Otuu et al., J Med Toxicol Res 2018, 1:2

Journal of Medical Toxicology Research

Research Article

A SCITECHNOL JOURNAL

Vehicular Activities and Tailpipe Carbon (II) Oxide Emission at Osisioma-Aba, Abia State, Nigeria: A Potential Public Health Hazard to Roadside Traders and Artisans

Otuu FC[1,2]*, Shu EN[1], Maduka IC[1,3], Ilouno L[4] and Okechukwu CC[5]

Abstract

Objective: Vehicular activities have been associated with Carbon (II) Oxide (CO) emission, which inhalation is implicated in the etiology of a cocktail of debilitating diseases. This study evaluated vehicular activities and the volume of CO emission at Osisioma-Aba, Abia State, Nigeria, to point out the potential public health challenges facing roadside traders and artisans.

Method: Vehicular activities and tailpipe CO emission were determined at designated locations (1, 2, 3 and 4) along the Osisioma-Port Harcourt Express road, using digital tally counter and Gasman gas monitors, respectively. The control location was at Owerre-Aba with less vehicular activity. Each location was clearly marked with Geographical Positioning System (GPS MAP$^{(R)}$ 78).

Result: The least number of vehicles (246) was recorded at location 3 between 8-9 am, while the highest number of vehicles (2540) was recorded at location 1 between 15:00-16:00 h, at the study site and between 89 and 244 at the control site. At all times, the total number of vehicles ranged from 1,109 vehicles between 8-9 am, to 9,417 vehicles between 15:00-16:00 h at the study site**.** The percentage differences between the vehicular load at the study site and that of the control site ranged between 91.98 during the period 8-9 am to 97.41 during the period between 15-16 pm. The vehicular load showed periodic and location variation with significant difference at $p<0.0001$. At the study locations, the CO volume ranged from 94.30 ppm (8-9 am) to 282.30 ppm (15-16 pm), and from 6.18 ppm (15-16 pm) to 8.56 ppm (9-10 am) at the control site. There were both location and periodic variations of CO volume at the study and control sites with significant difference at $p=0.0001$. There were significant correlations between vehicular load and CO emission ($r>0.8413$, $p<0.05$) at all the locations of the study site but not at the control site.

Conclusion: The values of tailpipe CO emissions at various points in the study site were above safety level as recommended by National and International regulatory bodies. This observation poses public health challenges to artisans and others who are continuously exposed to tailpipe CO emission at Osisoma-Aba.

Keywords

Tailpipe-emission; Carbon II oxide; Vehicular activities; Public health; Environmental pollution; Anthropogenic

Introduction

Urbanization, technological advancement and civilization are the triplet sisters responsible for air pollution. Air pollution is the introduction of foreign bodies in the ambient air or increasing the concentration of pre-existing ones beyond the normal environmental resilient properties and carrying capacity, resulting in systematic or total breakdown of the dynamic aero-equilibrium [1].

Automobiles in Nigeria are powered by petroleum products, which though consisting of hydrocarbons, contain some other chemical additives. On combustion, these constituent chemical compounds are released into the atmosphere, with potential for harming humans and animals. CO, a product of incomplete combustion, is a colourless, odourless and poisonous gas which has been associated with a lot of diseases, especially those of the respiratory and cardiovascular variant. The health effect of this gas appears to be age-dependent, as it is most pronounced in infants and aged people [2]. Immune compromised individuals are also highly susceptible to the deleterious effects of CO [3]. CO combustion is impaired by tail-pipe blockage commonly experienced in old vehicles which ply several roads in the cities of Nigeria, thus exposing the road users, hawkers, and artisans to the increased risk of inhalation and associated repercussions such as visual impairment, reduced work capacity and mental dexterity, poor learning ability, nausea, headaches, dizziness, and even death.

Some of the other by-products of petroleum products combustion such as CO_2, hydrogen sulphide, particulate matter, methane - are implicated in global warming and may synergistically interact with CO in disease aetiology. Exposure to motor vehicle pollutants can occur while inside vehicles and while working, walking or living along roadsides [4].

The environment of Aba Nigeria is dotted with artisanal shops and food vendors. In line with the increasing industrialization and concomitant urbanization, is an upsurge in vehicular activities. The vehicular activities pose a potentially grave danger to roadside traders and artisans who are constantly exposed to tailpipe CO emission and associated particulate matter pollutants. The urban atmosphere is subjected to large inputs of contaminants, the composition of which reflects the contribution of different sources [5]. These sources are mainly anthropogenic and include asphalt, weathered street materials, biomass combustion, industries and automobiles [6]. The contribution of urban atmospheric contaminants by automobiles appears to be more significant particularly in developing countries [7,8]. In most developing countries including Nigeria, vehicle emissions standards, even if they exist are not adequately enforced and in addition, the use of leaded fuel continues to persist. Pollution of the urban atmosphere by contaminants arising from automobiles and other sources is considered a real and serious problem [9]. This is because these contaminants have various effects including acceleration of the deterioration of materials, reduction in visibility and interference with human comfort and health [10,11].

***Corresponding author:** Otuu FC, Department of Pharmaceutics, Faculty of Pharmaceutical Sciences, University of Nigeria Nsukka, Enugu State, Nigeria, Tel: +234 703 245 4222; Email: fred.otuu@unn.edu.ng

Received: April 13, 2018 **Accepted:** May 24, 2018 **Published:** May 30, 2018

There is a need to investigate the relationship between heavy vehicular activities and CO emissions. This will aid in understanding the need to enforce mitigating measures against CO pollution of vehicular origin. Thus, this study is designed to assess the relationship between vehicular activities and tailpipe Carbon (II) Oxide emission at some points along Osisioma-Portharcourt express road in Aba, Abia State, Nigeria.

Materials and Methods

Study area

Aba is a cosmopolitan city reputed for its commercial activities and may be considered as a stop-over town for vehicles from Owerri, in Imo State, Umuahia, in Abia State and Enugu, in Enugu State en-route Port Harcourt in Rivers State and vice versa .The Aba general motor park for inter-state commuters is also located in Osisioma and so are many hotels, private and public schools. Military base and Abia State Polytechnics are within trekking distance to the study area. Automobile repair and service stations are common features with local eateries and other artisanal activities dotting the landscape .The environment of Aba is characterized by a beehive of human and vehicular activities, making it the busiest part of the Abia state, Nigeria. The control location was in Owerre-Aba, about three kilometres away from Osisioma, and known for low vehicular activity. All study and control locations were clearly marked with Geographical Positioning System (GPS).

Methodology

The vehicular activities were evaluated by numerical counting of total number of vehicles per hour for eight hours (8 am-4 pm) per day for five days, using hand-held digital tally counter. The average number of vehicles for 8 h on each day was taken as the vehicular activity for that day, from day 1 to day 5. Both gas monitoring and vehicular activities were done at designated locations (1, 2, 3 and 4).

The tail pipe CO gas emissions along Osisioma-Port Harcourt Express road was analyzed by direct reading engineering method (DREM) using Gasman gas monitors pre-calibrated according to manufacturer's instructions. The gas monitor was continuously exposed all through the day and readings were taken intermittently at 5 min interval for 12 readings in an hour. The average of the readings for one hour was taken as the cumulative CO gas emission in an hour and the average of the hourly readings for 8 h was taken as the cumulative gas emission for the day at each location, from day 1 to day 5.

One way Analysis of Variance (ANOVA) was used to compare gaseous emission and vehicular activities among the locations, while correlation analysis was used to determine the relationship between gaseous emission and vehicular activities at each location.

Results

The results of the study are presented in Tables 1 and 2 and Figures 1 (a-d). The least number of vehicles (246) was recorded at location 3 between 8-9 am, while the highest number of vehicles (2540) was recorded at location 1 between 15:00-16:00 h, at the study site and between 89 and 244 at the control site. At all times, the total number of vehicles ranged from 1,109 vehicles between 8-9 am, to 9,417 vehicles between 15:00-16:00 h at the study site**.** The percentage

Table 1: Total number of vehicles in five days of the week at the study and control sites.

Vehicle Type	**Time Interval**							
	8 -9 am	**9-10 am**	**10-11 am**	**11-12 am**	**12-13 pm**	**13-14 pm**	**14-15 pm**	**15-16 pm**
Location 1	291	438	891	1026	1188	1281	1581	2540
Location 2	283	418	514	605	826	1109	1234	2431
Location 3	246	531	681	661	736	1458	2068	2393
Location 4	289	415	521	733	918	1483	1883	2053
Total (Test)	1109	1802	2607	3025	3668	5331	6766	9417
Average One-way ANOVA (F = 49.36, P<0.0001)								
Total (Control)	89	114	102	126	183	189	186	244
% Difference	91.98	93.67	96.09	95.84	95.01	96.46	97.25	97.41

Table 2: Carbon II oxide levels (ppm) at various locations compared to the corresponding period of the Control site.

Locations	**Time Interval**							
	8 -9 am	**9-10 am**	**10-11 am**	**11-12 am**	**12-13 pm**	**13-14 pm**	**14-15 pm**	**15-16 pm**
	Mean (SEM)	**Mean (SEM)**	**Mean (SEM)**	**Mean (SEM)**	**Mean (SEM)**	**Mean (SEM)**	**Mean (SEM)**	**Mean (SEM)**
Control	4.91 (0.71)	8.56 (0.73)	3.19 (0.22)	3.21 (0.36)	4.11 0.60	4.94 (1.40)	7.23 (0.76)	6.18 (1.34)
Location 1	94.30* (4.87)	115.0* (8.54)	94.4** (14.67)	182.8* (14.91)	171.2*** (29.16)	191.3* (3.04)	201.9* (19.79)	282.3* (29.65)
Location 2	184.5* (21.34)	193.8* (17.34)	182.8* (26.78)	212.6* (29.47)	187.7* (20.95)	229.4* (24.38)	208.6* (8.90)	243.6* (17.32)
Location 3	171.4* (3.90)	181.5* (23.46)	148.0* (15.14)	187.6* (14.01)	222.0* (13.47)	206.5* (23.17)	242.6* (19.50)	260.0* (22.58)
Location 4	112.7* (9.88)	156.4* (12.22)	136.0* (12.27)	152.6* (7.02)	176.0* (16.58)	190.3* (6.68)	230.5* (10.85)	237.2* (13.87)
One-way ANOVA (F = 7.128, P = 0.0001)								
*P<0.0001, **P = 0.0003, ***P = 0.0004								

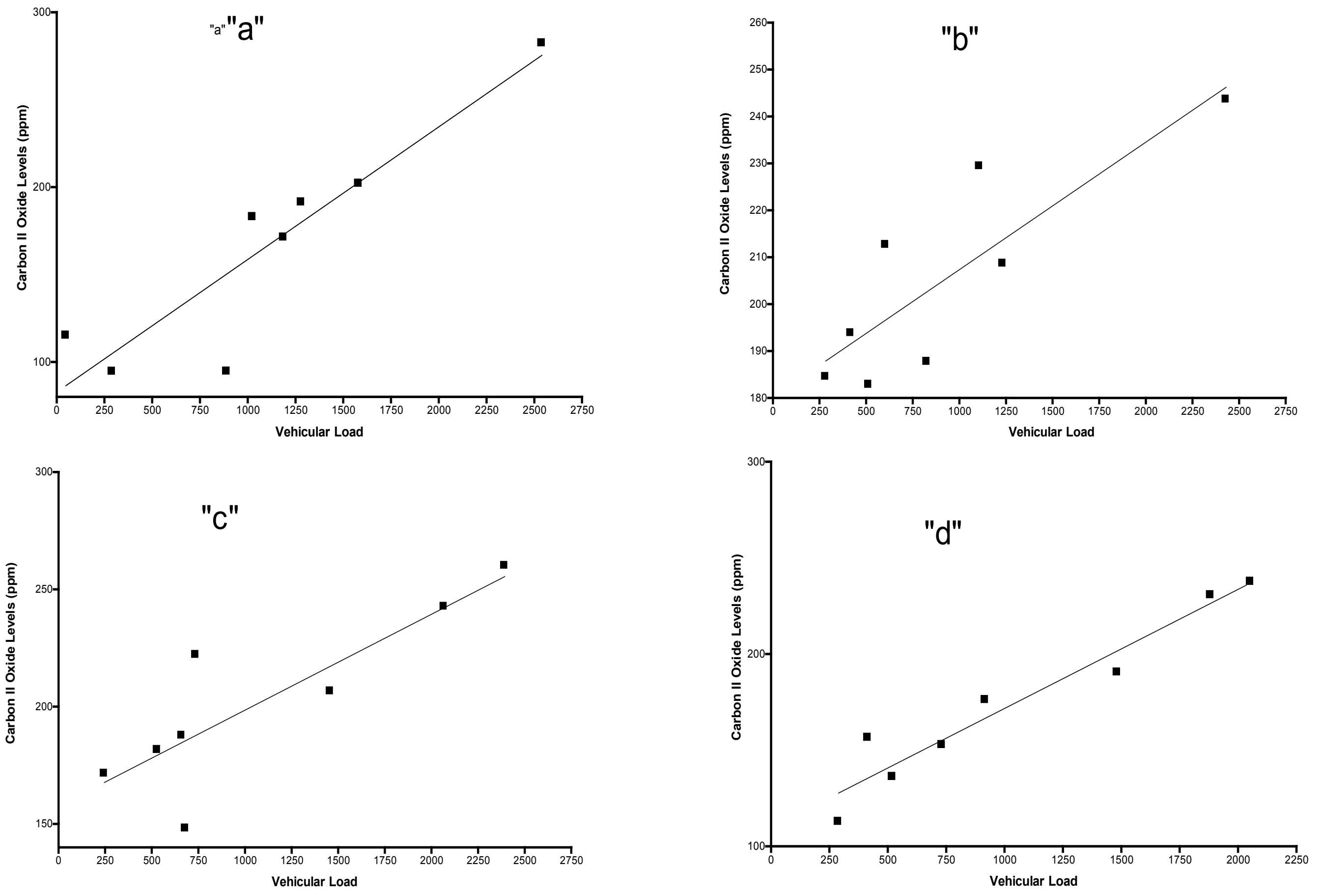

Figure 1: Figures 1(a-d) presents the correlation of vehicular load with CO values of various days at the study site. Figure 1a presents the vehicular load versus the CO emission at location 1, while Figures 1b, 1c, and 1d represent vehicular volume and CO values at locations 2, 3, and 4 respectively.

differences between the vehicular load at the study site and that of the control site ranged between 91.98 during the period 8-9am to 97.41 during the period between 15-16 pm.

Vehicular activities increased across the table from 8-9 am to 15-16 pm at all locations, with the peak period at 15-16 pm. The vehicular load showed periodic and location variation with significant difference at $p<0.0001$. During the period between 8-9 am, location 1, recorded the highest number of vehicles, followed by locations 4, 2 and 3, respectively. The period between 9-10 am recorded the highest vehicular load at location 3, followed by locations 1, 2 and 4 respectively. Location 1 recorded the highest numbers of vehicles during the period between 10-11 am, followed by locations 3, 4 and 2 respectively. The period between 11 am-12 pm recorded the highest number of vehicles at location 1, followed by locations 4, 2 and 3 respectively. During the period between 13-14 pm, the highest number of vehicles was recorded at location 4, followed by locations 3, 1 and 2 respectively. The highest number of vehicles was recorded at location 3, followed by locations 4, 1 and 2, during the period between 14:00-15:00. The vehicular number followed a decreasing order down the table from locations 1-4, during the period between 15-16 pm.

Table 2 presents the volume of carbon (ii) oxide (CO) in parts per million (ppm) emitted from the vehicles at various locations and times in the study site, compared to the control site locations. At the test location, the CO volume ranged from 94.30 ppm (8-9 am) to 282.30 ppm (15-16 pm) at location 1. The highest volume of CO at the control site was recorded during the period between 9-10am (8.56 ppm), followed by the periods between 14-15 pm (7.23 ppm) and 15-16 pm (6.18 ppm). There were both location and periodic variations of CO volume at the study and control sites with significant difference at $p=0.0001$.

At the study site the period between 8-9 am, recorded the highest volume of CO at the location 2, followed by locations 3, 4 and 1 respectively. The period between 9-10 am recorded the highest CO volume at location 2, followed by locations 3, 4 and 1 respectively. The same trend followed in the period between 10-11 am. The period between 11 am-12 pm witnessed the highest CO emission at location 2, followed by locations 3, 1 and 4. During the period between 12 am-13 pm, the highest volume of CO emitted was recorded at location 3, followed by locations 2, 4, and 1. The period between 13-14 pm recorded highest CO volume at location 2, followed by locations 3, 1 and 4. Location 3 recorded the highest volume of CO, followed by locations 4, 2 and 1, during the period between 14-15 pm, while the period between 15-16 pm recorded highest CO at location 1, followed by locations 3, 2 and 4.

Figures 1(a-d) present the correlation of vehicular load with CO values of various days at the study site. Figure 1a presents the vehicular load versus the CO emission at location 1, while Figures 1b, 1c, and 1d represent vehicular volume and CO values at locations

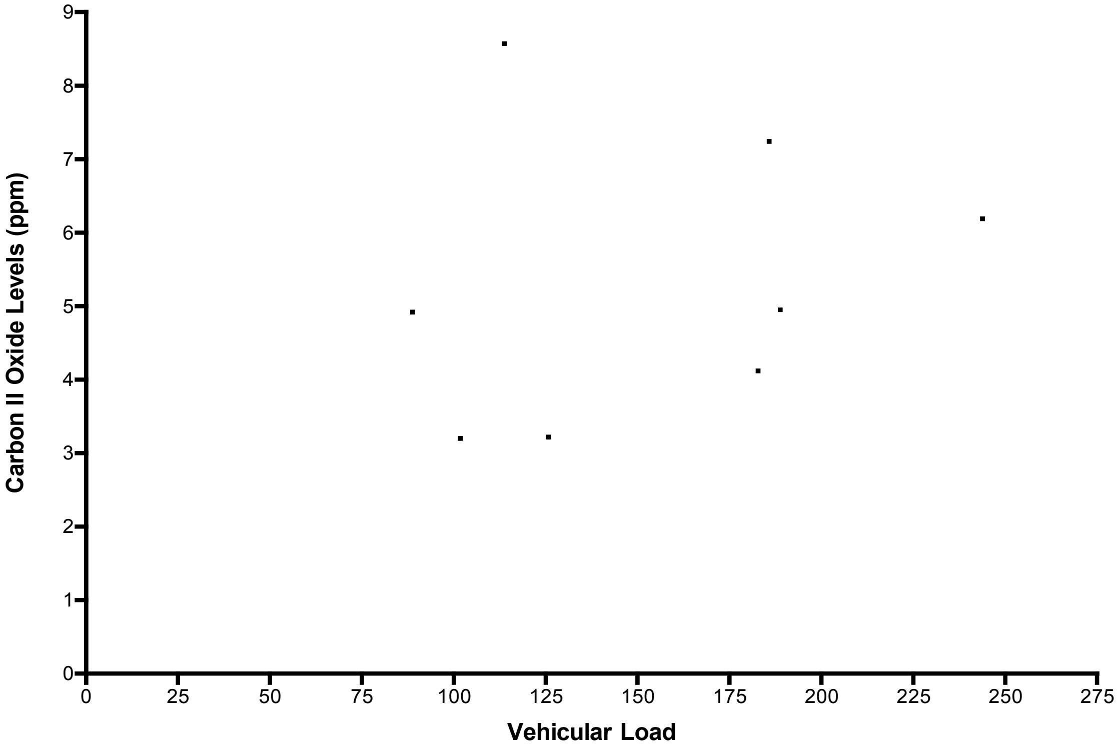

Figure 2: Figure 2 represents the vehicular load and the CO emission at the control site.

2, 3 and 4 respectively. At this study site, there were significant correlations between vehicular load and CO emission at location 1 (Pearson r=0.9136 at 95% confidence interval, p=0.0015), at location 2 (Pearson r=0.8413, p=0.0088), at location 3 (Pearson r=0.8505, p=0.0074), and at location 4 (Pearson r=0.9645, p=0.0001). Figure 2 represents the vehicular load and the CO emission at the control site, and there was no significant correlation between the vehicular load and CO emission (Pearson r=0.2166, p=0.6064).

Discussion

Ambient air pollution of anthropogenic origin remains one of the major environmental problems facing the global community. It is well known that urban environments contain higher ambient carbon (II) oxide or carbon monoxide (CO) concentrations, primarily due to automotive emissions, and non-smoking city dwellers have been found to have carboxyhemoglobin (COHb) levels in the 1-2% range [12]. CO from motor-vehicle exhausts is the single most common cause of poisoning deaths in the United States [13]. Of the 11 547 unintentional CO deaths during 1979-1988, 57% were caused by motor vehicle exhausts, 83% of these were associated with stationary vehicles.

Recently, the problems of environmental pollution have been forced into the mass consciousness in Nigeria, as a result of the devastating effects of petroleum-related pollution, especially the oil spills and gas flaring. Regrettably, little has been reported on the damaging effects of mobile transportation as a source of air pollution [14-16]. This study brought forth the case of vehicular activities and CO emission at some points along Osisioma-Port Harcourt express road in Aba, Abia State, Nigeria. In this study, at all times, the total number of vehicles ranged from 1,109 vehicles between 8-9 am to 9,417 vehicles between 15:00-16:00 h**.** The CO volume ranged from 94.30 ppm between 8am and 9 am to 282.30 ppm between 15.00 and 16.00 pm. The highest volume of CO at the control site (8.56ppm) was recorded during the period between 9-10 am, followed by 7.23 ppm and 6.18 ppm from 14.00-1500 pm and 15.00-16.00 pm respectively. The values of tailpipe CO emissions at various points in the study site were above safety level as recommended by National and International regulatory bodies. There were significant correlations between vehicular loads and CO emissions in each of the four locations of the study, but not in the control site.

Vehicular activities increased as the day progressed from early noon to early evening. This is usually the period of peak human activities when traders, artisans, school children and civil servants are involved in mass transit to or from their different points of engagements. The report agrees favourably with the study of Etiuma et al. [17]. At these periods, the volume of CO recorded showed an increasing trend; thereby implicating vehicular activities as a causative factor in tailpipe-CO emission [18-20].There were also variations in the vehicular load across the locations with locations 1 and 3 recording high number of vehicles at most times. These locations had multiple pot holes which slowed down vehicle transient period. At such point also, road side trading abounds, thereby increasing the population of people exposed to tail pipe CO emission.

Decrease in transient period resulted in more vehicular activities at such points and hence higher volume of CO emission. The works showed that the nature of roads in a city could affect vehicular load [21,22], with bad roads experiencing more congestion, higher number of vehicles per given time, and higher volume of vehicular tail pipe emission. The high values of CO obtained at the study site are in tandem with the works of Koku and Osantogun [23] who reported CO range of 233-317ppm in three cities (Lagos, Ibadan and Ado) in Nigeria.

The significant correlation between vehicular load and CO emission observed at the four points in the study site as opposed to no correlation at the control site pointed to the fact that artisans and road side traders along the Osisioma Port-Harcourt express road are at the risk of public health challenges associated with continuous exposure to tail pipe CO emission. Exposure to ambient air CO at short or long term has negative health implications. Inhaling the gas can lead to hypoxic injury, nervous system damage, and even death. Different people and populations may have different carbon monoxide tolerance levels [24]. On average, exposures at 100 ppm or greater is dangerous to human health [25]. In the United States, the Occupational Safety and Health, (OSHA) limits long-term workplace exposure levels to less than 50 ppm averaged over an 8-h period [26]. This is worrisome since the values of CO obtained at various locations are well above the statutory ranges, though the CO tolerance level for any person is altered by several factors, including activity level, rate of ventilation, a pre-existing cerebral or cardiovascular disease, cardiac output, anemia, sickle cell disease and other hematological disorders, barometric pressure, and metabolic rate [27,28] When a fragile economic base and high rate of illiteracy among the artisans and road side traders in Osisioma are considered, the future of their public health in a CO polluted environment is hazy.

Osisioma, located at the outskirts of Aba-a cosmopolitan city reputed for its commercial activities besides being considered as a stop-over town for vehicles from Owerri in Imo State, Umuahia in Abia State and Enugu in Enugu State en-route Port Harcourt in Rivers State and vice versa, may also be seen as a semi-industrialized sub-urban town. Canopy pollution of the urban cities resulting from urban industrialization is one of the micro-climatic problems faced by many urban cities [29]. The role of canopy pollution in increasing urban heat mass transfer contributes in the volatilization of tailpipe emissions, enhancing the distribution of CO beyond the immediate generation point, to residential houses, schools, hospitals, and eateries where children, pregnant women, aged people and patients may be exposed to the dangers of continuous exposure to CO inhalation.

The acute effects produced by CO in relation to ambient air concentration have been reported by Goldstein [30] and Struttmann et al. [31]. The following symptoms are associated with CO at various concentrations: headache and dizziness within six to eight hours of constant exposure (35 ppm), slight headache in two to three hours (100 ppm), loss of judgment (200 ppm), frontal headache within one to two hours (400 ppm), dizziness, nausea, and convulsions within 45 min; insensible within 2 h (800 ppm), headache, increased heart rate, dizziness, and nausea within 20 min; death in less than 2 h (1600 ppm), headache, dizziness and nausea in five to ten minutes, death within 30 min (3200 ppm), headache and dizziness in one to two minutes, convulsions, respiratory arrest, and death in less than 20 min (6400 ppm) and unconsciousness after 2-3 breaths, death in less than three minutes (12800 ppm). In a culture characterized by inadequate public health awareness, poor diagnostic facilities and ineffective national health policy, the possibility of deaths resulting from undiagnosed CO poisoning may not be ruled out.

The economic depression in Nigeria, coupled with illiteracy has forced many married women s tissue hypoxia by decreasing the release of maternal oxygen to the fetus. Carbon monoxide also crosses the placenta and combines with fetal hemoglobin, causing more direct fetal tissue hypoxia. Additionally, fetal hemoglobin has a 10 to 15% higher affinity for carbon monoxide than adult hemoglobin, causing more severe poisoning in the fetus than in the adult [32]. Elimination of carbon monoxide is slower in the fetus, leading to an accumulation of the toxic chemical [33]. The level of fetal morbidity and mortality in acute carbon monoxide poisoning is significant, so despite mild maternal poisoning or following maternal recovery, severe fetal poisoning or death may still occur [34].

CO intoxication follows many pathways, one of which is destruction of the mitochondrial respiratory enzyme-chain; this limits the effectiveness of tissue oxygen utilization, leading to the formation of metabolic intermediaries such as ketone bodies. Also, the rate of dissociation between carbon monoxide and cytochrome oxidase is slow, causing a relatively prolonged impairment of oxidative metabolism [35]. The situation is exacerbated when poor dietary knowledge is linked to illiteracy and poverty - the two common features among the low income street traders and artisans. The rising cases of dietary-related diseases in the country may not be without metabolic defects of environmental-induced cellular oxidative stress.

One other feature of Osisioma-Port-Harcourt express road is the proliferation of eateries and kiosks very close to the road. These provide food and snacks to the artisans and other people on transient, making Osisioma a bedlam of human activities at most times of the day. Stationary tricycles and commuter buses waiting for passengers play major roles in CO pollution of the study area, beside pockets of automobile repair and service stations littered within the environment.

Conclusion

Environmental pollution constitutes one of the major problems confronting the global community, especially in urban communities such as Aba where artisanal activities, operation of commercial tricycles and other vehicles are the predominant occupation among the peasants. This poses a significant public health problem when the poor road network and maintenance result in vehicular congestion at some populous locations. In such a situation, inhalation of CO from the atmospheric air exposes humans to dangers of airborne diseases.

CO pollution was found to be generally higher in the locations with highest traffic volume, suggesting the influence of location and traffic volume on atmospheric CO loads. The planting of trees to serve as sinks for these pollutants and the use of sustainable transport systems, particularly mass transit, should form the key focus of transport and urban planning in the congested high vehicular load of Osisioma-Aba.

Tailpipe CO pollution of the atmosphere is a real and serious problem especially in urban areas. Vehicular traffic is an important source of CO and heavy metals in the urban air. There is a need for appropriate government agencies to enforce the installation of emission monitoring devices on vehicles to checkmate the level of tailpipe emission in Aba urban community. Vehicles found not to be road worthy by virtue of CO emission beyond acceptable standards should be removed from circulation. The use of appropriate respirators by artisans and those whose occupations expose them to tailpipe emission should be encouraged.

Preventive and Intervention measures are important public health tools. When the case of old automobiles capable of generating high ambient CO concentration cannot be totally prevented, an intervention method using a Catalytic Connector to minimize discharge of CO may be adopted. This is where mass education on the health effects of CO is needed, as well as instigating stringent regulatory measures by the appropriate government agencies.

Citation: Otuu FC, Shu EN, Maduka IC, Ilouno L, Okechukwu CC (2018) Vehicular Activities and Tailpipe Carbon (II) Oxide Emission at Osisioma-Aba, Abia State, Nigeria: A Potential Public Health Hazard to Roadside Traders and Artisans. J Med Toxicol Res 1:2.

References

1. Otuu FC, Inya-Agha, Stella I, Ude CC, Chinyere CC, et al. (2014) Physico-chemical Profile and Phyto-remediation of Ebony Paint Industrial Effluent using n-Hexane de-fatted *Moringa Oleifera* Seed Powder. J Environ Sci Toxicol Food Technol 8: 59-64.
2. Olson K, Smollin C (2008) Carbon monoxide poisoning (acute). BMJ Clinical Evidence 2008: 2103.
3. Quinn DK, McGahee SM, Politte LC (2009) Complications of Carbon Monoxide Poisoning: A Case Discussion and Review of the Literature. Prim Care Companion J Clin Psychiatry 11: 74-79.
4. WHO (1999) Environmental Health Criteria 213: Carbon Monoxide (2 Edtn). World Health Organisation Finland.
5. Colombo JC, Landoni P, Bilos C (1999) Sources, distribution and variability of air borne particles and hydrocarbons in La Plata area, Argentina. Environ Pollut 104: 305-314.
6. Takada H, Onda T, Ogura N (1990) Determination of Polycyclic aromatic hydrocarbons in urban street dusts and their source materials by capillary gas chromatography. Environ Sci Technol 24: 1179-1186.
7. Gunn EO, Adinna EN, Ekop OB, Attah VI (2003) Towards a green transport policy for Nigeria. Snaap Press, Enugu, Nigeria.
8. Horaginamani SM, Ravichandran M (2002) Ambient air quality in an urban area and its effects on plants and human beings: A case study of Tiruchirappalli, India. J Sci Eng Techn 6: 13-19.
9. Beckett KP, Frees-Smith PH, Taylor G (1998) Urban Woodland: Their role in reducing the effects of particulate pollution. Environ pollution 99: 346-360.
10. Itam A (1990) Health effects of environmental pollutants. St Louis Press, Carlifornia, USA.
11. Ikuruekong EE (2003) Urban Vehicular Traffic and air pollution in Uyo. SNAAP Press, Enugu, Nigeria.
12. Stewart R, Baretta E, Platte L (1974) Carboxyhemoglobin levels in American blood donors. JAMA 229: 1187-1195.
13. Hampson NB (1998) Emergency department visits for carbon monoxide poisoning in the Pacific Northwest. J Emerg Med 16: 695-698.
14. Faboya O (1997) Industrial pollution and waste management. Ibadan Davidson Press, Nigeria: 26-35.
15. Magbagbeola NO (2001) The use of economic instruments for industrial pollution abatement in Nigeria: Application to the Lagos Lagoon. Ibadan, Nigeria: 535-556.
16. Iyoha MA (2002) The environmental effects of oil industry activities on the Nigerian Economy: a theoretical analysis. Proceedings of National Conference on the Nigerian Petroleum Industry and the Niger Delta Environment.
17. Etiuma R, Uwah I, Etiuma A (2006) Level of nitrogen dioxide (NO_2) in Calabar city, Nigeria and health implications. Int J Chem 4: 229-233.
18. Oluwande PA (1977) Automobile-traffic and air pollution in a developing country: an example of affluence-caused environmental problems. Int J Environ Res 11: 197-203.
19. Goyal S (2006) Understanding Urban vehicular pollution problem visa-vis ambient air qualities study of Megairty (Delhi, India). Environ Monit Assess 119: 557-569.
20. Oguntoke O, Yusuf AS (2008) Air pollution arising from vehicular emissions and the associated human health problems in Abeokuta metropolis, Nigeria. Asset Series 8: 119-132.
21. Arokodare L (1976) Road accident data, Nigeria 1972 to 1975, analysis and interpretation. Ibadan branch, Nigeria.
22. Alo B, Abayomi A, Osuntogun B, Olayinka K (2007) Urban highway runoff in Nigeria I. Heavy metals in sheet flow from the main expressway in Lagos metropolis. J Appl Sci 7: 2800-2805.
23. Koku CA, Osuntogun BA (2009) Environmental impacts of road transportation in Southwestern states of Nigeria. J Appl Sci 7: 2536-2360.
24. Raub JA, Mathieu-Nolf M, Hampson NB, Thom SR (2000) Carbon monoxide poisoning-a public health perspective. Toxicology 145: 1-14.
25. Prockop LD, Chichkova RI (2007) Carbon monoxide intoxication: an updated review. J Neurol Sci 262: 122-130.
26. Kao LW, Nañagas KA (2006) Toxicity associated with carbon monoxide. Clin Lab Med 26: 99-125.
27. Carbon Monoxide (2009) American Lung Association.
28. Lipman GS (2006) Carbon monoxide toxicity at high altitude. Wilderness Environ Med 17:144-145.
29. Raub (1999) International Programme on Chemical Safety. World Health Organization Geneva.
30. Goldstein M (2008) Carbon monoxide poisoning. J Emerg Nurs 34: 538-542.
31. Struttmann T, Scheerer A, Prince TS, Goldstein LA (1998) Unintentional carbon monoxide poisoning from an unlikely source. J Am Board Fam Pract 11: 481-484.
32. Omaye ST (2002) Metabolic modulation of carbon monoxide toxicity. Toxicology 180: 139-150.
33. Greingor JL, Tosi JM, Ruhlmann S, Aussedat M (2001) Acute carbon monoxide intoxication during pregnancy. One case report and review of the literature. J Emerg Med 18: 399-401.
34. Farrow JR, Davis GJ, Roy TM, McCloud LC, Nichols GR (1990) Fetal death due to nonlethal maternal carbon monoxide poisoning. J Forensic Sci 35: 1448-1452.
35. Hardy KR, Thom SR (1994) Pathophysiology and treatment of carbon monoxide poisoning. J Toxicol Clin Toxicol 32: 613-629.

Author Affiliations

Top

[1]*Molecular and Environmental Toxicology Research Group, Department of Pharmacology and Therapeutics, College of Medicine, University of Nigeria, Enugu Campus, Enugu, Nigeria*

[2]*Department of Pharmaceutics, Faculty of Pharmaceutical Sciences, University of Nigeria Nsukka, Enugu State, Nigeria*

[3]*Department of Human Biochemistry, Nnamdi Azikiwe University, Awka, Nigeria*

[4]*Department of Biochemistry and Molecular Biology, Federal University, Dutsinma, Katsina State, Nigeria*

[5]*Green Afrique Project, Plot 46, Gana Street, Maitama, Abuja, Nigeria*