2, CO, CO_2, hydrocarbon, lead compounds and smoke are part of the exhaust pollutants and can also be obtained from the incomplete internal combustions engines which burn the gasoline or fossil fuels, while pollutants like Cu and Sb are examples of the non-exhaust vehicular pollutants (emissions) (Asubiojo, 2016; Oladapo et al., 2017; Ugbebor and John, 2018).

One of the menaces that bug the global community is air pollution, researches have shown that air pollution is currently part of the world's biggest environmental health risk (Pier and Franchini, 2017; Hassan Bhat et al., 2021). In 2012, the global burden of disease included air pollution in the leading risk factors of disease. Air pollution was independently accountable for 3.1% of Disability-Adjusted Life Years (DALYs) (Ipeaiyeda and Adegboyega, 2017). The air pollutants: NOx, SO_2, CO, CO_2 due to their strong oxidation nature acts as irritants that damage delicate tissues in the eyes and respiratory passages (Amirreza et al., 2019). Still in 2012, The World Health Organization reports that air pollution was responsible for 11.6% of global deaths.

The low and middle-income countries experienced 90% of deaths related to air pollution. such as cancer of the lungs, chronic obstructive pulmonary diseases, and cardiovascular diseases (Okhumode, 2018). Also, air pollution increases the possibility of contracting chronic obstructive pulmonary disease, and acute respiratory diseases among children, this is the most important cause of death of newborn offspring in developing countries (Amirreza et al., 2019).

Not only the health sector, but the economic analysis also shows that air pollution has detrimental effects on the economy, hence the benefits of cleaner air can never be overemphasized (Zheng et al., 2015; Jiang et al., 2020). The yearly economic cost of untimely deaths caused by air pollution all-round the nations of the WHO European Region recorded US$1.43 trillion losses, and the global yearly monetary cost of health effects and death caused by air pollution, with estimates for illness costs was US$1.575 trillion (WHO, 2015).

1.1 Health impacts of CO and CO_2

Carbon dioxide is very useful to the ecosystem as it plays a vital role in photosynthesis. However, carbon dioxide on the other hand may be termed a harmful gas as it is a well-known greenhouse gas. Also, breathing too much CO_2 results in a high level in the blood thereby increasing blood acidity which produces effects on the respiratory, cardiovascular, and central nervous system.

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The health impacts of CO hinge on the concentration, exposure time, and health status of people. The effects of the short-term exposure to high concentration are analogous to that of low concentration Long-term exposure. As such, no exposure is preferred to the other. CO loading in blood also decreases the quantity of blood circulated to body tissues (Malakootian and Yaghmaeian, 2004)

In Nigeria, air pollution levels have been assessed among many cities and, unfortunately, many of the obtained results show values that are above the acceptable limits. Orisaleye et al. (2018) investigated the calamities posed by vehicular and industrial emissions on human health in some selected towns in Lagos State by administering a questionnaire. From the results, respondents complained of headaches, catarrh, cough, and some other complications related to air pollution such as asthma, sore throat, itching, and heavy eye.

Osuntogun and Koku (2007) assessed air pollution levels along roadsides in Lagos, Ibadan, and Ado-Ekiti and the results were above the levels recommended by the Federal Ministry of Environment of Nigeria.

In Abeokuta also, some anthropogenic exhaust pollutants; SO_2, H_2S, CO and CH_4, and their concentrations ranged between 73.72 ± 0.92 and 82.82 ± 3.38; 0.046 ± 0.005 and 0.067 ± 0.017; 0.217 ± 0.02 and 0.399 ± 0.02; 0.167 ± 0.017 and 0.256 ± 0.011; 0.171 ± 0.024 and 0.442 ± 0.385 mg/m^3 respectively. The corresponding liable health complications reported to health bodies include cough (56.4%) and breathing impairments (23.6%).

Air pollutants concentrations around main highways in residential, market, and industrial regions of Ibadan city, Nigeria and the results showed that the increase in the background amount of SO_2, NOx, O_3, and NH_3 are attributed to some anthropogenic activities such as household coal, excretion from the inhabited humans and fossil fuel consumption. The result also showed that the level of SO_2 measured exceeded the WHO limit which calls for long-term air quality monitoring to obtain a viable strategy for air management. Oladapo et al. (2017) assessed particulate matter-based air quality index (PMx) in Port-Harcourt Nigeria and the result at three industrial sites indicated higher concentrations compared to their controls; $PM_{2.5}$ and PM_{10}. The $PM_{2.5}$ and PM_{10} data indicated a seasonal variation with the dry season indicating concentrations higher than the local acceptable limits of 150 $\mu g/m^3$ and 230 $\mu g/m^3$. Consequently, people suffering from diseases that are related to respiration are liable to be affected if they are exposed to the particulate matter that is emitted from the industrial zones.

The need to investigate pollution sources at all levels as the bodies entrusted with the responsibilities of enforcing environmental laws and regulations: State Environmental Protection Agency (SEPA) and Federal Environmental Protection Agency (FEPA) have failed to provide information on the air quality status of the state. This work, therefore, is aimed at assessing the level of pollution of CO and CO_2 to make further recommendations appropriately.

1.2 Study Area

The research was carried out in Jalingo city. Jalingo is the capital of Taraba State, North-East Nigeria. It has geographical coordinates between latitude 8°53'37.21" N and longitude 11°21'34.56" E and latitude 8.880 N longitude; 11.37° E and an elevation of 351 m, a temperature of about 26.0 to 35.5°C, with an average annual rainfall of 958 mm. It is surrounded by Lau Local Government Area, Yorro Local Government Area, and Ardo-Kola Local Government Area to the north, south, and west respectively. It has a total land area of about 195 km^2 and according to the 2006 census, Jalingo has a population of 140,318 people.

2. EXPERIMENTAL SECTION

Four roads in Jalingo town were selected for the measurement of the concentrations of carbon dioxide CO_2 and carbon monoxide CO. The selected roads are Roadblock, Hammaruwa way, Market road, and Nigerian Labour Congress (NLC) road. Three of these roads (roadblock, Hammaruwa way, and market road) were chosen because they have high

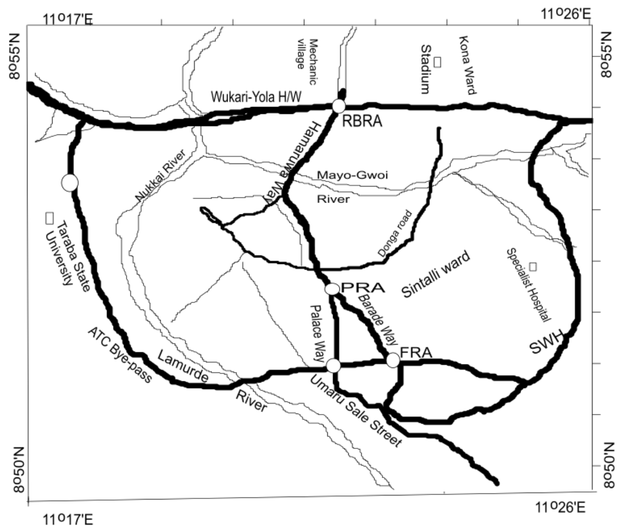

Figure 1. Map of The Study Area

vehicular traffic while the NLC road was chosen because it has low vehicular traffic and hence served as a control.

The instrument used for this study is the Lutron Air Quality Control Meter (model AQ-9901SD), it is a real-time recorder, it saves the recorded data into the SD memory card and can be downloaded to Excel thereafter. The air quality measurement application is multi-functioned: CO_2 (Carbon dioxide), CO (Carbon monoxide), O_2 (Oxygen in the air), relative humidity, and temperature. It measures CO_2 in ranges of 0 to 4000 ppm x 1 ppm, O_2 in ranges of 0 to 30.0 % x 0.1 %, CO in ranges of 0 to 1000 ppm x 1 ppm. Humidity ranges from 10 to 95 %RH and the temperature ranges from 0 to 50.0°C, it can also measure temperature in °F. The CO_2 sensor (NDIR) has long-term reliability. The CO and O_2 sensor is a Galvanic cell type. The Relative Humidity sensor is a precision capacitance sensor. The sampling time for the data recorder is 2 seconds to 8 hours. It has a separate probe, easy for remote measurement. The Meter can cooperate with 2 GB to 16 GB SD card, SD card is optional (Klein et al., 2017).

The method adopted for the data collection of this study is the semi/quantitative sampling method employing probes on air quality meter. Data were collected one meter away from the roadsides three times daily from 8:00 am – 11:00 am, 12:00 pm – 3:00 pm, 4:00 pm – 7:00 pm for four weeks [16^{th} to 23^{rd} April and 7^{th} to 26^{th} May 2018]. The average value of the three measurements represented the daily concentration of the measured pollutants.

2.1 Statistical Analysis

In this work, we adopt the one-way Anova test tool to compare the mean of CO_2 (ppm) and CO (ppm) separately as they are separate sets of data altogether. JB test on the data shows that it was obtained from a normal population, then we proceed with the following test hypothesis.

Null Hypothesis 1: (for CO_2) μ_1=μ_2=μ_3=μ_4 (the mean of CO_2 (ppm) along Roadblock road, Hamaruwa Way, Market way and NLC road are the same)

Alternative Hypothesis 1: Not all of the means are equal

Significance level α=0.05 Critical value and rejection region: F_α,(df_1 = k - 1,df_2 = N - k)

=$F_{0.05}$,(df_1 = 3,df_2 = 92) = 2.704

We will reject the null hypothesis if F $\geq$ 2.704 (P-value $\leq$ 0.05)

Null Hypothesis 2: (for CO) $\mu_1 = \mu_2 = \mu_3 = \mu_4$ (the mean of CO (ppm) along Roadblock road, Hamaruwa Way, Market way and NLC road are the same)

Alternative Hypothesis 2: Not all of the means are equal

Significance level $\alpha = 0.05$

Critical value and rejection region: F_α,(df_1 = k -1,df_2 = N - k) =$F_{0.05}$,(df_1 = 3,df_2 = 92) = 2.704

We will reject the null hypothesis if F $\geq$ 2.704 (P-value $\leq$ 0.05)

Let SS represent the sum of squares, SSTo be the total sum of squares, SSE be the sum of squares for error, MS be mean of squares, MSE be mean of squares for error, MSTr be mean of squares for treatments,

$$\mathcal{SST}r = \eta_i \sum_{i=1}^{n} (\dot{X} - \ddot{X})^2 i = 1, 2, 3, \ldots \quad (1)$$

Where $\dot{X}_i$ is the mean ppm measured at a particular roadside, η_i is the number of measurements made at each roadside

And $\ddot{X}$ is the mean of the averages obtained from the different roadsides.

$$\mathcal{SSE} = (\eta_i - 1) \sum_{j=1}^{\eta_i} S_i^2 \quad (2)$$

Where S_i^2 is the variance of the data obtained at each roadside.

$$\mathcal{SST}_o = \mathcal{SST}r + \mathcal{SSE} \quad (3)$$

$$M\mathcal{ST}r = \frac{\mathcal{SST}r}{K-1} (\text{k is the number of roadsides chosen}) \quad (4)$$

$$M\mathcal{SE} = \frac{\mathcal{SSE}}{N-k} (\text{N is the total number of measurements}) \quad (5)$$

$$\text{Then F-Statistic; F} = \frac{M\mathcal{ST}r}{M\mathcal{SE}} \quad (6)$$

The equations (1) to (6) were applied on Table 1 and Table 2 to obtain the results in Table 3 and Table 4 respectively.

3. RESULTS AND DISCUSSION

3.1 Result of Daily Variation of Measured Parameters

Tables 1 and 2 show the variation of measured parameters (CO_2 and CO) for four weeks (one month). While tables 3 and 4 compare the mean variations of CO_2 and CO respectively along the measured roadsides using Anova. The results were obtained by taking the average of daily variations (morning, afternoon, and evening) data of the selected roadsides (Roadblock, Hammaruwa way, NLC road, and market road).

Table 1. Average Daily Variations of CO_2 (PPM)

Sn	Road B.	H. way	Market	NLC
1	499.33	477.67	543.67	484.5
2	496.33	503.33	515.67	479.17
3	511.5	515.83	603.33	470.5
4	504.83	503.83	518.5	467.83
5	505.33	494.33	538.17	478
6	505.33	493.33	538.17	478
7	490.83	488.5	520	450.67
8	494.17	504.83	571.17	378.33
9	529	542.33	599.5	444.17
10	574	560.33	613.5	439.67
11	582.17	579.5	620.17	373.33
12	660.17	668.83	679.17	521
13	599.5	583.33	630.67	553.67
14	541.17	523.17	647.33	471.83
15	554.6	557.33	631	466.83
16	516	512.33	584	463.33
17	542.67	537.17	619.83	508.67
18	545.83	550.83	588	534.7
19	561.17	538.67	616.67	469.5
20	689	612.33	779	391.17
21	505.83	514.83	632.83	425.83
22	532.67	621.77	617.83	442.33
23	552	545.33	650.33	483.17
24	520.5	531.5	512.83	455
Variance $\mathcal{S}_i^2$	2551.043	2167.704	3800.841	1908.02
mean $\dot{X}$	542.2471	540.0513	598.8058	463.8
mean $\ddot{X}$		536.226		

The daily variation shows that the market road has the highest value of CO_2 (598.81 ppm) and CO (17.42 ppm). while NLC has the lowest value for CO_2 and CO. The high value of CO_2 and CO on these roads might be attributed to high vehicular activities on the roadside. This is because the market road (as the name implies) is the road that leads to Jalingo's main market which operates every day. Merchants and consumers within and outside Jalingo always come to buy or sell from the main market thereby keeping the road very busy. The NLC road which is the control site has the lowest values of CO_2 (463.80 ppm) and CO (1.08 ppm) throughout the four weeks and is suspected to be due to the low vehicular activities on the roadside.

Table 2. Average Daily Variations of CO (PPM)

SN	Road B.	H. way	Market	NLC
1	5.83	6.5	14	1.67
2	10.83	8.17	16.17	0.67
3	11.67	4.67	20	1.33
4	6.5	4.17	16.67	1.33
5	7.33	7.17	15	1.17
6	7.33	7.17	15	1.17
7	7.33	5	16.17	2
8	5.67	6.5	19.17	1
9	8.33	5.33	20.17	0.83
10	9.33	4.83	18	1.17
11	8	5.83	15	0.83
12	8	5.5	18	1
13	7.33	5	18.5	0.83
14	6.67	5.17	15.83	1
15	7.17	4.5	16.83	1
16	7.33	5.67	16.83	0.83
17	5.5	5.67	15.67	0.5
18	7	4.83	19.33	0.83
19	7.17	6.33	16.5	1.65
20	7.33	4.83	17.5	1
21	6.16	5.5	20	0.83
22	7.83	5	19.67	1.17
23	7.67	5	19.5	0.83
24	6.5	4.83	18.67	1.17
Mean $\dot{X}$	7.492083	5.54875	17.42417	1.075417
Mean $\ddot{X}$	7.885104			
variance $\mathcal{S}_i^2$	2.105017	0.95202	3.498643	0.115582

The NLC road harbors low vehicular traffic because there is no major business or activity along the road to cause vehicular traffic. Aside from that, the road is a good road that leads to offices, mini shops, churches, mosques, and other minor activities that are not capable of creating vehicular traffic. The Roadblock road and the Hamaruwa way also have traffic congestion but not always and when they have, it is not as intense as the market road. Consequently, their pollution levels are high (though still within the acceptable limits) but are less than that of the market road.

The results from the ANOVA show that we are rejecting the null hypothesis for both cases (CO_2 and CO). This is obviously because F=28.2708 $>$ 2.704 (P value=0.00001 $<$ 0.05) and F= 684.2634 $>$ 2.704 (P value=0.00001 $<$ 0.05) respectively. The F value is much greater than 2.704. This implies that the mean values (ppm) of CO_2 are very different at each roadside, the same applied to CO.

There is a serious need to begin the implementation of modalities that will help in lowering pollution levels along all roadsides in Jalingo. Such modalities may include: a

Table 3. ANOVA for CO_2

Source	df	Ss	MS = ss/df	F	P-value
Treatments	3	221097.9768	73699.3256	28.2708	P < 0.00001
Error	92	239834.984	2606.902		
Total	95	460932.9608			

Decision 1. Since $28.2708 \geq 2.704$ (P-value ≤ 0.05), we shall reject the null hypothesis. This is to say that the mean of CO_2 (ppm) along Roadblock road, Hamaruwa Way, Market way and NLC road are not the same

Table 4. ANOVA for CO

Source	df	Ss	MS = ss/df	F	P-value
Treatments	3	3428.16	1142.72	684.2634	P < 0.00001
Error	92	153.64	1.67		
Total	95	3581.8			

Decision 2. Since $684.2634 \geq 2.704$ (P-value ≤ 0.05), we shall reject the null hypothesis. This is to say that the mean of CO (ppm) along Roadblock road, Hamaruwa Way, Market way and NLC road are not the same

special guideline for industrialists, building more roads and flyovers to reduces traffic hold-ups, proper tuning of car engines, and so forth (Manisalidis et al., 2020; Mittal and Mittal, 2013). This is because Jalingo as the Taraba state capital is a developing city that welcomes migrants from rural areas who seek greener pastures as well as investors and manufacturing industries. Consequently, as time goes on, it is obvious that the population in Jalingo will keep increasing thereby increasing the burden on the roads. This implies that in the nearest future, the Road Block road, Hamaruwa way, and even the NLC road which serves as the control in this research will no longer be safe for inhabitants along with them and passengers as well.

It is therefore paramount to control these pollutants emanating from the vehicular exhaust to eradicate the consequences that are likely to behold the inhabitants of these areas.

4. CONCLUSIONS

Air pollution is not ignorable as it affects us in a variety of ways including health. There is a correlation between air pollution with mortality and morbidity as discussed earlier. Air pollution levels from vehicular exhaust have been assessed in four selected roadsides (roadblock, market road, Hammaruwa way, and NLC/control road) in Jalingo, Taraba State, Nigeria. The result shows that the market road's CO_2 value (603.29 ppm) exceeds the standard accepted level of (600 ppm) while the remaining roadsides fall within the safe limits. The values of CO for both roadsides all fall within the safe limits of 1-70 ppm (none of the measured values is up to 20 ppm). The statistical analysis (ANOVA) shows proof that the mean of CO_2 and CO varies considerably at each road side. It is recommended therefore that environmental control bodies should put in place mechanisms to control these menaces at this early stage. A tree-planting campaign along the roads and within the town should be adopted to help reduce drastically the amount of CO_2 in the environment.

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