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Research Article

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Carbon Monoxide (CO): A Correlation Assessment between Morning and Evening Concentrations Emitted from Vehicular Movements in Port-Harcourt City

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Abstract Port-Harcourt is a metropolitan city of oil and gas capital of Nigeria. The presence of oil and gas industries made the influx of people into the city a daily experience and a corresponding increase in traffic congestion and emission of carbon monoxide (CO) and other Criteria Pollutants. Six sampling points (Ada-george, Mgbuoba, Rumuokwuta, Rumuola, First Artillery, Eliozu and Rumuokoro junctions) were selected for the study. For morning segment of Day 5, Eliozu has the highest CO concentration value of 72ppm, which is more than seven times the set standard limit of 10ppm, while Adageorge has the highest CO concentration value of 78ppm for the evening segment of Day 3. These results show that the daily mean CO concentrations were much more than WHO set limit of 10ppm.Two sampling locations (Rumuokwuta and Rumuokoro) indicated weak positive correlations of 0.29 and 0.31 between morning and evening sections respectively, while the remaining five sampling locations (Ada-george, Mgbuoba, Rumuola, First Artillery and Eliozu junctions) showed weak negative correlations of -0.16, -0.21, -0.28, -0.39, and -0.75 between morning and evening sections respectively. Carbon monoxide affects human's health, foetal growth, central nervous system (CNS), cognitive capacity, and causes disorientation, coma and could lead to death if one is exposed to very high concentration. Hence, the need for awareness campaign and proffer solution to the problems of air pollution in the city.

Keywords Carbon monoxide, Correlation, Concentration, Vehicular Movements

Introduction

Air pollution has been identified as a global problem due its negative effects on man, ecosystem, and the environment in general. The major cause of this air pollution problem emanates from myriads of man's economic activities to better his standards of living and survival. The birth of industrial revolution in 1760, a period of changing from manual production method to machine, and the establishment of more factories for production of goods and services, led to the release of more pollutants such carbon monoxide (CO), carbon dioxide (CO_2), nitrogen (iv) oxide (NO_2), methane (CH_4), particulate matter (PM), Chlorofluorocarbons (CFCs) and others, worsen global air pollution scenario.

Air pollution has been reported to have caused 3million premature deaths yearly around the world [1]. In 2007, the World Health Organization (WHO) funded project on vehicular monitoring emission in Lagos undertaken by Lagos Metropolitan Area Transport Authority (LAMATA) showed that the concentrations of carbon monoxide (CO) and other gaseous pollutants exceeded the WHO guidelines at most locations in Lagos [2]. A study of probability models in monitoring environmental pollution in Nigeria established the fact that the carbon monoxide concentration in Lagos State exceeds the Lagos State Environmental Protection Agency (LASEPA) and the Federal Environmental Protection Agency (FEPA) Standards with probabilities 0.300819 and 0.231621 respectively [2].

Carbon Monoxide

According to Health and Safety Executive [3], carbon monoxide (CO) is a colourless, odourless, tasteless, poisonous gas produced by incomplete burning of carbon-based fuels, including gas, oil, wood and coal.

Carbon monoxide has been identified as the most common type of fatal air poisoning in many countries [4]. In England, the number of admission of patients to hospital with Carbon Monoxide (CO) poisoning have been reported to approximately 400 and around 40-50 deaths [5].

Carbon monoxide (CO) is one of the six criteria pollutants the United States Environmental Protection Agency (USEPA) included in the national air quality standards [6]. These six criteria pollutants are shown in figure 1.

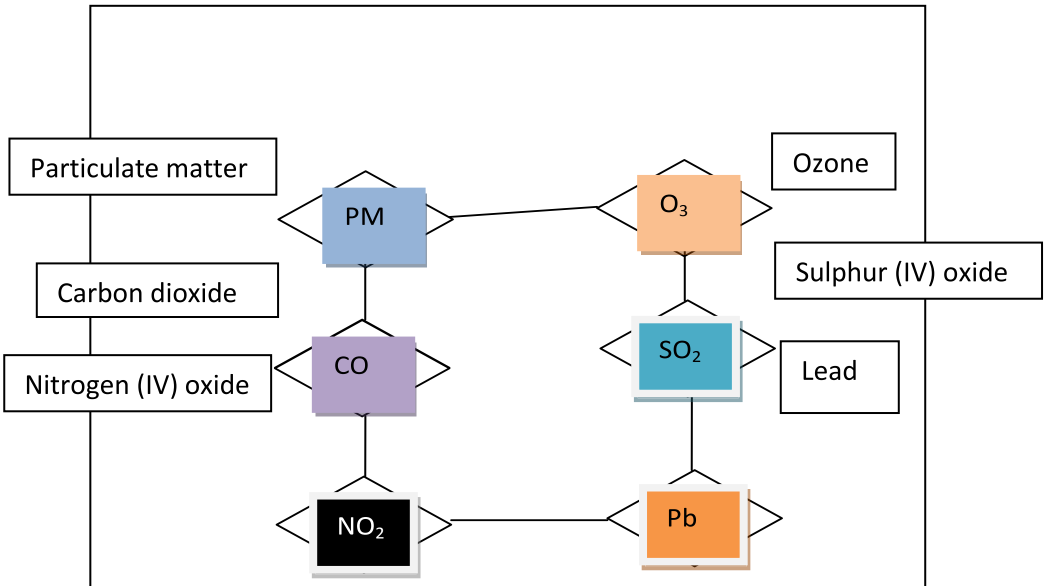

Figure 1: Criteria Pollutants

Sources of Carbon monoxide

Cars, trucks and other vehicles or machinery that burns fossil fuels are considered the greatest sources of CO to outdoor air [7]. Others are wood burning; gas-powered fireplaces, gas stoves, range tops and water heater are common sources of carbon monoxide in the home [8].

Effects of Carbon monoxide

According to National Academy of Sciences [9], carbon monoxide affects human health by impairing the ability of the blood to bring O_2 to body tissues. There is evidence of ambient CO exposure during pregnancy having a negative effect on foetal growth in epidemiologic studies [10]. Exposure to high levels of CO has long been known to adversely affect central nervous system (CNS) function, with symptoms following acute CO poisoning including headache, dizziness, cognitive difficulties, disorientation, and coma [11].

Materials and Methods

The Study Area

Port-Harcourt is the capital of Rivers state. Its geographical coordinates are $4^{0}\,47'\,21''$ North, $6^{0}\,59'\,55''$ East; and elevation of 52ft (16 meters) above sea level. Port Harcourt is situated at the coastal region of Nigeria and has an average temperature between 25^{0}C - 28^{0}C.

Port-Harcourt is a metropolitan city of oil and gas capital of Nigeria. The presence of oil and gas industries made the influx of people into the city a daily experience and a corresponding increase in traffic congestion and emission of carbon monoxide (CO) and other Criteria Pollutants.

Sampling Points

The sampling sites include Ada-george, Rumuokwuta, First Artillery, Mgbuoba, Rumuola, Eliozu and Rumuokoro junctions. Figure 2 shows map of Port-Harcourt Metropolis.

Figure 2: Port-Harcourt Satellite map with street view

Source:www.viewphotos.org/nigeria/fat-map-of- Portharcourt-70-html

Materials

The instrument used in the measurements of CO concentrations at the selected sampling points was EM-4 type Pocket Multi-P. The instrument was positioned 2 meters above the earth's surface; and measures CO concentrations in part per million (ppm) at the seven sampling points. The readings were taken for 1hour at 10 minutes interval. The measurement covered two sections (morning and evening).

Morning section started from 6am - 1pm, while the evening section commenced from 4pm to11 pm for a period of one week (1^{st} to 7^{th} March, 2015). Figure 1.3 is the picture of EM-4type pocket multi-P detector.

Figure 3: EM-4 type Pocket Multi-P detector

Results and Discussion

Table 1: Measured CO concentration daily mean in (ppm) at the selected sampling Sites for the morning segment of March 1st – 7th, 2015

Names of sampling site	Day1	Day2	Day3	Day4	Day5	Day6	Day7
Ada-george	9.50	19.50	11.00	12.50	17.50	26.50	15.00
Mgbuoba	9.00	21.50	12.00	30.00	27.00	35.50	19.50
Rumuokwuta	10.00	57.00	42.00	25.00	51.00	20.50	29.00
Rumuola	38.50	22.50	29.00	46.00	18.50	20.00	18.50
First Artillery	15.50	38.00	19.00	28.50	45.00	19.50	41.00
Eliozu	20.00	10.00	25.50	51.50	72.50	26.00	24.00
Rumuokoro	35.00	26.50	24.50	33.50	51.00	29.50	52.50

Error: ±0.01

In Table 1, the measured daily mean CO concentrations for morning section ranged between 9.0ppm and 72.0ppm.

Table 2: Measured CO concentration daily mean in (ppm) at the selected sampling sites for the evening segment of March 1st – 7th, 2015

Names of Sampling site	Day1	Day2	Day3	Day4	Day5	Day6	Day7
Ada-george	13.00	11.00	78.00	23.00	16.50	16.50	15.50
Mgbuoba	21.50	27.50	20.00	21.00	12.50	20.50	18.00
Rumuokwuta	23.50	39.00	28.00	30.50	21.50	25.00	39.50
Rumuola	26.00	29.00	15.00	14.00	25.00	47.50	23.50
First Artillery	16.50	25.00	19.00	17.00	21.00	50.00	21.00
Eliozu	17.00	23.00	23.00	22.50	18.50	50.00	38.00
Rumuokoro	28.50	10.50	30.00	33.50	50.50	56.50	30.50

Error: ±0.01

In Table 2, the measured daily mean CO concentrations for evening segment of March 1st – 7th, 2015 ranged between 10.50ppm and 78.0ppm.

Statistical Analysis

Pearson correlation method was used to determine if there is correlation between the CO concentrations emitted during the period (morning and evening segments) under study.

Mean: The mean for the two segments of CO concentration measurement is given by equations 1.1 and 1.2

$$\bar{X} = \sum \frac{X}{N} \quad (1.1)$$

$$\bar{Y} = \sum \frac{Y}{N} \quad (1.2)$$

Where, $\bar{X}$and $\bar{Y}$ are the mean values of CO concentration for the morning and evening segments respectively, and N is the number of days.

Correlation Coefficient

Correction coefficient is a measure of the strength of linear association between two variables.

Pearson correlation coefficient returns a value of between -1 and + 1. A -1 means there is strong negative correlation and +1 means that there is a strong positive correlation.

The Pearson correlation coefficient (r) is given by

$$(r) = \frac{N\sum(XY) - (\sum X)(\sum Y)}{\sqrt{[N\sum X^2) - (\sum X)^2\,][N\sum Y^2) - (\sum Y)^2]}} \quad (1.3)$$

where,

N = Number of values or elements (7 days)

X = First scores (weekly mean CO concentration for the morning segment).

Y = Second scores (weekly mean CO concentration for the segment)

ΣXY = sum of the product of first and second scores (sum of the product for the weekly mean CO concentration for the morning and evening segments)

ΣX = Sum of first scores (sum of weekly mean CO concentration for the morning segment)
ΣY = Sum of second scores (sum of weekly mean CO concentration for evening segment)
ΣX^2 = Sum of square first score (sum of square CO concentration for the morning segment)
ΣY^2 = Sum of square second scores (sum of square CO concentration for the evening segment).

Table 3: Correlation coefficient for morning and evening segment of March 1st – 7th, 2015

Sampling Site	Correlation Coefficient (r)	Coefficient of Determination (r^2)
Ada-george	-0.39	1.5221
Mgbuoba	-0.16	0.0256
Rumuokwuta	0.29	0.0841
Rumuola	-0.75	0.5625
First Artillery	-0.21	0.0441
Eliozu	-0.28	0.0788
Rumuokoro	0.31	0.0961

In Table 3, two sampling sites (Rumuokwuta and Rumuokoro) indicate weak positive correlation coefficient of 0.29 and 0.31 between the morning and evening sections of the 1-hour daily mean CO concentration, while the rest of the sampling sites (Ada-george, Mgbuoba, Rumuola, First Artillery and Eliozu indicate weak negative correlation coefficient of -0.75,-0.39, -0.28, -0.21 and -0.16 between morning and evening segments of the 1-hour daily mean CO concentrations.

Implication of Results

In Tables 1 and 2 the values of the measured daily mean CO concentrations are relatively high when comparing with the set standard limits by the United States Environmental Protection Agency (USEPA) of 9ppm, the Nigerian Federal Environmental Protection Agency (FEPA) and World Health Organization (WHO) of 10ppm limits. This shows that high level of CO concentrations are being emitted at these traffic junctions on a daily basis and the people living or doing business around these junctions are exposed to this poisonous gas and the associated health problems.

Conclusion

The results of the study showed that only the daily mean CO concentration values of 9.00ppm, 9.50ppm were less than 10ppm limits set by Federal Environmental Protection Agency (FEPA) and the World Health Organization (WHO), but the rest of the daily mean CO concentrations were much more than this set limits. This is also more than seven times the set Standard limit of 10ppm. Finally, only two sampling points showed weak positive correlation of 0.29 and 0.31 between morning and evening sections, while the remaining five sampling points showed weak positive correlations of -0.16, -0.21, -0.28, -0.39,and -0.75 between morning and evening sections. For morning segment of Day 5, Eliozu has the highest CO concentration value of 72ppm, which is more than seven times the set standard limit of 10ppm, while Adageorge has the highest CO concentration value of 78ppm for the evening segment of Day 3. This calls for adequate measures to be put in place in order curb the problems of air pollution occasioned by high volume of vehicular movements in the city.

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