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Toxicity potential of automobile carbon monoxide emission along a major highway in Sango-Ota, Ogun State, Nigeria

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Abstract: This study investigated the toxicity potential of carbon monoxide along a major highway in Sango-Ota, an emerging city, in Nigeria. Ambient air carbon monoxide was monitored and measured at ten different locations using the GM8805 benetech carbon monoxide monitor. Coca-Cola junction was selected as the control location for this study. The 1-hr averaging period measured for carbon monoxide concentrations within the selected locations ranged between 25.2 ppm and 29.3 ppm while at the control point, it was measured to be 8 ppm. The extrapolated 8-hr averaging period for carbon monoxide concentration ranged between 14.076 ppm and 16.366 ppm with the concentration at the control point being at 4.4688 ppm. The extrapolated 24-hr averaging period for carbon monoxide concentration ranged between 10.357 ppm and 12.042 ppm with the concentration at the control point being 3.288 ppm. An assessment of toxicity potential of these locations based on Federal Environmental Protection Agency (FEPA), United States Environmental Protection Agency (USEPA) and World Health Organization (WHO) statutory limits were all above unity (one) except at the control location and this poses as a threat to human lives. These values showed unhealthy air conditions at these regions of the emerging city. This study establishes that traffic congestions contribute significantly to the ambient air thereby reducing its quality thus calls for the attention of regulatory bodies to rise to protection of commuters and businessmen along the major highways in emerging cities in Nigeria.

Keywords: Developing countries, emerging cities, highways, carbon monoxide emission, and toxicity potential

1. Introduction

Automobiles emit pollutants, such as carbon dioxide, that add to global climate and environmental changes, and are within the class of ozone harming substances. One gallon of gasoline makes 18 pounds of CO₂ [1]. The U.S. alone produces 22 billion tons a year of CO₂ [1]. The transportation area as of now represents over a fourth of all U.S. ozone harming substance discharges [2]. Global effects: Carbon monoxide (CO) being a poisonous gas that influences carbon dioxide (CO₂), methane (CH₄) and tropospheric (lower atmospheric) ozone (O₃). Thus, CO plays a role in air contamination and climatic change and so, consequently controlled in numerous parts of the globe (Matthew *et al.*, 2018). CO is exceptional among air pollutants in the tropopause (lower atmosphere) in that it persists for approximately a month, sufficiently long to be conveyed long distances yet not does not take time to become circulated uniformly [2]. [3] examined the long-lasting impact of greenhouse gas (GHG) emissions on health aftermaths in Nigeria using data of time series and reported that human undertakings increase GHG to the atmospheric ambience through burning of fuels from fossils.

Being an evolving country, Nigeria is threatened by pollution being emanated from traffic congestion which occurs separately from pollution arising from sources like wide-ranging industrial



pollution and pollution from oil industries [4]. This threat is an outcome of importation of old and over used automobiles, poorly constructed roads and inefficient agencies that do not ensure regulations are maintained nor enforce the implementation of pollutants level projected to be good to human health [5]. Carbon Monoxide is most toxic during power outages due to storms, inappropriate practice of using gasoline-powered portable generators to generate electricity and indoor use of charcoal briquettes for cooking and heating. Carbon Monoxide poisoning can also arise from sources like exhaust from generators and propulsion engines on houseboats [6].

Nigeria is considered as one of Africa's most populous country (170 million people as of 2012). Nigeria's population increased by 60% between 1990 and 2008 and it is also projected to fall within the range of 0.5 – 1 billion people by 2100 [7]. The GDP rate in Nigeria as at 2012 was supposed to be 7% every year, conjecture to proceed [8], is viewed as one of the most elevated on the planet. The Nigerian economy recently surpassed South Africa as the biggest on the continent. This quick growth in Nigeria causes a variety of ecological concerns including air quality. Pollution from vehicular sources is worsened by inefficient automobiles, disrupted street systems, inadequately built streets, traffic clog, and polluted fuels [8]. [9] was able to establish that increase in the use of automobiles and establishment of industries contribute significantly to the high level of carbon monoxide concentration in Lagos State, Nigeria.

Sango-Ota is an emerging city in Ogun State, Nigeria and is experiencing an increasing population as more companies, houses are being built within the area. This situation is leading to slow flow of traffic and longer time spent in congestions, which in return increasing burning of fossil fuels, thereby polluting the air. Hence, measuring the concentration of CO being emitted and determining the toxicity potential of automobile carbon monoxide emission in the ambient air along Sango-Ota highway is of paramount importance.

2. Materials and methods

2.1 Description of the studied emerging city

The study area is Sango-Ota, an emerging city in Ogun State, Nigeria (Figure 1). It borders Lagos State to the south, Oyo and Osun States to the north, Ondo to the east and the Republic of Benin to the west. It lies on the geographical coordinates of $6^{\circ} 42' 0''$ N, $3^{\circ} 14' 0''$ E. It is located in Ado-odo/Ota local government area, Ogun state. It covers a land area of 878 km². Sango-Ota was separated into four expansive sub-areas based on the residential features and socio-economic dissimilarities. The sub-divisions are: Sango fly-over neighborhood and Oju-Ore being the two-conspicuous indigenous developed pieces of Sango-Ota; the new private neighborhood area of Iyana-Iyesi covering the two colleges and the Winners Church neighborhood; and the high-status neighborhood zone of Toll-gate possessing the south-eastern segment of the city [10].

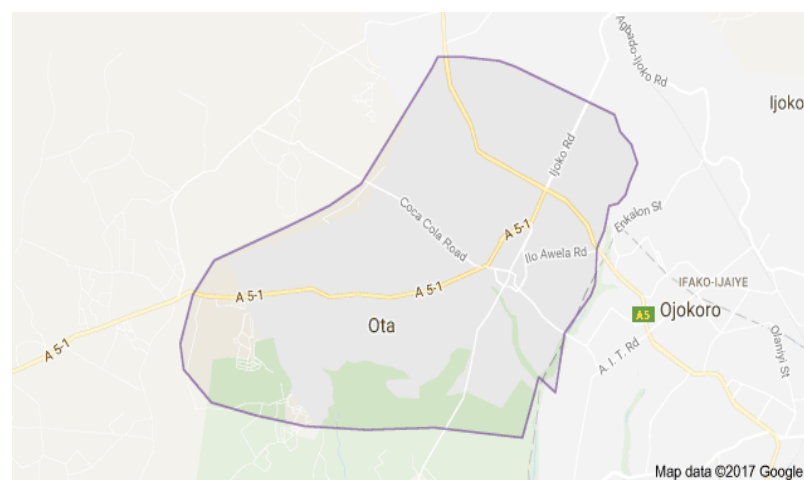


Figure 1: The highlighted region shows the studied emerging city, Sango-Ota.

2.2. Sampling of CO along Sango-Ota highway

Tours were made to identify different sampling locations at ten active junctions along Sango-Ota Highway. The choice of the different locations was based on the accessibility, central location and congestion in the areas. Ogun State, being a fast-rising industrious part of Nigeria has her highways with automobile activities and hence, automobile emissions in which CO emission is one. A user friendly GM8805 benetech CO monitor (Plate 1) was utilized to measure the CO concentrations at the selected sampling locations along Sango-Ota Highway. The CO monitor was put on and left to countdown for about 10 seconds so as to prepare internal systems ready. The monitor- GM8805 benetech CO - was positioned at an appropriate height, between 1.5 m and 2.0 m to dodge measuring emission that could be fugitive. Readings were taken at 2 minutes interval for one hour at each of the identified sampling locations.



Plate 1: GM8805 benetech CO monitor

The toxicity potential of CO emission at each of the designated sampling locations was determined. To do this, first of all, the mean concentration of CO was determined on the averaging period of 1-hour and extrapolated to 8-hour per day and 24-hour averaging time concentrations using the atmospheric stability formula [11] given in equation 1. Then, the toxicity potential of CO emission was determined at each sampling location and on each averaging period using model equation 2 [12] mulling over the surrounding air quality statutory standards of CO by the FMENV, WB and that of the WHO as revealed by FEPA in 1991, WB in 1998 and WHO in 1979, separately.

$$C_o = C_1 \times F \quad (1)$$

where,

C_o = the concentration at the averaging period, t_o

C_1 = the concentration at the averaging period t_1

F = factor to convert from the averaging period t_1 to the $t_o = (t_1/t_o)^n$, $n = 0.28$ (the stability dependent exponent)

$$\text{Toxicity Potential (TP)} = \frac{M_{CO}}{S_{CO}} \quad (2)$$

where,

M_{CO} = measured CO

S_{CO} = statutory limit set for CO

3. Results and discussion

In this study, the impact of carbon monoxide on humans was explored. Furthermore, the different levels of exposure and toxicity potential of Carbon Monoxide based on the specific averaging periods were quantified. This approach allows a more accurate prediction of the effect of Carbon Monoxide emission on humans along this highway. Summarized in Table 1, are the mean values of the measured 1-hr averaging period of CO concentrations at the various selected sampling points at the junctions selected. With the average values calculated at each sampling location, the average concentration ranged from 25.20 ppm to 29.30 ppm with that of the control location being at 8.00 ppm. From Table 2, the 1-hr averaging period when extrapolated to 8-hr averaging period, the concentration ranged from 14.076 ppm to 16.366 ppm while the concentration at the control location was 4.469 ppm. Again, as seen in Table 3, the 1-hr averaging period was extrapolated to 24-hr averaging period. The concentration ranged from 10.357 ppm to 12.042 ppm with the control location at 3.288 ppm. The means maximum and minimum Carbon Monoxide concentrations were recorded at Ifo Junction and Toll-Gate Junction correspondingly. This could be ascribed to the vehicular activities seen along this highway.

Table 1. Mean 1-hr Values from Measured CO concentration

S/N	Junction	CO (ppm)
1	Winners	25.40
2	Toll-Gate	29.30
3	Industrial Estate	25.47
4	Iyana-Iyesi	29.20
5	Oju-Ore	25.50
6	Idi-Iroko (Obasanjo)	27.70
7	Joju	25.73
8	Coca-Cola	8.00
9	Ifo	25.20
10	Iyana-Ilogbo	25.77

Table 2. Extrapolation from $t_1 = 1$ hr to $t_0 = 8$ hrs

S/N	Junction	C_1 (ppm)	$F = (t_1/t_0)^{0.28}$	C_0 (ppm)
1	Winners	25.40	0.5586	14.188
2	Toll-Gate	29.30	0.5586	16.366
3	Industrial Estate	25.47	0.5586	14.227
4	Iyana-Iyesi	29.20	0.5586	16.311
5	Oju-Ore	25.50	0.5586	14.244
6	Idi-iroko (Obasanjo)	27.70	0.5586	15.473
7	Joju	25.73	0.5586	14.372
8	Coca-Cola	8.00	0.5586	4.469
9	Ifo	25.20	0.5586	14.076
10	Iyana-Ilogbo	25.77	0.5586	14.395

Table 3. Extrapolation from $t_1 = 1\text{hr}$ to $t_0 = 24\text{hrs}$

S/N	Junction	C_1 (ppm)	$F = (t_1/t_0)^{0.28}$	C_0 (ppm)
1	Winners	25.40	0.411	10.439
2	Toll-Gate	29.30	0.411	12.042
3	Industrial Estate	25.47	0.411	10.468
4	Iyana-Iyesi	29.20	0.411	12.001
5	Oju-Ore	25.50	0.411	10.480
6	Idi-iroko (Obasanjo)	27.70	0.411	11.384
7	Joju	25.73	0.411	10.575
8	Coca-Cola	8.00	0.411	3.288
9	Ifo	25.20	0.411	10.357
10	Iyana-Ilogbo	25.77	0.411	10.591

At Ifo Junction where the mean minimum carbon monoxide concentration was recorded could be as a result of lesser automobile movements in comparison to the rest of locations. In Ifo Junction, main activities that take place there include trading, car repairs etc. Important places which include gym and fitness club, schools, churches, can also be seen along this junction. Ifo junction is a developing area compared to other junctions along Sango-Ota highway and as such, less traffic congestion is seen. However, there are higher volumes of traffic at Toll-gate, when compared to other junctions due to how important a highway it is linking both Lagos State, commercial region of the country, and Ota, Ogun State, which contain factory plants to various industries. The automobile users reduce their speeds, always, around this location because of the poorly tarred road and the commercial buses that park along the highway negotiating with passengers. Although the activities at these two junctions are almost the same, the higher volume at this sample location could be ascribed to higher volumes of traffic experienced by Toll-gate junction than Ifo junction. Winners, Iyana-Iyesi, Joju, Idi-iroko, Iyana- Ilogbo, and Industrial Estate Junctions, all of which have lower number of automobiles than Toll-Gate junction but higher number of automobiles than Ifo Junction. This situation might be due to the lower mean CO concentrations in these sampling locations as compared to that of Toll-Gate Junction and the higher concentrations in comparison to Ifo Junction. The 8-hr and 24-hr averaging periods extrapolated CO concentrations followed the same trend in magnitude in all the sampling locations as the concentrations measured, where Ifo Junction had the least concentration and Toll-Gate Junction had maximum concentration.

From the Tables 4 to 6 above, it can be seen that the Toxicity Potential values gotten at 9 junctions after 1hr were between 2.52 and 3.525 across the regulating bodies, values gotten after 8hrs and 24hrs were above unity i.e 1. Toxicity Potential higher than unity engenders severe health issues to the inhabiting populace and the businessmen of the atmosphere where such is gotten. This shows the level of exposure commuters are exposed too. Minimum toxicity potential value is seen at Ifo Junction, this junction had least traffic congestion when compared with the others and fewer automobiles were seen at this junction. The toxicity potential ranged from 1.4076 to 1.564 for 8hrs and 1.0357 to 1.1507 for 24hrs. The cause for this tendency could be as earlier deduced for the measured levels of CO. At the selected control sampling point being Coca-cola Junction, the toxicity potential ranged from 0.44688 to 0.4965 for the 8-hr and 0.3288 to 0.3653 for 24hrs extrapolation. At this junction, the standards and regulations were maintained and toxicity potential values calculated at various times of the day were all below 1. Maximum toxicity Potential is seen at Toll Gate Junction where a large number of automobiles are seen regularly and regular traffic occurs. This is a major worry for every road user along the particular road that passes through this axis to get to their various destinations. The regular traffic along this route shows more reason why attention should be given to this region in general.

Table 4. Toxicity Potential calculated for 1hrs based on FEPA, WHO, USEPA Statutory limits

S/N	Junction	TP _{FEPA}	TP _{WHO}	TP _{USEPA}
1	Winners	2.540	2.540	2.822
2	Toll Gate	2.930	2.930	3.255
3	Industrial Estate	2.547	2.547	2.830
4	Iyana-Iyesi	2.920	2.920	3.244
5	Oju-Ore	2.550	2.550	2.833
6	Idi-iroko (Obasanjo)	2.770	2.770	3.077
7	Joju	2.573	2.573	2.8588
8	Coca-Cola	0.800	0.800	0.888
9	Ifo	2.520	2.520	2.800
10	Iyana-Ilogbo	2.577	2.577	2.863

Table 5. Toxicity Potential calculated for 8hrs based on FEPA, WHO, USEPA Statutory limits

S/N	Junction	TP _{FEPA}	TP _{WHO}	TP _{USEPA}
1	Winners	1.4188	1.4188	1.5764
2	Toll Gate	1.6366	1.6366	1.8184
3	Industrial Estate	1.4227	1.4227	1.5800
4	Iyana-Iyesi	1.6311	1.6311	1.8123
5	Oju-Ore	1.4244	1.4244	1.5826
6	Idi-Iroko(Obasanjo)	1.5473	1.5473	1.7192
7	Joju	1.4372	1.4372	1.5968
8	Coca-Cola	0.4469	0.4469	0.4965
9	Ifo	1.4076	1.4076	1.5640
10	Iyana-Ilogbo	1.4395	1.4395	1.5994

Table 6. Toxicity Potential calculated for 24hrs based on FEPA, WHO, USEPA Statutory limits

S/N	Junction	TP _{FEPA}	TP _{WHO}	TP _{USEPA}
1	Winners	1.0439	1.0439	1.1598
2	Toll Gate	1.2042	1.2042	1.3380
3	Industrial Estate	1.0468	1.0468	1.1631
4	Iyana-Iyesi	1.2001	1.2001	1.3334
5	Oju-Ore	1.0480	1.0480	1.1640
6	Idi-Iroko(Obasanjo)	1.1384	1.1384	1.2648
7	Joju	1.0575	1.0575	1.1750
8	Coca-Cola	0.3288	0.3288	0.3653
9	Ifo	1.0357	1.0357	1.1507
10	Iyana-Ilogbo	1.0591	1.0591	1.1767

The toxicity potential values ranged from 1.6366 to 1.8184 for 8-hrs and a range of 1.2042 to 1.338 for 24hrs. The next highest TP is Iyana-Iyesi Junction, with a range from 1.6311 to 1.81234 for 8hrs and a range from 1.2001 to 1.3334 for 24hrs. This is a route for a number of automobiles. This region is regularly filled with commuters and passengers.

It was observed from the field that the 24-hour averaging period, as extrapolated, of Carbon Monoxide concentration at Toll-Gate Junction breached the standard. So, did every other sampling location except that of Coca-Cola Junction. Since automobiles contribute considerably to ambient gaseous emissions (Xing et al., 2012) decrease in the traffic holdups in the vicinity of this segment of the

high possibly will cut the Toxicity Potential. Likewise, at Iyana-iyesi Junction, the subsequent peak Toxicity Potential range in order of degree occurred here. This shows that road users along the road extend all the way to Iyana-Iyesi Junction. Shown in Figure 2 is the percentage impact of each of the selected sampling positions to the Carbon Monoxide level, overall, along Sango-Ota highway. This ranges between 10.357% and 12.042 %. Locations like Ifo, Winners and industrial estate are the least contributors (10.357%, 10.439 % and 10.4685%) (With exception to the control point) while Toll gate remains the highest contributor (12.042 %) with Iyana-Iyesi Junction as the next highest contributor (12.001). This ratifies the previous observation that traffic holdups around this segment of the highway should be minimized if not absolutely eliminated in order reduce the exposure of road users (commuters) to high level of Carbon Monoxide on the highway. Also, Coca-cola Junction being at 3.288 remains the control point.

TOXICITY POTENTIAL VALUES FOR 24HRS IN PERCENTAGE



Figure 2: Pie-chart showing 24-hrs Toxicity Potential Values in Percentages

4. Conclusion

The outcome of the study showed that emissions from automobiles contribute considerably to CO levels in the outdoor air with great health impact on humans along the highways in evolving cities. The toxicity potential greater than unity at the selected locations, besides the control location, calls for attention most especially for allergic persons, aged persons, young ones as well as persons with respiratory diseases. Transport related emissions contribute significantly to the Carbon Monoxide present in ambient air along this highway. In emerging cities where people prefer commuting in cars, this work is of great value to change people's perception on the levels of exposure to carbon monoxide that are experienced in traffic congestions and the effect of intake of carbon monoxide. Having known the toxicity potential of carbon monoxide from automobiles along Sango-Ota expressway through this study, appropriate agencies need to be made aware and road networks need to be intensified to decongest traffics along highways in emerging cities in developing countries.

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