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Assessment of the Concentration of Carbon Monoxide in Ambient Air Environment of Abakaliki Urban Area, Nigeria

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Abstract

Carbon monoxide (CO) is a well known gaseous atmospheric pollutant. In this study the baseline concentration of CO in the ambient air environment of Abakaliki Urban Area, Nigeria was estimated using digital CO gas monitor. Ten sites were monitored for their CO levels and the data collected were statistically analyzed. Results show that the mean concentration of ambient CO in Abakaliki Urban Area, Nigeria was 1.01 ± 0.30 ppm. The range was 0.160 – 2.60 ppm. Vanco Junction site had the highest concentration of CO (2.60 ppm) while Rice Mill Area had the lowest CO concentration (0.160 ppm). The results also indicated a gradual increase in CO concentration with increase in the time of day from 6am to 6pm with a peak CO concentration (1.34 ppm) occurring at 4pm. High traffic density was responsible for the observed variations in ambient CO concentrations. However, the concentration of CO in the study area was far below the Federal Environmental Protection Agency and World Health Organization threshold of 10 ppm and 9 ppm respectively for 8 hours averaging period.

Keywords: Carbon Monoxide, Air, Abakaliki, Baseline Data, Human Health.

Introduction

Carbon monoxide (CO) is a colourless, odourless, flammable gas that is very toxic to human and animals. It is generally formed by the incomplete combustion of carbon-containing fuels such as petroleum, charcoal, wood and coal [1]. The main source of CO in the atmosphere is the incomplete burning of fuels such as petrol and diesel in automobile engines, power generating plants and gas flaring [2, 3]. Other sources include use of fuel wood, kerosene stoves, kerosene lamps, hurricane lamps and candles.

Toxicity of CO in humans is associated with its irreversible reaction with haemoglobin (Hb) in the blood leading to the formation of carboxy-haemoglobin in the blood [4]. The binding of CO to Hb therefore reduces the amount of oxygen reaching the organs and cells in the body. The adverse health effects of CO toxicity include reduction in visual perception, shortness of breath, mild headache and drowsiness [5, 6]. In severe cases, if 50 % or more of the Hb is bound to CO an affected person could become unconscious and may result to death due to suffocation.

Analytical detection and estimation of CO can be carried out using the oxidation of CO to carbon (iv) oxide [CO_2] by iodine pentoxide (I_2O_5) [7, 8]. In this reaction iodine is quantitatively liberated. Amplification titrimetric analysis of the liberated iodine [9] affords the estimation of CO. Other approaches in gas analysis involves diffusing and adsorbing or absorbing the gaseous molecule in suitable adsorbent or absorbent materials [10 – 13] and thereafter determining the amount of gas adsorbed by appropriate instrumental methods such as Ultra Violet/Visible spectrophotometry [10 – 12], ion chromatography [13]. A more recent technique in gas analysis is the use of digital gas sensors and monitors [14]. This technique is selective, simple, robust, accurate and easy to operate but relatively expensive.

Several studies have reported the levels of gaseous atmospheric pollutants such as nitrogen dioxide, sulphur dioxide and carbon monoxide [10 – 14]. According to one of the reports [14] the dry season, wet season and annual mean concentrations of CO in Ogoja Urban Centre, Nigeria was 0.477ppm, 0.249ppm and 0.360ppm respectively.

In general, ambient concentrations of atmospheric pollutants depend upon the strength of the sources, efficiency of their dispersion, topography of the area and other meteorological conditions like turbulence and inversion, wind speed and wind direction [15].

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The objective of the present study was to assess the ambient concentration of CO in Abakaliki Urban Area and compare with Regulatory Agencies approved guideline limits. It is hoped that the data generated would serve as baseline data for Town Planners, Environmental Managers, Ministry of Environment, Environmental Protection Agency and for epidemiological studies.

Materials and method

Instrument used: The Crowcon Gasman Digital Carbon Monoxide Gas Monitor (Model 19256H) range 0 – 100ppm used for the study was obtained from the Department of Soil Science and Environmental management, Faculty of Agriculture, Ebonyi State University, Abakaliki, Nigeria.

The Study Area: The study area encompasses Abakaliki Urban Centre and its environs. Abakaliki, the capital of Ebonyi State, is one of the fast developing towns in Nigeria. It is also the largest urban centre in Ebonyi State. Abakaliki lies at latitude 6.18°N – 6.21°N and longitude 8.03°E – 8.07°E [16]. The town is situated in the tropical climate characterized by two distinct seasons – dry and wet. The natural vegetation includes slight forest and plantation. The town is inhabited predominantly by civil and public servants, traders, farmers and students with location of batteries of small and medium scale industries.

Sampling/Data Collection: Ten sampling sites were selected for the study and coded (Table 1) as to cover the town. The geo-referencing was done using the Garmin GPS Model etrex H chart plotting receiver. The Crowcon Gasman Digital Carbon Monoxide Gas Monitor was used for detecting and estimating the concentration of CO. Measurements were done by holding the sensor to a height of 2 metres above the ground level in the direction of the prevailing wind. Readings of CO concentration were taken directly at the steady state of the sensor. The reading for each site at a particular time was taken in triplicate and averaged. Gas measurements were carried out for ten days between Monday 28th March, 2011 and Wednesday 6th April, 2011.

Table 1: Carbon monoxide monitoring sites

S/No.	Site name	Site code	*GPS coordinate
1.	Union Bank Roundabout	UBR	N 06º 19.475', E 008º 06.558'
2.	Vanco Junction	VCJ	N 06º 19.131', E 008º 06.710'
3.	Hossana Park	HOP	N 06º 19.209', E 008º 06.728'
4.	Meat Market	MMK	N 06º 19.272', E 008º 06.745'
5.	Spera in Deo Junction	SDJ	N 06º 18.579', E 008º 05.405'
6.	Presco Junction	PRJ	N 06º 19.470', E 008º 05.115'
7.	Rice Mill Area	RMA	N 06º 19.107', E 008º 08.119'
8.	Mechanic Village	MEV	N 06º 18.685', E 008º 07.811'
9.	Government house roundabout	GHR	N 06º 19.660', E 008º 06.412'
10.	Iyiokwu Bridge Dumpsite	IBD	N 06º 18.835', E 008º 05.777'

**GPS = Global Position System.*

Results and discussion

Table 2: Ambient mean CO concentration (ppm) as a function of time of day with Reference Standards

Site code	Time of day					Site mean±SD	Regulatory limits	
	6.00am	8.00am	12noon	4.00pm	6.00pm		FEPA	WHO
UBR	1.3	1.5	1.6	2.5	1.9	1.76±0.47	10.00	9.00
VCJ	1.6	1.9	3.0	3.5	3.0	2.60±0.81		
HOP	0.3	0.4	0.5	0.5	0.3	0.40±0.10		
MMK	1.1	1.4	1.8	2.3	2.5	1.82±0.59		
SDJ	0.2	0.4	0.3	0.5	0.4	0.36±0.11		
PRJ	0.4	0.6	1.0	1.3	1.6	0.98±0.49		
RMA	0.1	0.1	0.2	0.3	0.1	0.16±0.09		
MEV	0.1	0.3	0.2	0.4	0.3	0.26±0.11		
GHR	1.0	1.3	1.5	1.7	2.0	1.50±0.38		
IBD	0.2	0.2	0.3	0.4	0.3	0.28±0.08		
Hourly mean±SD	0.63±0.56	0.81±0.65	1.04±0.93	1.34±1.12	1.24±1.08	1.01±0.30		

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SD = standard deviation; ppm = parts per million; FEPA = Federal Environmental Protection Agency; WHO = World Health Organization

The concentration of ambient CO as a function of time of day per sample site studied together with the FEPA and WHO regulatory limits are presented in Table 2. The results indicate that the range of ambient CO concentration in all the various sites monitored was 0.16 – 2.60ppm with a mean and standard deviation of 1.01 ± 0.30ppm. The mean CO concentration calculated was higher than those earlier reported in Ogoja Urban Centre [14] with values 0.477ppm (dry season); 0.249ppm (wet season); 0.360ppm (annual). The lowest value of 0.16 ppm recorded at RMA was probably due to the day of sampling (Sunday) being a work-free day whereby there is very low traffic and no rice milling operations taken place. The highest CO concentration recorded at VCJ (2.60ppm) could be attributed to the high traffic density usually observed in the place no matter the day. VCJ is a very busy area where lots of business activities take place as well as high nature of vehicular emissions. The results also show that there was a gradual rise in the level of CO at the early hours of the morning between 6.00am and 8.00am with a spontaneous rise in CO level in the afternoons between 12.00 noon and 4.00pm at sites UBR, VCJ and MMK. These are the areas that usually experience high vehicular traffic which is usually the time most workers and marketers begin to depart to their homes after the day's activity. A peak ambient CO concentration of 1.34 ± 1.12ppm occurred at 4.00pm. There was a decrease in trend of the CO concentration between 4.00 and 6.00pm. Low traffic density and low business activities take place in the early hours (morning session) of a typical working day in the study area whereas high traffic density and high business activities occur in the afternoon session. These factors accounted for the variations in the CO concentrations observed during the day. There could also be low efficiency in CO dispersion in the ambient air environment [15]. The discrepancies in the ambient CO concentrations observed between 4.00pm and 6.00om at MMK, PRJ and GHR could also be attributed to these stated factors. Major sources of CO in the study area were automobile exhaust gases, fumes from power generating plants, organic solvents and vapours from small and medium-scale industries (artisans) and gaseous emission from refuse dumps in some locations. However, the concentration of CO found in the study area were far below the FEPA and WHO recommended limits of 10 ppm and 9 ppm respectively [17, 18]. Therefore, the ambient CO levels in Abakaliki Urban Centre may not adversely affect the health of its inhabitants.

Conclusion

The mean concentration of ambient CO in Abakaliki Urban Area as at the period of this study was 1.01 ± 0.30ppm. This value does not present a health risk to the inhabitants of the area being lower than approved standards. The concentration of CO increased with time of day. The CO concentration was at its highest peak (1.34ppm) at 4.00pm. Highest value of CO levels was recorded at Junction areas where there were high volumes of traffic and commercial activities

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