

STUDIES ON THE STATUS OF AIR POLLUTION LEVEL FROM DUMPSITES IN JIMETA, ADAMAWA STATE, NIGERIA

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ABSTRACT

The occurrence of unwanted items discarded on dumpsites has made Jimeta metropolis one of the dirtiest cities in Nigeria. A study on the status of air pollution from those dumpsites as a result of human activities in the 11 wards of Yola North local government was undertaken among other objectives to elucidate on concentration levels of air pollutants and their implications on the health of environment and humans. An experiment was conducted during the raining season from August to October, 2018 where gaseous pollutants for selected emission concentration levels of CO, CO₂, NO₂ and SO₂ were obtained from field measurements by the use of a portable air monitoring device; Crowcon (Tetra 3). Readings were obtained after instrument calibration, field calibration and laboratory calibration tests. The results showed that the concentration levels of pollutants: CO, NO₂, and SO₂ were found to range between 0.013-0.093 ppm and 32.0-37.0 ppm for Rumde; 0.015- 23.0 ppm for Demsawo. The results of other wards like Limawa, Gwadabawa, Karewa and Alkalawa had low values of CO, NO₂ and SO₂ emission concentrations. This could be likely due to human population in those areas is low hence less domestic activities resulting in lower levels of air pollutants. Bivariate Pearson's correlation coefficients (r) between traffic and pollutant concentrations were found to be r = 0.758; r = 0.828; r = 0.766 for CO, NO₂, and SO₂. Available results also showed that the concentrations of pollutants (CO, NO₂ and SO₂) were higher in the evening and morning periods but relatively lower during afternoon period. More studies on the movement of these pollutants from dumpsites into the biosphere have been recommended.

Keywords: Emission concentration, dumpsites, gaseous pollutants, crowncon Tetra 3

1 INTRODUCTION

Jimeta-Yola (also called Yola Metropolis) is particular experiencing an increase in per capita vehicle ownership and increased illegal waste disposal sites coupled with an increase in security check spots. This situation is leading to slow flow of traffic and longer times spent in congestions, which in turn increase burning of fossil fuel thereby polluting the air. Although Yola is not an industrialized city, some minor notable industries exist such as Adama Beverages, Adama Plastics, bakeries, packaged water factories, etc, and since most inhabitants used generator sets for alternative power supply in the event of any interruption as well as fire wood for cooking. All this contribute to the resultant atmospheric pollution. The resultant effects of these emissions on human health cannot be overemphasized as several epidemiological studies have found an association between exposure to atmospheric pollutants and adverse health effects, such as the increase in the number of hospitalizations and mortality, novel corona virus disease, and even decrease in life expectancy [1]. To make the situation more complicated, air pollutants which include products of automotive engine combustion such as carbon monoxides (CO), nitrogen dioxides (NO₂), sulphur dioxide (SO₂) and other volatile organic compounds (VOCs) which are primarily hydrocarbons are an important fraction of green-house gases (especially carbon dioxide) which is a major parameter attributed to global warming. Global average temperatures have risen above 0.85°C over the last 10 years with temperatures further projected to increase by an estimated average of 3°C by 2100 to reach

1.8 - 4°C above pre-industrial times [2]. As a result, extreme hot days and warm nights have increased over recent decades and indications suggest that this trend will continue. In addition to the adverse effects of heat exposure from landfills on general population, occupational health and safety is also affected [3]. Workers in industrial sectors such as agriculture, forestry, fisheries and construction are exposed to outside gas emissions, temperatures and solar heat waves load making them vulnerable to the adverse health effects of heat exposure in hot weather. Furthermore, those working in hot indoor environments without air conditioning such as manufacturing, smelting plants, bakeries, laundries, and restaurant kitchens can also be affected by heat cramps, heat syncope, fatigue, heat exhaustion, heat stroke and heat shock are often the well-known and documented adverse direct effects of heat and gaseous pollutants on health [4]. These outcomes have been reported in the occupational setting among others, such as: surface mine workers, agricultural workers and radiation decontamination workers [5]. Therefore, for the benefit of public health and sustainability of the natural functioning of ecosystems it is necessary to carry out a study to determine the contribution of these emissions to air pollution particularly in the study area. The rationale behind this study is that there is increasing concern about occupational and carcinogenic illness, injury and productivity losses due to hot weather in a changing climate. Most of the current understanding appears to relate relatively little regarding injuries from air emission pollutants. This paper sought to elucidate on concentration levels of air pollutants and their implication on the health of environment and humans, describe their aetiological mechanisms in the study area and to provide policy suggestions and further research directions.

2 STUDY AREA

The study was carried out in Yola North Local Government Area of Adamawa State which consists of 11 wards as: Ajiya, Alkalawa, Doubeli, Gwadabawa, Jambutu, Karewa, Limawa, Luggere, Nasaarawo, Runde, and Yelwa. Yola North is located at latitude 10° 25'35'' North and longitude 11° 26'50'' East with relative humidity ranging between 20-30 %. The area lies between the guinea savanna climate zone and annual rainfall of 700 mm with distinct dry and raining seasons [6]. The lower temperature range is from 24-28°C around December to February and high temperature range is 38-48°C around March to May. The experiment was conducted during the raining season from August to October, 2018.

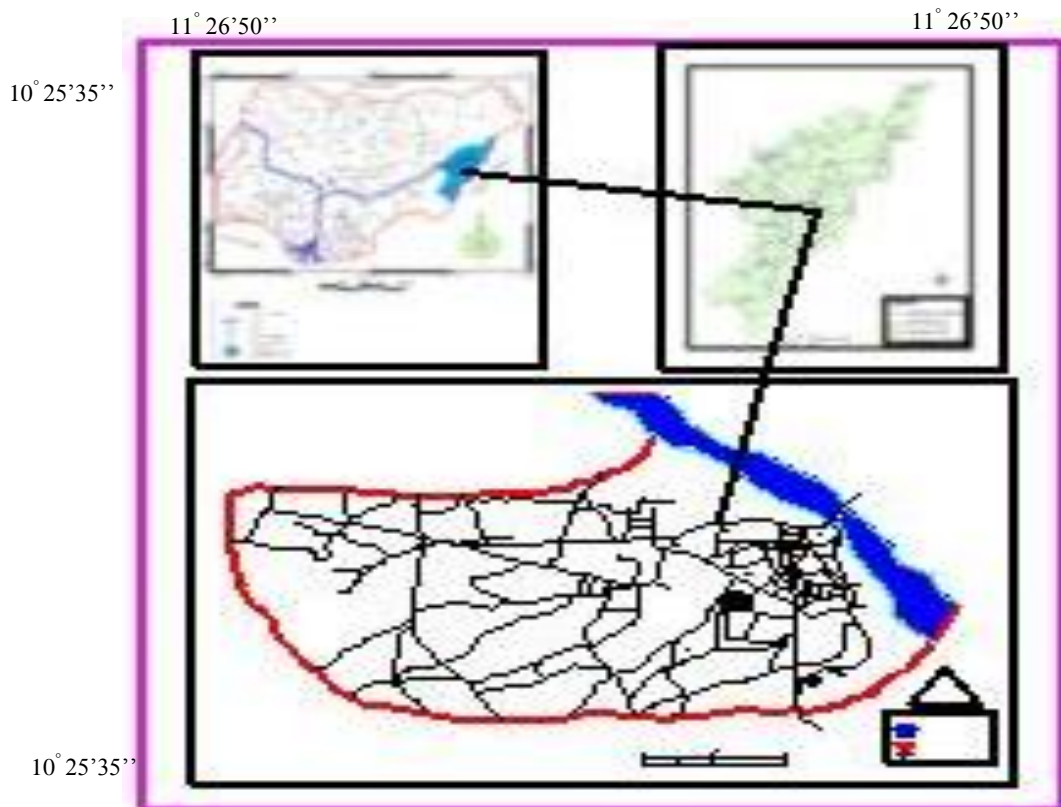


Figure 1: Map of Nigeria showing Adamawa State and the Study Area

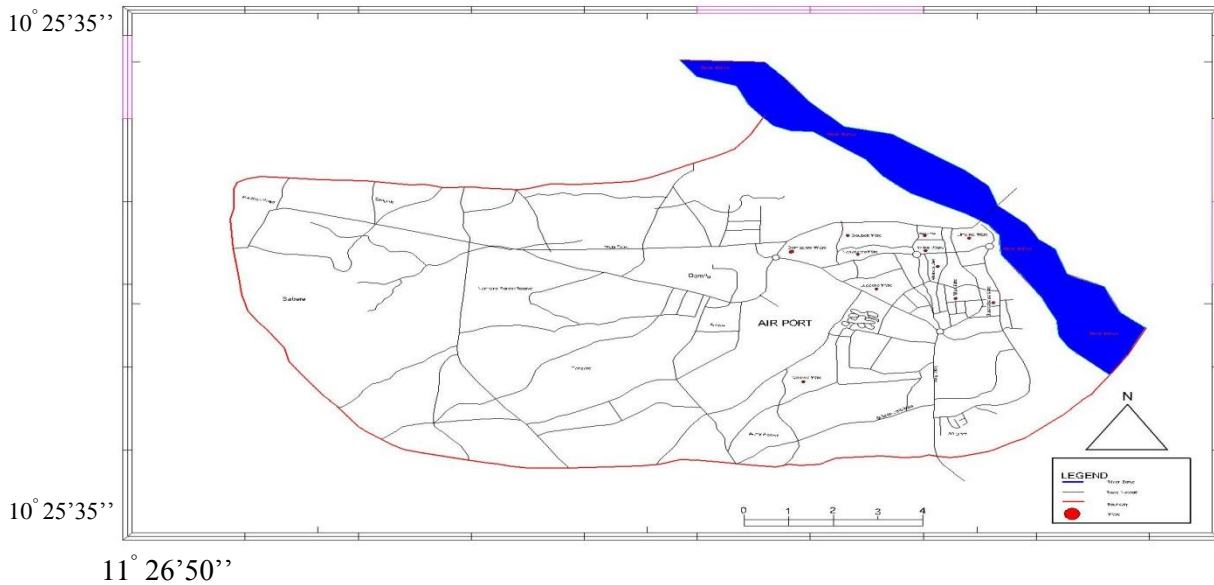


Figure 2. Map of Yola North Local Government Area of Adamawa State (study area)

3 MATERIALS AND METHODS

3.1 Method of Data Collection

Gaseous pollutants and emission levels of CO, CO₂, NO₂ and SO₂ were obtained from field measurements by the use of a portable air monitoring device; Crowcon (Tetra 3) having a model number of IECEX BAS 05.0059 (Figure 3)



Figure 3. Crowcon Tetra 3 (Portable Air Monitoring Device), Source: IECEX BAS, U.K.

Sampling Procedure

Two sampling stations were mapped out namely stations 'A' and 'B'. Station 'A' represents locations with high population density. While station 'B' represents lesser population which served as control station. At station 'A', air samples were measured at four selected locations in each ward. These locations were selected based on their potential high population density and urban land use classification. The air pollutants were measured using Crowcon (Tetra 3), a unique and portable multi-gas monitor for detection of Carbon monoxide (CO), Nitrogen dioxides (NO₂), and Sulphur dioxides (SO₂). It is a portable gas detector with embedded software designed that met the requirements of International Electro-technical Commission (IEC 61508-3) which is the international

standard for electrical, electronic and programmable electronic safety related systems certified by Lloyds Register.

Sampling time

The time frame for data collection from the five sampling points including the control station was carried out concurrently for one month, one week per each sampling point, and three time periods for duration of seven days of a week; from Monday to Sunday at the sampling points. These times were categorized as follows: 7:30 – 9:30 am morning peak hours; 12:30 – 2:30 pm off-peak hours; 4:30 – 6:30 pm evening peak hours. Readings were obtained after 10 minutes from each station.

Instrument Calibration Methods

Gas Test: Tetra 3 unit was switched on and allowed for ten minutes to complete the booting; and to ensure normal operation. The flow plate was then clipped onto the front of the unit and a hose attached from the trigger regulator. The outlet hose was then attached to the 'vent gas away' and the magnet was swiped over the bubble label in the front of the unit, near the main button. Then Tetra 3 began the gas test and showed 'GAS TEST' on the display screen. A countdown progress bar also appeared at the bottom of the display screen. The Trigger regulator was then used to apply gas to the Tetra 3 whilst the progress bar was still counting down. It took thirty to forty five seconds to complete the progress bar. The instrument was then disconnected from the test gas and the unit returned to its normal mode. The unit compared what it measured from the bottle with the standard gas values it knows.

Laboratory Calibration Test

Tetra 3 calibration was performed in the laboratory using the Portable computer software which is equipped with an auto zero function on start-up. This function is configured to operate automatic, on user confirmation. Then a test gas of known composition was applied to verify sensors response and alarm function, this process was repeated three consecutive times to ensure accuracy and eliminate errors before the instrument was taken for field calibration test as required before data collection.

Field Calibration Test

On arrival to the field the Tetra 3 unit was set on zero for 15 minutes before commencing the gas test, for this was the recommended time set by the manufacturer's instructions. The device was then switched on to ensure normal operation. Then the flow plate was clipped onto the front of the unit and the hose was attached from the trigger regulator. The outlet hose was also attached to the 'vent gas away' and the magnet was swiped over the bubble label in the front of the unit, near the main button. Then the device began the gas test and showed 'GAS TEST' on the display. A countdown progress bar also appeared at the bottom of the display. An alternate screen message also beeped up from the display and the button was pressed within 10 seconds to confirm Calibration. Automatic, Tetra 3 began to display a progress bar at the bottom of the screen; the names of the gas sensors fitted appeared in reverse image with a cross beside each. The Trigger regulator was then used to apply gas to the Tetra 3 whilst the progress bar was still counting down. As gas flows Tetra 3 allowed the sensors to respond and then adjusted the value for each gas channel to match the stored calibration gas value within each sensor i-module. Confirmation message beeped up on the display reading 'calibration successful' which means that all channels calibrated successfully within the allowed time. The concentration levels of the gaseous emissions (CO, NO₂, and SO₂) were measured with Crowncon (Tetra 3) digital multi-gas remote monitor and was compared with the safe limits of [7] standards, which are: CO (10- 20 ppm), NO₂ (0.04-0.06 ppm), and SO₂ (0.01-0.1 ppm).

3.2 Method of Data Analysis

Bar charts were plotted to show the variation between the measured emission levels and the safe limits [7]. The total and mean emission levels of these gases for each day were calculated and also represented in tables. This was achieved by using the formula developed by Duncan Multiple Range Test as given below [8]:

$$TEL = EL_s (M + N + E) \tag{1}$$

$$MEL = \frac{EL_s (M + N + E)}{3} \tag{2}$$

Where; TEL = Total Emission Level, EL_s = Emission Levels, MEL = Mean Emission Level
 M = Morning, N = Noon, E = Evening.

The concentration levels of the gaseous emissions measured at the two sampled stations A and B, i.e. the city center and the control station respectively were compared by using the ANOVA (analysis of variance) and DMRT (Duncan Multiple Range Test). This helped to confirm if human activities contributed to air pollution in the study area. Microsoft Excel 2007 and Statistical Analysis Software SPSS (Version 9) were used for statistical analysis.

4 RESULTS AND DISCUSSION

Table 1 shows the average air emission pollutant rates at the eleven sampling points. The results showed that the concentration levels of pollutants: CO, NO₂, and SO₂ measured were found to range between 0.013-0.093 ppm and 32.0-37.0 ppm for Rumde; 0.015 and 23.0 ppm for Demsawo. The results of other wards were also given as can be observed from the table. Some wards like Limawa, Gwadabawa, Karewa and Alkalawa have low values of CO emissions accompanied with very low NO₂ and SO₂ concentrations. This could be likely due to the fact that human population in those areas is low hence less domestic activities resulting in lower levels of air pollutants.

Table 1. Air Emission Concentration Levels at 11 Sampling Points (Wards)

Sampling Points	Average pollutant concentrations per week in parts per million (ppm)								
	CO			NO ₂			SO ₂		
	M	A	E	M	A	E	M	A	E
Rumde	33.0	32.0	37.0	0.093	0.013	0.062	0.060	0.071	0.070
Demsawo	29.1	23.0	31.0	0.055	0.066	0.015	0.072	0.037	0.083
Karewa	3.84	2.42	4.00	0.038	0.092	0.083	0.016	0.062	0.090
Yelwa	19.31	22.44	25.35	0.089	0.018	0.040	0.015	0.035	0.065
Ajiya	14.55	13.35	11.56	0.047	0.011	0.009	0.061	0.008	0.049
Gwadabawa	7.66	8.92	9.86	0.006	0.026	0.048	0.026	0.083	0.038
Alkalawa	5.24	5.68	7.05	0.010	0.063	0.035	0.096	0.017	0.025
Luggere	29.3	31.4	35.4	0.064	0.048	0.097	0.041	0.053	0.050
Nassarawo	15.6	12.5	19.7	0.017	0.069	0.063	0.040	0.016	0.065
Limawa	4.18	3.68	5.91	0.066	0.008	0.037	0.072	0.022	0.0746
Doubeli	21.2	24.6	31.3	0.046	0.073	0.099	0.096	0.041	0.093

Key: M = Morning readings, A = Afternoon readings, E = Evening readings

Plate 1 is one of the sampling landfills at Doubeli ward, Yola (3 m high and 9.3 tons).



Plate 1. Sample of one disposal site at Doubeli Ward, Yola

Carbon Monoxide (CO)

For a good understanding of the data collected, a bar chart was used to illustrate this data for each pollutant type (Figure 4).

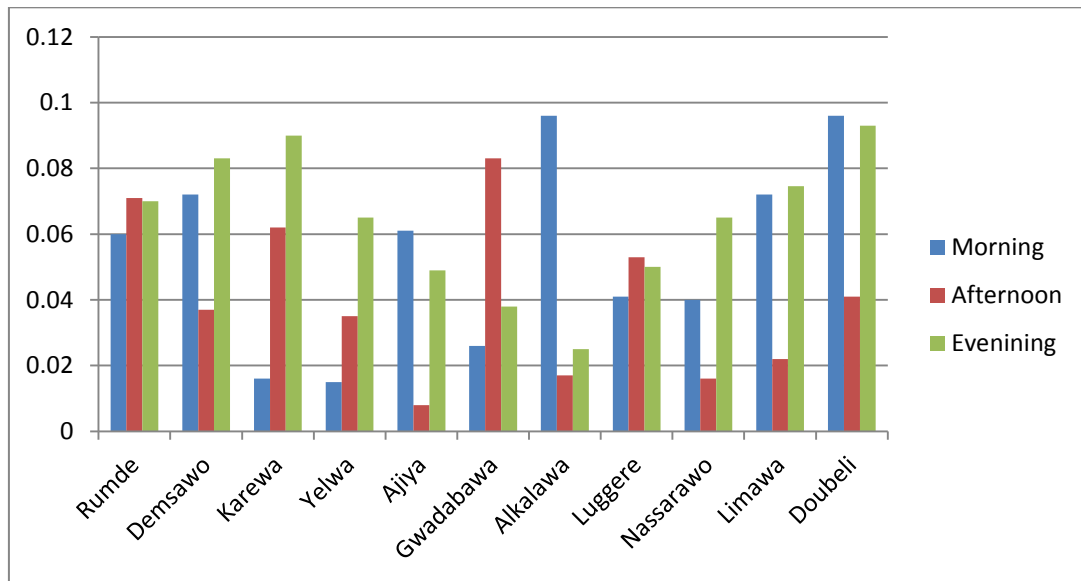


Figure 4. Mean carbon monoxide (CO) levels across periods at the sampling points

From observation of the figure above, it reveals that pollution is usually at its peak in the morning between 7:30 - 9:30 am followed by evening hours of 4:30 - 6:30 pm and finally the afternoon. This is as a result of the fact that most anthropogenic activities such as cooking, burning, driving take place more during morning and evening than in the afternoon. Generally, at all the sampling points the CO variation across the periods revealed that air quality was poor (greater than 20 ppm for NESREA safe limit) at all sampling points with exemption of Karewa, Limawa, Gwadabawa, Alkalawa. This further indicates that the environments around these sampling points are exposed to CO emissions. And it was said that exposure to CO is associated with potential health risk because it reduces the oxygen carrying capacity of blood, which in turn impairs oxygen release into tissue and adversely affects sensitive organs such as the brain and heart.

Nitrogen Dioxide (NO₂)

Figure 5 gives the mean results of nitrogen oxide for morning, afternoon and evening across sampling points.

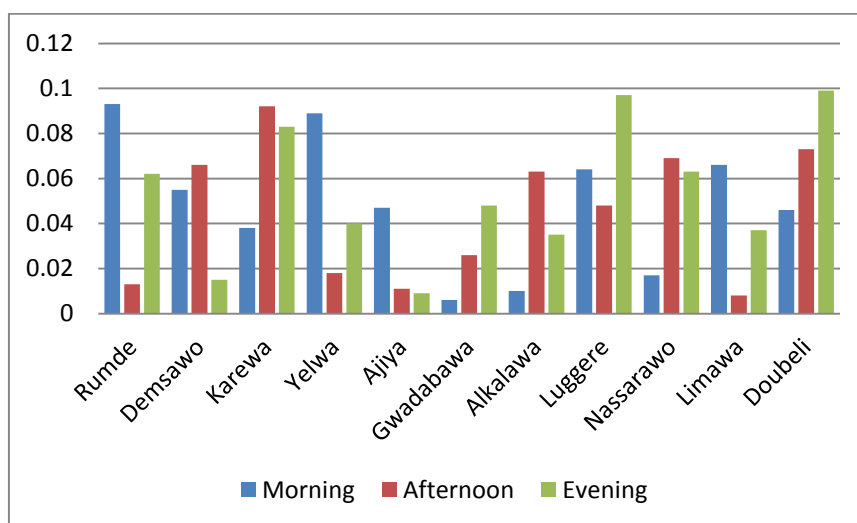


Figure 5. Mean nitrogen oxide (NO₂) levels across periods at sampling points

It was observed from the chart that NO₂ during the evening hours between 4:30 - 6:30 pm for Doubeli, Nassarawo, Gwadabawa, Luggere, Karewa, and Rumde were relatively high while during the morning hours between 7:30 - 9:30 am for Rumde, Demsawo, Yelwa, Luggere and Limawa were also relatively high. This result is a strong indication of consistent domestic activities which leads to NO₂ emissions in these areas. However NO₂ concentration is still within the safe limits set by [9] for NO₂ which is 0.04 - 0.06 ppm.

Sulphur Dioxide (SO₂)

Figure 6 shows daily average of SO₂ concentrations across the periods at sampling points. The results maintain the same pattern as before for carbon monoxide and nitrogen dioxide; that is, high concentrations were more prominent in the morning than evening hours in the sampling points. It was also observed that only Gwadabawa ward had its peak concentration during the afternoon hours which is quite rare but likely due to burning activities during that period.

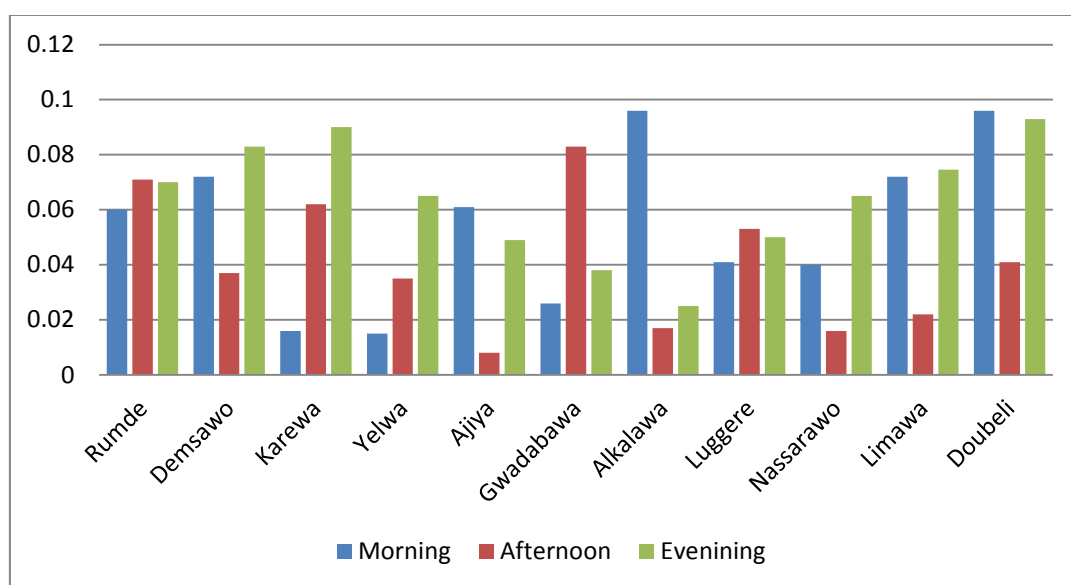


Figure 6. Mean Sulphur dioxide (SO₂) levels across the periods at sampling points

Table 2: Correlations among pollutant concentrations and sampling points

Gaseous pollutants	CO	NO ₂	SO ₂
CO	1		
NO ₂	0.758206**	1	
SO ₂	0.828449**	0.76636**	1

** Correlation is significant at the 0.01 level (2-tailed)

Table 2 shows the degree of relationship between pollutants concentrations across the sampling points. This was examined using Bivariate Pearson’s correlation (r), the correlation coefficient between sampling points and pollutant concentrations was found to be r = 0.758; r = 0.828; r = 0.766 for CO, NO₂, and SO₂ respectively. The result indicated that all variables (CO, NO₂, and SO₂) had a very strong positive correlation with each other at 0.01 and 0.05 significant levels which implied that they tend to be generated simultaneously through same set of activities which agrees with the findings of [9]. Further analysis showed that there was no significant difference in air pollutant concentrations between sampling points. Tables 3, 4 and 5 present the results of analysis of variance for carbon monoxide, nitrogen dioxide and Sulphur dioxide produced.

Table 3. Analysis of Variance Results for Carbon Monoxide (CO)

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	8141.721	10	814.1721	305.5598	2.01E-44	2.007792
Within Groups	146.5489	55	2.664526			
Total	8288.27	65				

Table 4. Analysis of Variance Results for Nitrogen Dioxide (NO₂)

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.010195	10	0.00102	3.583609	0.00104	2.007792
Within Groups	0.015647	55	0.000284			
Total	0.025842	65				

Table 5. Analysis of Variance Results for Sulphur Dioxide (SO₂)

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.010195	10	0.00102	3.583609	0.00104	2.007792
Within Groups	0.015647	55	0.000284			
Total	0.025842	65				

The results in the table showed that there was a significant difference in air pollutant concentrations between sampling points. For CO, p-value is approximately zero and F-calculated value (305.5598) was greater than F-critical (2.007792) making it almost impossible to attain a possibility of no significance. Similar results were obtained for NO₂ and SO₂ which is an indication to reject the hypothesis at 0.01 level of significance.

5 CONCLUSIONS

From the results obtained, it can be concluded that the concentrations of pollutants (CO, NO₂ and SO₂) were higher in the evening and morning periods than afternoon periods. This result also agrees with the findings of other researchers conducted. The study also showed that the levels of CO recorded were high at all the sampling points with exemption of Karewa, Gwadabawa, Alkalawa and Limawa. The highest levels of CO recorded were around Rumde sampling point with concentration value up to 36.59 ppm. Comparing the concentration values of CO at the eleven (11) sampling points, the highest value was observed at the sampling point near Rumde roundabout due to dense population which triggers intense activities as well as high traffic congestion by cars, taxis intra-city commercial buses, trucks and commercial tri-cycles congestions as well as burning of old tires and dumpsites around this area. Throughout the sampling points, the highest levels of SO₂ recorded were still during the evening hours, 0.071 ppm Rumde; 0.075 ppm Karewa; 0.082 ppm Gwadabawa; 0.093 ppm Alkalawa; and 0.09 ppm Doubeli. There was positive significant correlation at 0.01 confidence levels (0.828 and 0.766) between CO, NO₂ and SO₂ during this period. However, the concentration of SO₂ is lower than ranges of 3.21 - 5.18ppm, 7.4 – 15.5 ppm, and 16 – 64 ppm as reported in similar studies.

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