Assessment of Carbon (II) Oxide and Sulphur (IV) Oxide Emissions at Some Selected Traffic Areas in Jos Metropolis, North Central Nigeria

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Abstract: **The concentration levels of Carbon (II) oxide (CO) and Sulphur (IV) oxide (SO_2) were determined using ALTAIR 5X Multigas Detector at seven strategic points in Jos metropolis noted for high traffic activities. This includes Polo roundabout, Hill Station Junction, Old Airport Junction, Zololo Junction-Bauchi road, University of Jos Permanent Site Gate, Faringada Market Road and ECWA Staff Secondary School (control) for a period of one month during morning rush hour (7:30am-8:30am) and off-peak hour (11:40am-12:40pm). For the morning rush hour period, the measured CO and SO_2 concentration level were 32.120ppm and 0.130ppm respectively while measured concentration levels of CO and SO_2 for the off-peak hour were 12.090ppm and 0.057ppm respectively.**
Student t-test statistics comparison of difference in mean in CO and SO_2 levels in the different periods of the day between the sites revealed that they were significant ($p<0.05$). The result revealed that the emission levels of CO and SO_2 in Jos metropolis especially during the morning rush hour (7:30am-8:30am) was higher than the Nigerian Ambient Air Quality Standards accepted safe limits of 10 ppm for atmospheric CO and 0.01 ppm for SO_2. Thus, most of the people doing businesses, commuting along these routes and/or living around these traffic areas are at high risk of inhaling these gaseous pollutants. Environmental management that improves motor traffic flow and control which requires good city road network and creates reliable and efficient mass transport system to reduce the number of vehicles on these spots would greatly ameliorate the emissions and there deleterious effects.

Key words: **CO, SO_2, air pollution, vehicular emission, environment.**

1.0 INTRODUCTION

Clean air is considered to be a basic requirement of human health and well-being. However, air pollution continues to pose a significant threat to health worldwide (WHO, 2005). The rate of pollution most especially in developing nations is at an alarming rate. Air pollution can harm human health, the environment, and cause property damage (Mabahwi et al., 2014). Recent epidemiological studies reveal that air pollutants contribute to increased mortality and hospital admissions. Human health effects can range from nausea and difficulty in breathing or skin irritation, to cancer (Kampa and Castanas, 2008).

Vehicular emissions are one of the leading causes of air pollution. Traffic congestion increases vehicle emissions and degrades ambient air quality (Zhang and Batterman, 2014). Exhausts from engines contain all kinds of pollution, notably particulates (soot of various sizes), carbon monoxide (CO, a poisonous gas), nitrogen oxides (NOx), volatile organic compounds (VOCs), and lead (Woodward, 2010). In fact, Mohammed and Caleb (2014) observed that concentration of toxic gases emitted from the exhaust pipes of vehicles is a major health concern for the residence of Kaduna metropolis. This is also corroborated by Sikirulahi and Salami (2013), who observed that emission of CO and SO_2 as a greenhouse gas has been contributing to environmental problems in Niger State.

Sulphur dioxide (SO_2) reacts with the moisture content in the nose, nasal cavity and throat and, in this way, it destroys the nerves in the respiratory system and harms human health. When the SO_2 concentration is higher than the World Health Organization (WHO) standards, it negatively affects especially those with asthma, bronchitis, cardiac and lung problems (Öztürk, 2005). Traffic emissions impact highly on the CO levels in Enugu urban (Ngele, 2014). The high Carbon monoxide concentrations in urban areas are associated with health problems in the cities (Ariko et al., 2014). CO has negative effects on infant health both before and after birth (Curie et al., 2009). People suffer from vehicular emission related diseases such as headaches, loss of vision, forgetfulness and fatigue (Osuntogun and Koku, 2007). It was also found by Bayram et al., (2006) that these emissions increases the risk of acute respiratory tract diseases especially in children and that it causes an increase in cardio respiratory morbidity and mortality.

The level of these gaseous pollutants in Jos metropolis has become so great due to the poor road network and the increase in the influx of vehicles to the city. This has often led to major traffic congestions most especially in the early hours (7:00 - 9:00am) of the day and around 4:00 – 5:30pm in the evening. Hence the need to carryout ambient monitoring of the areas where traffic congestions are endemic within Jos metropolis in order to ascertain the potential impact of these emissions to both human and public health.

In this study, the concentrations of carbon (II) oxide and sulphur (IV) oxide were continuously monitored in selected traffic sites in Jos metropolis and assessed for morning rush hour (7:30am-8:30am) and off-peak hour (11:40am-12:40pm) and also compared to the National Ambient Air Quality Standards.

2.0 MATERIALS AND METHODS

Jos is the capital of Plateau State in North Central Nigeria. The city is located at 9°56' N 8°53' E with an elevation of about 1238m. Jos is the most densely populated area in Plateau State, Nigeria (900,000 inhabitants as of the 2006 population census estimate) (www.wikipedia.com/jos). Jos City hosts many industrial sites such as steel, brewery, textile, smelting. It also includes power plant and experiences some of the state heaviest road traffic. It enjoys a more temperate climate than much of the rest of Nigeria. The State is characterized by landscape of undulating highlands and peaks like the famous Shere Hill over 4829 meters above sea level (Mafuyai et al., 2014).

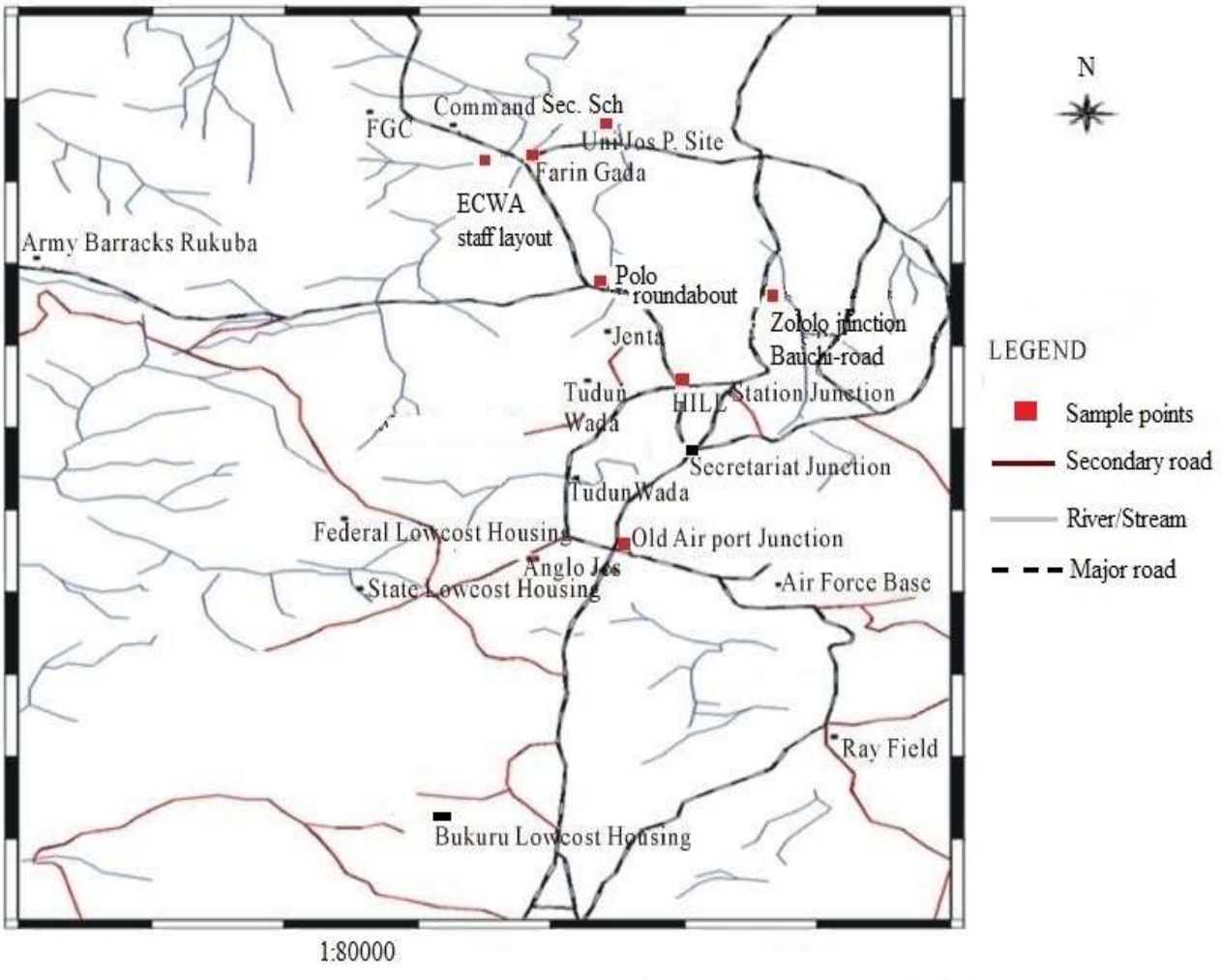

Figure 1: Map of Jos showing study areas

2.1 Sites selection and description

The seven sites were selected to suit the objective of this study. These are commercial and residential (control area). In these sites, there are high volumes of commercial activities which necessitate high traffic flow except for the control area where these are abysmally low. The main source of air pollution is vehicular traffic emissions. The magnitude of this pollution may be due to poor combustion as a result of older and poorly maintained vehicles that are almost completely devoid of catalytic converters and fuelled almost entirely with leaded petrol (Oucher and Kerbachib, 2012). Other minor sources include electric generators being operated in the commercial and residential areas and dump site fires (Mohammed and Caleb, 2014., Rim-Rukeh, 2014). The main route for transportation of people to the market (Faringada Market), the University of Jos (the largest academic institution in the city) and the Terminus Market through Zololo Junction is densely characterized by high volume of traffic activities. Also, another route that hosts much vehicular activities is Zaria Road, terminating at Polo Roundabout. This road has a great traffic influx where congestion readily takes place. This route leads to the Hill Station Junction and Old Airport junction. Table 1 show the locations and elevations of these sites.

Table 1: Study sites and description

1	A (commercial)	Site 1	Polo Roundabout	Elevation: 1166m N 09° 55'45.1" E 008° 52' 28.9"	Located in a 3-way roundabout, several shops, plazas and offices, eatery, 1filling station, 3 bus stations, polo field.
2	B (commercial)	Site2	Hill station junction	Elevation: 1226m N 09° 54'35.0" E 008° 52' 54.5"	Located in a 4-way roundabout, offices, 1 plaza, Hill station hotel, JTF (Joint Task Force) headquarters Jos.
3	C (commercial)	Site 3	Old airport junction	Elevation: 1299m N 09° 52'36.1" E 008° 52' 24.0"	Old air port junction: located in a 3-way roundabout, plazas, offices, shops, 3 bus stations, a tricycle Park, NASCO group of companies (NASCO pack, foods, household and fibre).
4	D (residential)	Site 4	Zololo junction - Bauchi road	Elevation: 1189m N 09° 55'43.2" E 008°53' 31.73"	Located at a t-junction, residential houses, and shops.
5	E (commercial)	Site 5	The Permanent Site of University of Jos (Gate)	Elevation: 1146m N 09° 57' 31.2" E 008° 52' 55.6"	Shops, 3 filling stations, moderate traffic mostly private cars and tricycles.
6	F (commercial)	Site 6	Market road – Farin gada	Elevation: 1123m N 09°57' 28.9" E 008° 51'53.7"	1 secondary school, 4 filling stations, shops, 1 bank, 1 church, busy road side market, high traffic.
7	G (control)	Site 7	ECWA staff layout	Elevation: 1146m N 09° 57'02.2" E 008° 51' 09.3"	ECWA staff secondary school, residential houses, no traffic, quiet and serene environment with trees.

2.2 Monitoring Procedures

ALTAIR 5X Multigas Detector which is specific for measurement of a particular gas was employed to measure CO and SO_2. The equipment was positioned in the direction of the prevailing wind by holding at about 1.5m above the ground. This detector was handheld at some notable Junctions described in Table 1 for an average of 10-15 minutes in order to obtain emissions (CO and SO_2) at regular intervals. Monitoring was carried out for about 2 hours for

morning rush hours (7:30am-9:30am) for the seven sites and another 2 hours from 11:40am – 1:40pm for the off-peak hour. The monitoring was carried out for five days in November, 2015.

3.0 DATA ANALYSIS

The monitored data of CO and SO_2 was analysed using descriptive statistics to obtain the mean and standard deviation for both morning rush hour and off-peak hour. The daily mean morning rush hour and off-peak hour and overall average for the one month period were also computed. Student t-test for difference in mean between morning rush hour and off-peak hour among the sites was also computed.

4.0 RESULTS AND DISCUSSION

The results obtained for all the monitoring points are presented below in tables 2 to 6 respectively.

4.1. Daily Mean Concentrations of Pollutants.

Table 2: Daily Mean concentrations of CO and SO_2 for Monday (2.11.2015); Week 1

Sample points	Morning rush hour CO(ppm)	Off-peak hour CO(ppm)	Morning rush hour SO_2(ppm)	Off-peak hour SO_2(ppm)
Polo roundabout (A)	16.444	7.727	0.111	0.009
Hill station junction (B)	16.857	7.333	0.086	0.011
Old airport junction (C)	58.769	16.846	0.392	0.100
Zololo junction-Bauchi road (D)	27.538	9.000	0.146	0.000
Unijos p.site (E)	22.375	13.273	0.113	0.027
Faringada market road (F)	38.600	22.050	0.190	0.095
Mean	**30.097**	**12.705**	**0.173**	**0.040**

Table 3: Daily Mean concentrations of CO and SO_2 for Monday (9.11.2015); Week 2

Sample points	Morning rush hour CO(ppm)	Off-peak hour CO(ppm)	Morning rush hour SO_2(ppm)	Off-peak hour SO_2(ppm)
Polo roundabout (A)	56.150	7.636	0.255	0.009
Hill station junction (B)	15.750	6.083	0.083	0.000
Old airport junction (C)	26.143	7.727	0.243	0.009
Zololo junction-Bauchi road (D)	17.444	12.500	0.094	0.010
Unijos p.site (E)	15.643	10.200	0.050	0.010
Faringada market road (F)	18.000	12.000	0.145	0.009
Mean	**24.855**	**9.358**	**0.145**	**0.008**

Table 4: Daily Mean Concentration of CO and SO_2 for Monday (16.11.2015); Week 3

Sample points	Morning rush hour CO(ppm)	Off-peak hour CO(ppm)	Morning rush hour SO_2(ppm)	Off-peak hour SO_2(ppm)
Polo roundabout (A)	82.750	8.400	0.190	0.050
Hill station junction (B)	101.125	7.538	0.400	0.008
Old airport junction (C)	55.261	10.000	0.283	0.107
Zololo junction-Bauchi road (D)	12.000	36.375	0.013	0.200
Unijos p.site (E)	11.417	22.909	0.025	0.268
Faringada market road (F)	25.611	11.632	0.044	0.137
Mean	**48.027**	**16.142**	**0.159**	**0.128**

Table 5: Daily Mean Concentration of CO and SO_2 for Monday (23.11.2015); Week 4

Sample points	Morning rush hour CO(ppm)	Off-peak hour CO(ppm)	Morning rush hour SO_2(ppm)	Off-peak hour SO_2(ppm)
Polo roundabout (A)	29.040	12.167	0.004	0.067
Hill station junction (B)	22.053	11.231	0.000	0.023
Old airport junction (C)	32.130	10.800	0.013	0.047
Zololo junction-Bauchi road (D)	19.533	9.438	0.013	0.031
Unijos p.site (E)	5.364	8.125	0.018	0.006
Faringada market road (F)	44.880	9.167	0.204	0.125
Mean	**25.500**	**10.155**	**0.042**	**0.050**

Table 6: Overall average of pollutants CO and SO_2

DAYS	Morning rush hour CO (ppm)	Off-peak hour CO(ppm)	Morning rush hour SO_2 (ppm)	Off-peak hour SO_2(ppm)
Monday 2.11.15 week 1	30.097	12.705	0.173	0.040
Monday 9.11.15 week 2	24.855	9.358	0.145	0.008
Monday 16.11.15 week 3	48.027	16.142	0.159	0.128
Monday 23.11.15 week 4	25.500	10.155	0.042	0.050
Overall average	**32.120**	**12.090**	**0.130**	**0.057**

NOTE: ECWA staff layout (control area) did not appear on tables 2-5 because it had zero reading throughout the time of this analysis as it had little or no activity of sort constituting to air pollution

4.2 Results of student's t-test variation between morning rush hour and off-peak hour for the different study sites.

The results of student's t-test variation show definite contrast between the morning rush hour and off-peak hour for the selected monitoring sites are presented in tables 7- 10.

Table 7a: Student's t-test for Monday Monitored Data (2.11.2015); Week 1

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Morning rush hour CO (ppm)	6	30.09717	16.262007	6.638937
Off-peak hour CO (ppm)	6	12.70483	5.867971	2.395589
Morning rush hour SO_2 (ppm)	6	0.17300	0.113130	0.046185
Off-peak hour SO_2 (ppm)	6	0.04033	0.045156	0.018435

Table 7b: One-Sample Test for Monitored Data for Monday, Week 1

	Mean Difference	95% Confidence Interval of the Difference	
		Lower	Upper
Morning rush hour CO (ppm)	30.097167	13.03124	47.16310
Off-peak hour CO(ppm)	12.704833	6.54678	18.86289
Morning rush hour SO_2 (ppm)	0.173000	0.05428	0.29172
Off-peak hour SO_2 (ppm)	0.040333	-0.00706	0.08772

Table 8a: Student's t-test for Monday Monitored Data (9.11.2015); Week 2

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Morning rush hour CO (ppm)	6	24.8550	15.81589	6.45681
Off-peak hour CO (ppm)	6	9.35767	2.604318	1.063208
Morning rush hour SO_2 (ppm)	6	0.14500	0.086225	0.035201
Off-peak hour SO_2 (ppm)	6	0.00783	0.003869	0.001579

Table 8b: One-Sample Test for Monday Monitored Data (9.11.2015); Week 2

	Mean Difference	95% Confidence Interval of the Difference	
		Lower	Upper
Morning rush hour CO (ppm)	24.85500	8.2572	41.4528
Off-peak hour CO (ppm)	9.357667	6.62460	12.09073
Morning rush hour SO_2 (ppm)	0.145000	0.05451	0.23549
Off-peak hour SO_2 (ppm)	0.007833	0.00377	0.01189

Table 9a: Student's t-test for Monday Monitored Data (16.11.2015); Week 3

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Morning rush hour CO (ppm)	6	48.0273	37.99508	15.51142
Off-peak hour CO (ppm)	6	16.142	11.3772	4.6447
Morning rush hour SO_2 (ppm)	6	0.1592	0.15932	0.06504
Off-peak hour SO_2 (ppm)	6	0.1283	0.09570	0.03907

Table 9b: One-Sample Test for Monday Monitored Data (16.11.2015); Week 3

	Mean Difference	95% Confidence Interval of the Difference	
		Lower	Upper
Morning rush hour CO (ppm)	48.02733	8.1539	87.9007
Off-peak hour CO (ppm)	16.1423	4.203	28.082
Morning rush hour SO_2 (ppm)	0.15917	-0.0080	0.3264
Off-peak hour SO_2 (ppm)	0.12833	0.0279	0.2288

Table 10a: Student's t-test for Monday (23.11.2015); Week 4

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Morning rush hour CO (ppm)	6	25.5000	13.30427	5.43145
Off-peak hour CO (ppm)	6	10.15467	1.498871	.611912
Morning rush hour SO_2 (ppm)	6	.04200	.079637	.032512
Off-peak hour SO_2 (ppm)	6	.04983	.042306	.017271

Table 10b: One-Sample Test for Monday (23.11.2015); Week 4

	Mean Difference	95% Confidence Interval of the Difference	
		Lower	Upper
Morning rush hour CO (ppm)	25.50000	11.5380	39.4620
Off-peak hour CO (ppm)	10.154667	8.58170	11.72764
Morning rush hour SO_2 (ppm)	0.042000	-0.04157	0.12557
Off-peak hour SO_2 (ppm)	0.049833	0.00544	0.09423

4.3 Range of Results

The range of mean concentration of CO for morning rush hour and off peak hour are presented in table 2 as 16.444 – 58.769 (ppm) and 7.333 – 22.050 (ppm) respectively for day 1 monitoring while the range of concentration of mean SO_2 for morning rush hour and off peak hour for the same day are also presented in table 2 as 0.086 – 0.392 (ppm) and 0.000 – 0.100 (ppm) respectively.

The range of mean concentration of CO levels for day 2 monitoring for morning rush hour and off peak hour were 15.643 – 56.150 (ppm) and 6.083 – 12.500 (ppm) as presented in table 3 while that of SO_2 for both morning rush hour and off-peak hour were 0.050 – 0.255 (ppm) and 0.000 – 0.010 (ppm) respectively as presented in table 3.

Furthermore, the range of mean CO concentration levels for day 3 monitoring , for morning rush hour and off peak hour were 11.417 – 101.125 (ppm) and 7.538 – 36.375 (ppm) respectively as presented in table 4 while that of SO_2 for both morning rush hour and off-peak hour were 0.013 – 0.400 (ppm) and 0.008 – 0.268 (ppm) respectively as presented in table 4.

The day 4 monitoring had CO concentration ranges of 5.364 – 44.880 (ppm) and 8.125-12.167 (ppm) respectively for morning rush hour and off peak hour as shown in table 5 while the mean SO_2 concentration levels for the same day for both morning rush hour and off peak hour were 0.000 – 0.204 (ppm) and 0.006 – 0.125 (ppm) respectively as presented in table 5.

4.4 Results Analysis

The highest mean level of CO concentration (101.125 ppm) during morning rush hour was recorded at hill station on Monday 16.11.15 on day 3 as presented in table 4 and the least level (5.364 ppm) was recorded at University of Jos Permanent Site main gate in day 4 as presented in table 5 while the highest mean level CO concentration (36.375 ppm) during off-peak hour was recorded at Zololo junction-Bauchi road on day 3 as presented in table 4 and the least (6.083 ppm) was recorded at Hill Station Junction on day 2 also as presented in table 3.

On its part, the highest mean concentration level (0.400 ppm) of SO_2 for morning rush hour was recorded at Hill Station Junction on day 3 as shown in table 4 and the least (0.000 ppm) was recorded at Hill Station Junction on day 4 as shown in table 6.

However, assessing the concentration level of SO_2 reveals these; the highest mean concentration level (0.268 ppm) was recorded for off-peak hour at the Permanent Site University of Jos on day 3 as presented in table 5 and the least (0.000 ppm) was recorded at Zololo Junction on Bauchi road on day 1 as presented in table 3 and Hill Station Junction on day 2 as presented table 4 respectively.

From the overall average as seen on table 6, it is observed that the morning rush hour concentration of the selected pollutants (CO and SO_2) were relatively high compared to the 10.00ppm and 0.01ppm limit stipulated by the National Ambient Air Quality Standards (NAAQS) for CO and SO_2 respectively. This could be attributed to the increase in traffic volume since the monitoring was deliberately carried out on working days where there were beehive of transport activities due to the concentration of vehicles; workers and commuters hurried to resume work or went about their daily businesses. However, evaluating the trend of daily variation of these pollutants reveal that the concentration of pollutants during the off-peak hour is lower than that monitored during the morning rush hour. This could be due to the conventional daily transport pattern in the selected areas monitored and generally in Jos Metropolis; during the off peak hour (between 11.40am-2.40pm), there is general reduction in traffic build-up in the residential area and commercial areas as most people especially car owners are at their places of work and the students are in their classes.

The concentration of the control area was consistently unchanged for both morning rush hour and the off-peak hour, due to minimal traffic activity in this area regardless of time.

The mean and standard error for CO concentration for morning rush hour for week 1 are presented in Table 7. In this table, the mean and standard error are 30.1±6.6ppm and 12.7±2.4ppm for morning rush hour and off-peak hour respectively for CO while the mean and standard error for SO_2 are 0.17±0.05ppm and 0.04±0.02ppm for morning rush hour and off-peak hour respectively.

The mean and standard error for CO concentration for morning rush hour and off-peak hour are 24.9±6.5ppm and 9.4±1.1ppm respectively for week 2 while the morning rush hour and off-peak hour for SO_2 are 0.15±0.04ppm and 0.007±0.002ppm respectively.

For week 3, the mean and standard error for CO concentration for both morning rush hour and off-peak hour are 48.0±15.5ppm and 16.1±4.6ppm respectively while that of SO_2 for week 3 for both morning rush hour and off-peak hour are 0.16±0.07ppm and 0.13±0.04ppm respectively. The mean and standard error for CO concentration for both morning rush hour and off-peak hour for week 4 are 25.5±5.4ppm and 10.2±0.6ppm respectively while that of SO_2 for morning rush hour and off-peak hour are 0.04±0.03ppm and 0.05±0.0.2ppm respectively.

Again, the comparative analysis of the overall mean and standard deviation of CO and SO_2 show that the morning rush hour has higher concentration of the pollutants than the off-peak hour and the concentrations of pollutants measured are higher in the commercial areas than the control area. An environmental impact assessment of these sites reveals that the vehicular emissions sampled at these selected sites are hazardous to both human and public health based on the National Ambient Air Quality Standards.

The student's t-test for difference in mean between the different day periods in the different sites shows that the level of CO and SO_2 is statistically significant ($p < 0.05$). This is consistent with the observed nature of the sites which is characterized by high traffic volume (Ngele, 2014).

5. CONCLUSION

Vehicular traffic emissions contribute adversely to the pollution of the environment by reducing the quality of air. Result of this study shows that vehicular emission related pollution in the city of Jos is significant and need to be monitored. The quality of air will deteriorate as the city continues to grow which will result in possible severe health consequences. Residents and commuters in Jos who do their businesses or live along high traffic roads are at risk. Most of such people are exposed to vehicular pollution for several hours every day. The result provided in this study shows that the morning rush hour has higher concentration of the pollutants (CO and SO_2) than the off-peak hour.

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