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Variation of Carbon Monoxide (CO) Levels in Enugu-a Comparison of High Traffic and Industrial Sites Measurements

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ABSTRACT: *This study assessed the day-time variation of carbon monoxide, CO in two sites in Enugu (a high traffic, site 1 and a low traffic/industrial area, site 2) using VRAE programmable multi-gas monitor. The results showed variation of CO concentration with the period of the day (morning, afternoon and evening), weekday and weekend and between the two sites. The CO levels measured in the evening period (4.30-6.00 pm) were relatively higher than that of the other periods; similarly site 1 values were higher than that of site 2. Student t-test statistics comparison of pair-wise difference in mean in CO levels in the different periods of the day between sites 1 and 2revealed that they were significant($p<0.05$).Also analysis of variance(ANOVA) for difference in mean of CO levels at the different day periods within each site showed a significant difference ($p<0.05$).Homogeneity test of the CO means for the different day periods in each site using Duncan multiple mean comparison test showed that the mean for the evening is statistically significant from that of the other periods($p<0.05$) .The CO levels were generally within the WHO 8hours guideline limit of 9ppm at the time of the study but was found to approach this value in 33% of the evening periods in site 1.*

KEYWORDS*: carbon monoxide, high traffic site, industrial site, comparison, RAE gas monitor.*

I. INTRODUCTION

Carbon monoxide, CO is a colourless, odourless, tasteless gas with low reactivity and solubility in water. In terms of absolute concentration, CO is the most prevalent of the toxic air pollutants hence it is measured in the unit of milligram per cubic meter (mg/m^3) in contrast to lesser units such as microgram per cubic meter ($\mu g/m^3$) used for other pollutants. The global background level of CO ranges between 0.05 and 0.15 ppmv (0.06 and 0.17mg/m^3) [1]

Ambient air levels of CO in urban cities in Nigeria and elsewhere has been reported in literature [2-5]. Reported levels of CO in a Nigerian urban city (Akure) indicated that WHO 8-hours mean was exceeded in some sites throughout the week during the day time except on Sundays and levels about four times higher than that of rural sites were recorded[6] . In another Nigerian site (Kaduna) Arko *et al* [7] reported that the CO 8-hours means value was exceeded on daily basis in the evening period in contrast to the control site. Several studies on CO levels in Nigerian urban sites showed that CO concentrations in the cities exhibited distinct diurnal and day of week variation with respect to traffic rush hours [6, 4, 8]. The sources of CO in the ambient air comes from both natural activities such as volcanic eruptions biogenic processes and human activities such as combustion of fossil fuel in motor engines and in power generation facilities, combustion of solid waste in dumpsites, agriculture activities, bush burning, industrial activities.

Mechanisms that emit CO into the air have been categorized into two namely direct emissions of CO from different sources and chemical formation from other pollutants such as oxidation of methane and other hydrocarbon [1].
Also draft 5.2 version CO position paper to European commission[9] reported that about 44 million tons of CO was emitted into the air by EU countries in 1994 noting transport to be the largest sources and to have accounted for two-third of the CO emissions.

The effect of CO on human blood haemoglobin is well known [10] as it has higher affinity for the haemoglobin relative to oxygen forming carboxyhaemoglobin. Hence in the presence of CO especially at high

concentration, the oxygen carrying capacity of the blood is reduced. Acute exposure to CO could lead to heart attack as the highly oxygen demanding organs and tissues of the body such as the heart and brain are deprived of enough oxygen they needed to function. World Health Organization (WHO) has recommended that carboxyhaemoglobin level of 2.5% should not be exceeded and has adopted four guideline for the maximum CO concentration exposure as follows: 100 mg/m^3 for 15 minutes, 60mg/m^3 for 30 minutes, 30mg/m3 for 1 hour and 10 mg/m3 (9pmm)for 8 hours[9]

The indirect effect of CO on the environment has also be noted to include increase in CO_2 and ozone levels due to its reactions in the atmosphere thereby indirectly aiding global warming (CO_2) and damage (from ozone) to materials in the environment[9].

The objective of this study therefore is to assess the level of the CO in the two sites (high traffic site and industrial sites and also compare the level (in the day-time) of the two sites among themselves and with the WHO 8-hours average.

II. MATERIALS AND METHODS

The study area: Enugu, the study area is located in the South Eastern Nigeria. Enugu is capital of the defunct East Central State of Nigeria and is known for coal deposit and production before the advent of crude oil.

It is located between latitude $6^0 22'$ N and $6^0 38'$ N and longitude $7^0 28'$ E and $7^0 37'$ E [11].
Enugu has tropical climatic conditions with two distinct seasons namely dry season and wet season. Dry season usually starts from December and last till March while wet season starts from April to November. Enugu urban has a population of 722, 664 and population density of 6,400/km^2 [12].

Site selection and description

The two stations or sites were selected to suit the objective of the study.
Site I is located in a 3-way round about, adjacent to Ogbete main market, three motor parks, Enugu North Local Government secretariat and Banks and located in a built-up area. The GPS coordinates of site 1 is N$06^0$26.326' E$007^0$29.241' while that of site 2 is N$06^0$28.106' E$007^0$36.122'. Site 2 is located in out-skirt of the city, close to a high way and is within an industrial layout. Industries in the layout include Emenite Nig Ltd, Innoson tech industries Ltd, Juhel Nig Ltd, Adris-hydrometers, Tarry well Nig Ltd, Obika Industries Ltd, ANAMCO Nig Ltd, Sologi Company Ltd, St. John Aluminum Company, Intercolour Nig Ltd, Intencil Company, El-Shadai Aluminum, ALO-Aluminum, Niger steel company. Other facilities close to site 2 that can impact on the air quality in the site include NNPC depot and the Akanu Ibiam International Airport.

Sampling of the CO

The CO level in each of the two sites was measured simultaneously using portable VRAE programmable multi gas monitor model PGM7840 REV.E by standing the monitor at a height of about two meters above the ground level. The monitoring involves obtaining morning, afternoon and evening daily average levels of CO in the two sites from 2nd January to 31st January 2009 (30 days monitoring). The morning, afternoon and evening average measurements for each day was obtained from the monitor's thirty minutes logged intervals recording between 7.30-9.00am, 1.00-2.30pm and 4.30 – 6.00pm for morning, afternoon and evening measurements respectively as downloaded into computer from the monitor's data logged computer communication port..

III. DATA ANALYSIS

The data fed into computer was analyzed using social science statistical software (SPSS) version 10 for morning, afternoon and evening mean for each day. The daily mean, morning, afternoon and evening average for the month (January) was also computed. Student t-test for difference in mean between the two sites was also computed and analysis of Variance (ANOVA) was computed for the morning, afternoon and evening mean of each site.

IV RESULTS AND DISCUSSION

Table 2A: The Results of the student's t-test variation between sites 1 and sites 2 among periods of the day

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
VALUE1	MORNING	30	4.5200	1.02769	.18763	3.00	7.00
	NOON	30	4.1267	1.02417	.18699	2.00	6.00
	EVENING	30	6.3733	1.69073	.30868	3.50	10.00
	Total	90	5.0067	1.60867	.16957	2.00	10.00
VALUE2	MORNING	30	.3400	.14527	.02652	.10	.60
	NOON	30	.2667	.09589	.01751	.10	.40
	EVENING	29	.6172	.25644	.04762	.30	1.20
	Total	89	.4056	.23177	.02457	.10	1.20

N/B: value1 and 2 = Sites 1 and 2 respectively.
B: Analysis of variance of mean within sites among the periods of the day

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
VALUE1	Between Groups	86.371	2	43.185	26.101	.000
	Within Groups	143.945	87	1.655		
	Total	230.316	89			
VALUE2	Between Groups	2.007	2	1.004	31.730	.000
	Within Groups	2.720	86	.032		
	Total	4.727	88			

C: The Duncan tests for homogeneity of mean within sites

VALUE1

Duncan

SOURCE	N	Subset for alpha = 0.05	
		1	2
NOON	30	4.1267	
MORNING	30	4.5200	
EVENING	30		6.3733
Sig.		.240	1.000

VALUE2

Duncan

SOURCE	N	Subset for alpha = 0.05	
		1	2
NOON	30	.2667	
MORNING	30	.3400	
EVENING	29		.6172
Sig.		.116	1.000

Table 1: Day time variation of CO levels (ppm) in sites 1 and 2 in Enugu

CHRIST/OGBETE ROUNDABOUT ENUGU (SITE 1)						ITF JUNCTION EMENE ENUGU (SITE 2)				
DAY	MORNING MEAN	AFTERNOON MEAN	EVENING MEAN	DAILY MEAN	STANDARD DEVIATION	MORNING MEAN	AFTERNOON MEAN	EVENING MEAN	DAILY MEAN	STANDARD DEVIATION
FRI-2-09	6	4.5	7	5.833333	1.258306	0.4	0.3	0.6	0.433333	0.152753
SAT-3	5	5	9	6.333333	2.309401	0.3	0.3	0.7	0.433333	0.23094
SUN-4	3	2	4	3	1	0.2	0.1	0.4	0.233333	0.152753
MON-5	7	5	10	7.333333	2.516611	0.6	0.4	1	0.666667	0.305505
TUE-6	5	4	6	5	1	0.3	0.2	0.5	0.333333	0.152753
WED-7	6	3.5	5.5	5	1.322876	0.4	0.3	0.6	0.433333	0.152753
THUR-8	4.6	5.8	7	5.8	1.2	0.3	0.2	0.6	0.366667	0.208167
FRI-9	5.5	6	8	6.5	1.322876	0.4	0.3	0.8	0.5	0.264575
SAT-10	5	5.5	7.6	6.033333	1.379613	0.5	0.3	1.2	0.666667	0.472582
SUN-11	3.4	2.9	3.7	3.333333	0.404145	0.2	0.1	0.3	0.2	0.1
MON-12	4.8	5.6	8.5	6.3	1.946792	0.6	0.4	0.9	0.633333	0.251661
TUE-13	4.2	4.7	6	4.966667	0.929157	0.3	0.3	0.5	0.366667	0.11547
WED-14	4.5	3.8	5.6	4.633333	0.907377	0.2	0.2	0.4	0.266667	0.11547
THUR-15	4	3.5	5.8	4.433333	1.209683	0.3	0.2	0.6	0.366667	0.208167
FRI-16	3.5	3.3	6.2	4.333333	1.619671	0.4	0.4	0.8	0.533333	0.23094
SAT-17	4.8	4.1	7.2	5.366667	1.625833	0.2	0.3	1	0.5	0.43589
SUN-18	3.1	2.9	3.5	3.166667	0.305505	0.4	0.1	0.5	0.333333	0.208167
MON-19	5.7	5.3	6.9	5.966667	0.832666	0.3	0.3	0.7	0.433333	0.23094
TUE-20	3.8	3.4	5.9	4.366667	1.342882	0.2	0.2	0.4	0.266667	0.11547
WED-21	4.8	4.2	6	5	0.916515	0.3	0.2	0.3	0.266667	0.057735
THUR-22	4.1	3.9	5.8	4.6	1.044031	0.2	0.2	0.4	0.266667	0.11547
FRI-23	4.9	4.5	6.7	5.366667	1.171893	0.3	0.4	1.1	0.6	0.43589
SAT-24	5.1	4.8	8.9	6.266667	2.285461	0.6	0.4	0.9	0.633333	0.251661
SUN-25	3	2.8	4.1	3.3	0.7	0.5	0.1	0.3	0.3	0.2
MON-26	5.2	4.6	7.8	5.866667	1.70098	0.1	0.3	0.7	0.366667	0.305505
TUE-27	3.5	3.2	5.6	4.1	1.30767	0.4	0.3	0.4	0.366667	0.057735
WED-28	3.2	3	4.2	3.466667	0.64291	0.2	0.3	0.3	0.266667	0.057735
THUR-29	3	2.9	4.5	3.466667	0.896289	0.1	0.2	0.4	0.233333	0.152753
FRI-30	4.5	4.1	5.5	4.7	0.72111	0.4	0.3	0.6	0.433333	0.152753
SAT-31	5.4	5	8.7	6.366667	2.030599	0.6	0.4	1.2	0.733333	0.416333

Table 1 shows the mean morning, afternoon and evening levels of CO in sites1 and 2 for the 30 days sampling, and also the computed daily means and standard deviation for the mornings, afternoon and evenings of the month January (30 days). The range of mean CO levels within the thirty days of the measurement in site 1 was 3.17 – 7.33 ppm while that of site 2 was 0.2 – 0.73ppm (Table 1). Site 1 recorded the highest daily mean CO level on Monday, 5th January (7.33 ppm) while, the least was on Sunday, 18th January (0.31ppm) (Table 1). In site 2, the highest CO level (0.73 ppm) within study period was on Saturday, 31st January while the least level (0.2 ppm) was on Sunday, 11th January (Table 1). The highest mean CO level occurring on Monday, 5th January in site 1 may be attributed to increase in traffic volume following resuming of work, business and schools after the new year festivities as site 1 is a traffic station and very close to the major market in Enugu

(Ogbete) and motor parks.. The minimum CO level in the two sites was record on Sunday corresponding to a day of low traffic and industrial activities in the two sites respectively

30 days average: The mean and standard error for concentration in the morning of January gave 4.52 ± 0.19; afternoons gave 4.13 ±0.18 while evening gave 6.37 ± 0.31ppm for site 1. The corresponding values for site 2 were 0.34 ± 0.03, 0.27 ± 0.02 and 0.62 ± 0.05 ppm respectively (Table 2A). Weekday-weekend variation in the daily mean CO level existed in the two sites but the variation is more pronounced in site 1.Within the week day, the CO level generally peaks on Monday decreases afterward and peak up again on weekend (Friday and Saturday) and lowers to minimum on Sunday (Figs. 1a-d and 2a-d). This observation is in line with similar studies in traffic prone sites in urban areas of Nigeria [6, 7].

Variation between the periods of the day: The analysis of variance between the mean of CO concentrations in the morning, afternoon and evening showed that there exist significant difference in the level of CO between the different day periods in the two sites (P <0.5) (Table 2B). The mean levels were generally higher in the evening compared to the morning and afternoon values. This may be attributed to peak in traffic and traffic hold up associated with close of work and business in the evening.

Variation between sites 1 and 2: The student t-test for difference in mean (pair wise comparison) between the different day periods in sites 1 and 2 showed that the level of CO in site 1 and 2 was statistically significant p < 0.5 (Table 2A) and this is collaborated by the CO mean level of 4.5200, 4.1267 and 6.3733 ppm for morning, afternoon and evening for site 1 respectively as against 0.3400, 0.2667 and 0.6172 ppm for site 2. This is consistent with the observed nature of the site which is characterized by high traffic volume and build-up areas and hence less ventilated and could imply that traffic may have a higher impact (contribution) to CO concentration in Enugu compared to that from industries within the period of the study.

The present CO concentration obtained in the study does not exceed on the average in the two sites the 8 hours WHO guideline limit of 9 ppm except in the evening of Monday, 5 January in site I with a value of 10ppm (Table1). The CO levels in evening in site 1 had levels that ranged between 7 to 9 ppm in 10 days out of the 30 days measurement (Table 1)

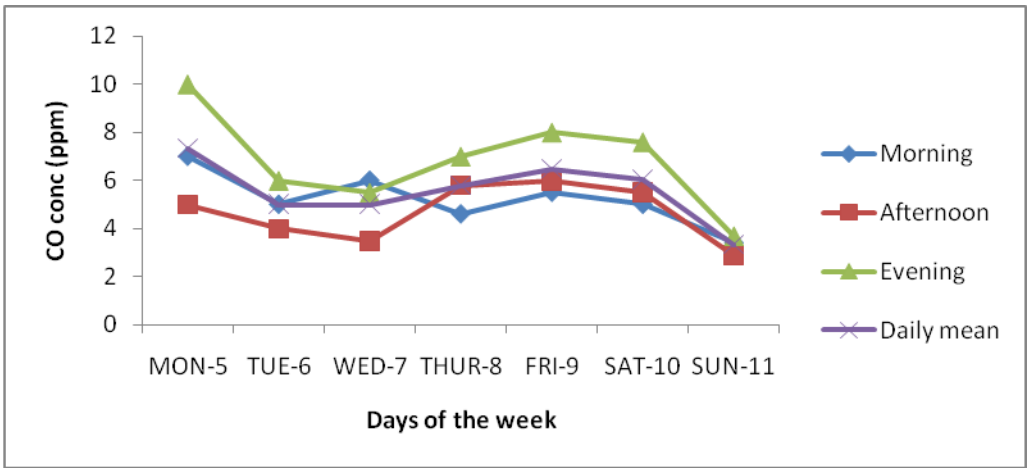
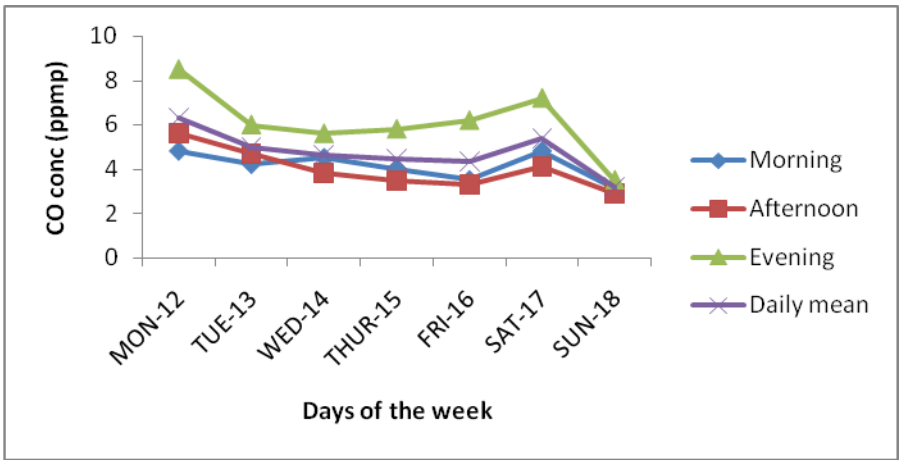
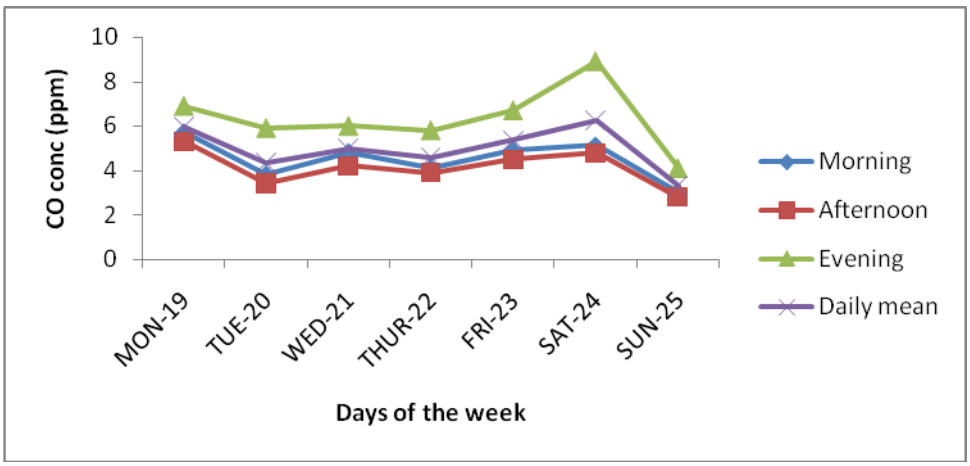


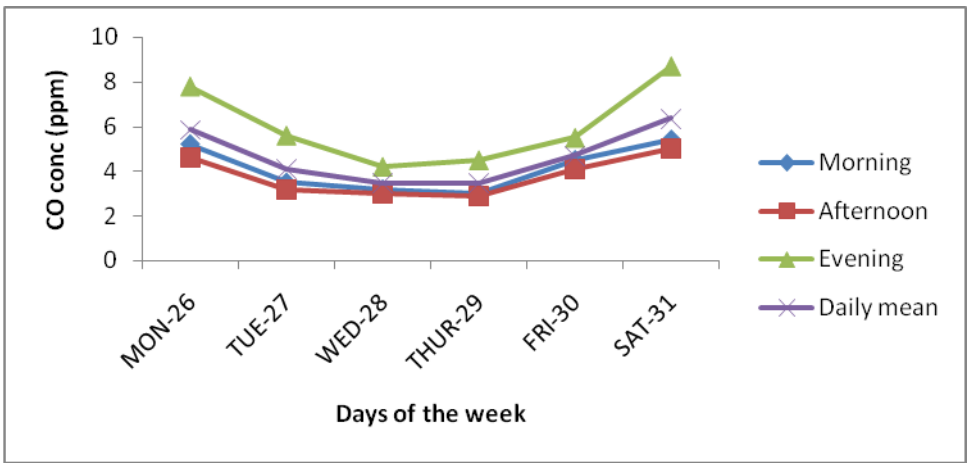
Fig. 1a: CO daily variation in site 1 for the week 1.



1b: CO daily variation in site 1 for the week 2



1c: CO daily variation in site 1 for the week 3



1d: CO daily variation in site 1 for the week 4

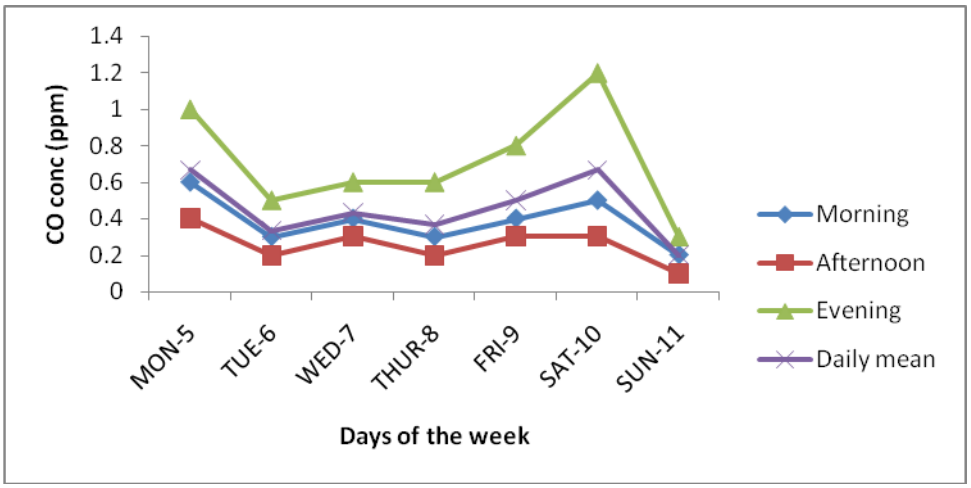
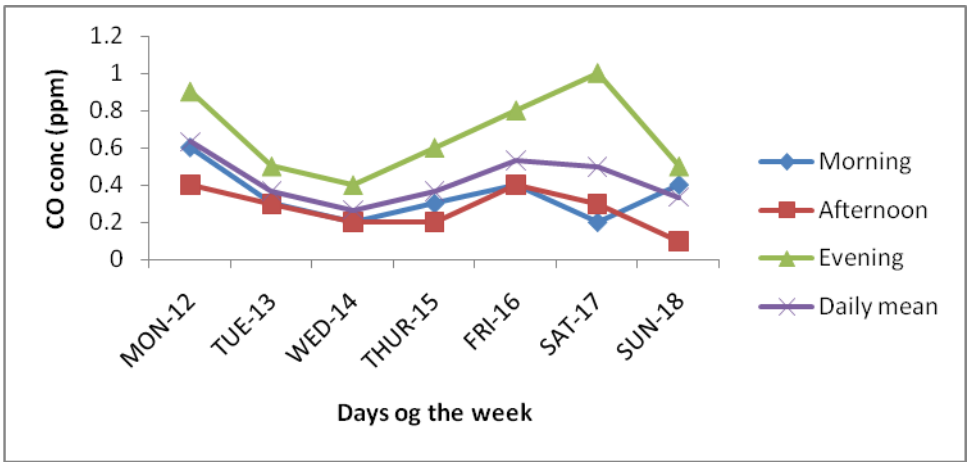
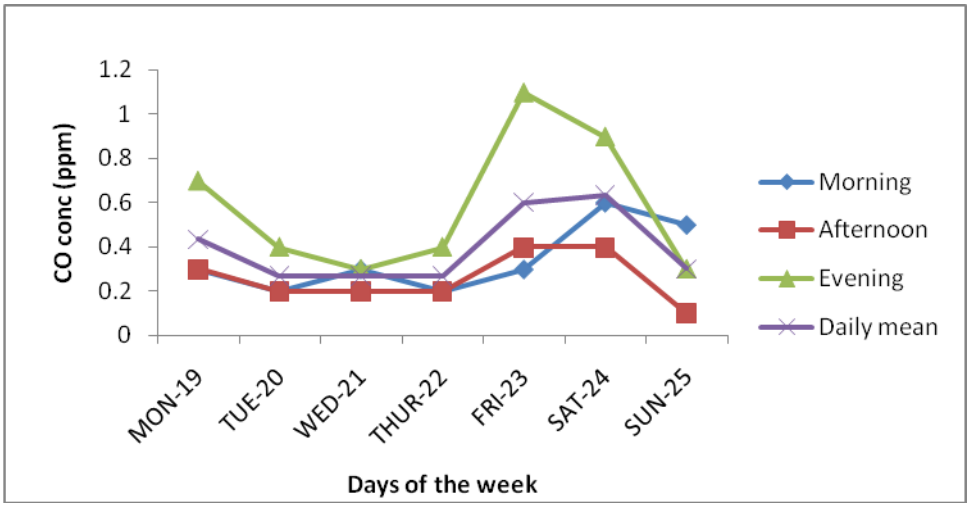


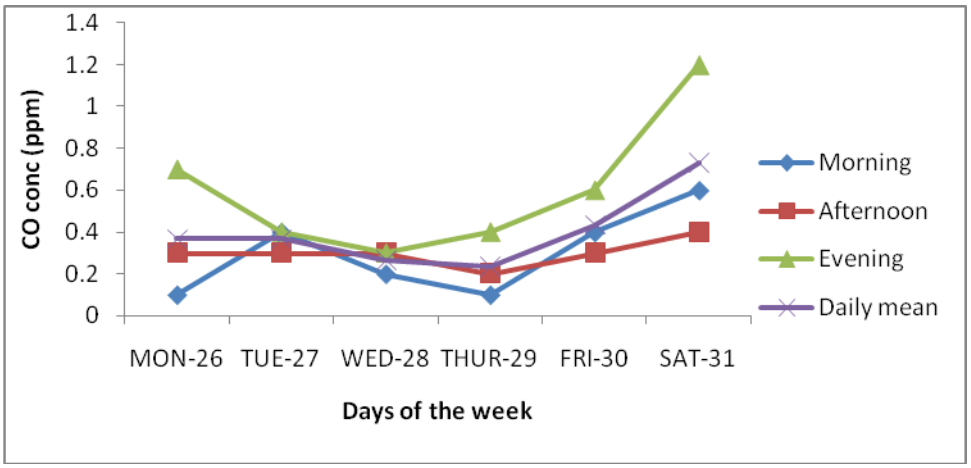
Fig. 2a: CO daily variation in site 2 for the week 1



2b: CO daily variation in site 2 for the week 2



1c: CO daily variation in site 2 for the week 3



1d: CO daily variation in site 2 for the week 4

V CONCLUSION

This study has provided data on CO levels in the sites in Enugu urban and revealed that there is variation in CO levels within the sites, within the period of the day, between weekend and other week days on one hand and between an industrial site (low traffic site) and traffic site in the other hand. CO levels as measured the two sites within the period of the research suggest that traffic emissions impact highly on the CO levels in Enugu Urban.

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