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ASSESSMENT OF IN-TRICYCLE EXPOSURE TO CARBON MONOXIDE EMISSION ON ROADS IN NIGERIAN URBAN CENTRES

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ABSTRACT

This research project investigates in-tricycle exposure to carbon monoxide emission on roads in Nigerian urban centres. Pollution was discussed with air pollution as priority, carbon monoxide a criteria air pollutant was used as case study. The minor and adverse effects of carbon monoxide exposure were buttressed, including its sources, majorly from incomplete combustion of fuel in automobile. This research displays a basic audit of overall research work led to portray CO exposure inside tricycles. Specific sampling roads were selected in urban areas, majorly areas with high traffic congestion, measurement methods for field testing are exhibited alongside levels of exposure of the passengers to the measured carbon monoxide. Using the results obtained from this research statistical and graphical analysis were carried out, five out of the six sampling routes were identified to have concentrations that exceed standards of environmental and regulatory bodies. Governmental and environmental limits for carbon monoxide, range between the values of 9-10ppm. The control road showed an ideal in-tricycle carbon monoxide level due to less traffic, therefore was considered safe. This research also proved that the level of exposure to carbon monoxide on roads is relative to the extent of traffic congestion. Extrapolation was carried out to obtain 8-hour and 24-hour averaging periods to determine the exposure level over time, even if the traffic disperses, the out of the six roads still showed high concentration values after 8 hours and 24 hours. This research proved that passengers are exposed to carbon monoxide in tricycles. The level of exposure can also be present in concentrations *enough to harm the health of passengers. Recommendations were made to help reduce high carbon monoxide concentrations in tricycles.*

Keywords: Carbon Monoxide, Emission, Air Quality, Standards.

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1. INTRODUCTION

Transportation is no doubt whatsoever an irreplaceable catalyst for actuating, stimulating and activating the tempo of economic, social, political and strategic advancement in any country all over the world. Consequently, efficient and effective functioning of urban centres relies upon provision of basic infrastructures one of the most essential being transport. This suggests that transport framework must be rationally developed to guarantee that movement of people and goods happens speedily, economically, safely, comfortably and in an environmentally-friendly manner (Sumaila, 2012). But despite that report, environmental research has shown that increase in influx of means of transport has also increased the pollution rate drastically. Therefore the fact that transportation is major source of air pollution cannot be over emphasized.

According to the European Union council directive on integrated pollution prevention and control (IPPC) (1996), pollution is defined as the indirect or direct introduction of substances, vibrations, heat or noise in the air, water or land, as a result of human activity which may be harmful to health and the quality of the environment. This results in damage to property, interference with amenities and other uses of the environment that are legitimate. Air pollution can also be defined as the presence of one or more gaseous or particulate contaminants in the indoor or outdoor atmosphere in quantities, characteristics and of duration such a way that it is injurious and harmful to human life, plants, animals or property, which creates unreasonable interference with the comfortable enjoyment of life and property (Odigure, 1998).

Industrial revolution, transport system included, has led to global problem of air pollution. The problem poses adverse effects on industrialised areas of the world and urban centres including Port Harcourt metropolis, located in the southern part of Nigeria, therefore assessments of air quality studies in Nigeria have majorly focused on urban centres. In urban centres, industrial processes, traffic congestion and domestic activities usually part of everyday life, constitute major sources of air pollution (Fagbeja et al., 2008; Robert, 2015). Air pollution is associated with increasing cases of many adverse health and environmental effects, e.g. mortality, respiratory diseases, global warming, cancer. Aside of the widely known, drastic and documented effect on human health, the high concentration of these gaseous emissions can lead to stunted growth of plants, haze, damage to buildings, etc.

In Nigeria, road transport is a major mode of transportation, owing to its flexibility. As of the year 2000, the population of the world vehicle grew to 700 million (Ghose et al., 2004). So, in developing countries like Nigeria. Incomplete combustion is paramount as a result. This has led to an increase in criteria air pollutants (CO_2, CO, NO_X, SO_2, PM, etc) due to incomplete combustion taking place in such vehicles as a result of lack of maintenance. There is an increase in consumption of motor fuel including petrol and diesel, therefore corresponding increase in criteria air pollutants including carbon monoxide. In 2013, National Environmental Standards and Regulation Enforcement Agency (NESREA) carried out air quality monitoring in selected areas of the Federal Capital Territory (FCT) Abuja in Nigeria, which showed high levels of gaseous emissions such as; CO, CO_2, SO_2, NO_x and Particulate matter, in areas with high concentration of vehicular activities (NESREA, 2013). Previous studies in Nigeria had given more attention to pollution emanating from industries, and have overlooked the pollution caused by mobile means of transportation (Faboya, 1997). Ambient air studies on roads in urban centres have been carried out with respect to some of the gaseous pollutants (Nwagaozie et al, 2015), monitoring of carbon monoxide exposure at road junctions (Robert, 2015), assessment of particulate based matter air quality index (Oladapo et al, 2017), studies on traffic evaluation in urban centres and its relation to air pollution (Mustapha et al, 2011) had been reported.

Despite the research areas covered so far, a gap has been identified: In-tricycle Exposure to Emissions. So far, no research has been conducted in this area. It cannot be denied that the use of tricycle in Nigeria today, especially as a commercial means of transportation in urban centres with high concentration of traffic is rapidly measuring up to the populace of cars and buses, especially in areas like Port Harcourt metropolis, Owerri, Lagos state capital, Ikeja where the use of commercial motorcycles have been banned, tricycle has taken over the commercial transport system, as it is considered a means of affordable and fast transportation, “to beat traffic”. The rate of importation of tricycle, also known as “keke” is annually increasing. We have to ascertain the health and safety of people relating to the use of this means of transport. Therefore this research focuses on the exposure of individuals to carbon monoxide level when on aboard in tricycles in Nigerian urban centres. Urban centres proven to have a high concentration of traffic congestion, due to several activities carried out, will be the primary focus of this research. Carbon monoxide, a deadly gas, can lead to instant death by direct exposure and other health consequences, is the specific pollutant of study in this research, as the major source of carbon monoxide present in our environment is due to incomplete combustion of exhausts of transport vehicles, tricycles included.

National Environmental Standards and Regulations Enforcement Agency (NESREA) established environmental standards which need to be enforced starting from the point of view of carbon monoxide exposure monitoring. In-tricycle Carbon Monoxide Emission Exposure needs monitoring in urban settlement, most especially around residential areas, considering its drastic risk on human health.

2. RESEARCH METHODOLOGY

2.1. The General Experimental Procedures

In this chapter, the various procedures and materials used in the study are discussed. The general procedure included: identifying sampling locations on major roads in Port Harcourt an urban centre in Rivers State, Nigerian; measuring carbon monoxide (CO) concentrations at the sampling locations on the identified roads; and determining the levels of exposure of the passengers to the measured concentrations of CO emission.

2.2. The Study Area

Port Harcourt (latitude 4°49/N, longitudes 7°2/E) is the capital of Rivers state, located in the Southern part of Nigeria at the coastal region (along the Bonny river). Port Harcourt city has been carefully elected for this study due to some of the characteristics it possesses and the fact that not much air pollution studies have been carried out in the highly industrialised city. It is one the most important urban centres in Nigeria with a dynamic population of more than two million residents. It is a metropolitan city, with several industries located in it ranging from manufacturing to oil and gas majorly. The city is the capital of oil and gas in Nigeria. Its metropolis extends from International air terminal at Omagwa and furthermore from the

Refinery at Eleme to Choba Community, the whole city is a zone in the vicinity of 1300 and 1800 km^2.

2.2.1. Climate

The city has a tropical wet climate with heavy and long rainy season and a short dry season. The average month to month precipitation ranges between 20.7 and 434.0 mm, with a yearly level of more than 3000 mm. November to January is its most reduced rainfall period while February to June is its first peak, followedd by the second peak in September. The temperature has little variation average between 25-28°C.

2.3. Identification of Sampling Points on Major Roads in Port Harcourt

A trip was taken round the metropolitan city of Port Harcourt to identify major roads always having traffic congestions. The busy roads selected were the ones involving tricycles (Plate 3.1). Five of these roads were selected and one road with free flow of traffic as control axis.

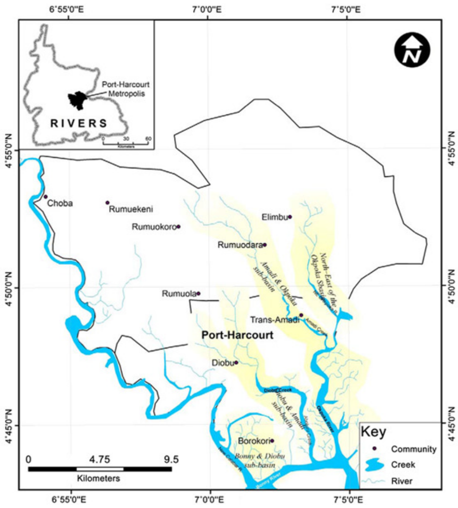

Figure 3.1 A map of the study area in Port Harcourt

Source: Google maps.

Plate 3.1 Scenarios of the selected roads

2.4. Measurement of Carbon Monoxide Concentrations on the Identified Sampling Roads

This involves the description of the major equipment used and the actual measurement of the carbon monoxide concentrations on the identified sampling routes on the selected major roads.

2.4.1. Description of the equipment used, GM8805 benetech carbon monoxide monitor

The GM8805 benetech carbon monoxide monitor is a language compatible gas monitor suited to both the low, medium and moderately high concentrations of carbon monoxide measurement (Plate 3.1). It has the capacity to measure CO concentrations in the range of 0 to 1000 ppm with both resolution and minimum reading of 1 ppm. The basic error is ± 5% (F.S), ± 10ppm while the response time is 60 seconds with a sensor type of Electrochemical CO. GM8805 benetech carbon monoxide monitor has buzzer alarm limit settings with the capacity to check the highest and the lowest concentrations. It has the ability to retain maximum and average data. It possesses auto power off function with low power indicator.

GM8805 benetech carbon monoxide monitor is a device with factory fitted LCD backlight and design to work in the environment of temperatures ranging from 0 ~ 50ºC (32 ~ 122ºF). It works within the relative humidity of 10 ~ 75%. GM8805 benetech has the dimensions of 55.7 x 29.9 x 135.5mm and weight of 104g with 2x1.5V AAA battery. It is widely used in petroleum, chemical, metallurgy, papermaking, food, textile and other industries.

2.4.2. Experimental procedure

A user friendly GM8805 benetech carbon monoxide monitor (Plate 3.1) was used to measure the CO concentrations at the identified sampling routes on the selected majour roads.The carbon monoxide monitor was switched on and allowed to countdown for 10 seconds, in order to get all internal systems ready. The GM8805 benetech carbon monoxide monitor was positioned (Plate 3.2) at a distance between 1.5 m and 2.0 m from the ground level while on- board in the tricycles to avoid fugitive CO emission. Readings were taken at 2 minutes interval for 60 minutes along each road experiencing traffic jam, while readings were taken at 2 sec. interval along the road without traffic jam.

Plate 3.1 Benetech Carbon Monoxide Meter GM8805

Source: Benetech.

Plate 3.3 Experimental set-up for road experiencing traffic jam

2.5. Determination of the Levels of Exposure of Passengers to CO Emission while on Board in Tricycles

The levels of in-tricycle exposure to carbon monoxide emission on each of the road were determined. To achieve these, the mean concentration of CO emission in each tricycle on each road was determined on 1-hour averaging period, 8-hour averaging period and 24-hour averaging period. The CO concentrations for these averaging periods were compared the national permissible standards by WHO, Nigeria and the United State of America.

3. RESULTS AND DISCUSSION

3.1. RESULTS

The results obtained from measurement of carbon monoxide (CO) concentrations at the identified six sampling roads, including the control road, are represented in Tables 1, 2, 3, 4, 5 and 6 respectively. Table 6 shows the control route.

Table 3.1 Measured Average Concentration in Part Per Million (ppm) at selected Sampling Sites for 1-hour Averaging period:

NAME OF SAMPLING ROUTE	AVERAGE (ppm)
Ikwerri Road	42.50
Trans Amadi	26.90
Rumuokoro	24.00
East West Road (Rumuodara axis)	14.17
Eliohani	13.87
Woji (Control)	4.53

Table 3.1.1: For 8-hour Averaging period, using extrapolation:

NAME OF SAMPLING ROUTE	1-hour averaging period (C_1)	8-hour averaging period (C_0)
Ikwerri Road	42.50	23.74
Trans Amadi	26.90	15.03
Rumuokoro	24.00	13.41
East West Road (Rumuodara axis)	14.17	7.92
Eliohani	13.87	7.75
Woji (Control)	4.53	2.53

Table 3.1.2: For 24-hour Averaging period, using extrapolation

NAME OF SAMPLING ROUTE	1-hour averaging period (C_1)	24-hour averaging period (C_0)
Ikwerri Road	42.50	17.47
Trans Amadi	26.90	11.06
Rumuokoro	24.00	9.86
East West Road (Rumuodara axis)	14.17	5.82
Eliohani	13.87	5.70
Woji (Control)	4.53	1.86

Table 3.2 Comparison of Average concentration values of 1-hour, 8-hours and 24-hours averaging period

NAME OF SAMPLING ROUTE	1-hour averaging period	8-hour averaging period	24-hours averaging period
Ikwerri Road	42.50	23.74	17.47
Trans Amadi	26.90	15.03	11.06
Rumuokoro	24.00	13.41	9.86
East West Road (Rumuodara axis)	14.17	7.92	5.82
Eliohani	13.87	7.75	5.70
Woji (Control)	4.53	2.53	1.86

3.2. DISCUSSION OF RESULT

For sampling route 1 (Ikwerri Road), concentration values obtained are within the range 28-56 ppm (table 7.1), each of the values are all above set standards of 9-10ppm (FEPA, USEPA, WHO) (figure 5.1). This sampling route showed the highest average concentration of carbon monoxide at a value of 42.5ppm (see figure 5.7). In road 1, values above 50 ppm were obtained, long exposure of human beings to carbon monoxide above 50 ppm has been proven to cause "carboxyhaemoglobin", this is a complex of carbon monoxide and haemoglobin that forms in the red blood cells upon inhalation causing severe harm to the body system.

For sampling route 2 (Trans Amadi), concentration values obtained are within the range 10-56 ppm (table 7.2) all above the set standards (figure 5.2), the mean concentration values obtained on this sampling route was 26.9 ppm (table 4,1). For sampling route 3 (Rumuokoro), concentration values obtained in this sampling route are within the range 18-36 ppm (table 7.3), all the values measured are above set standards (figure 5.3). The mean concentration values obtained on this route was 24 ppm (table 4.1).

For sampling route 4 (East West Road (Rumuodara Axis)), concentration values obtained are within the range 3-102 ppm (table 7.4). In this sampling route, at the starting point, within the first 16 minutes, the values were at a safe range, then a sudden hike in concentration giving a value of 102 ppm, which declined to 37 ppm after two minutes. The subsequent values fluctuated, increasing and decreasing at various points. Most of the values obtained were above set standards (figure 5.4). The average concentration value obtained for this route was 14.17 ppm (table 4.1).

For sampling route 5 (Eliohani), the values of carbon monoxide concentration obtained were within the range 6-39 ppm (table 7.5). Mean value of concentration obtained was 13.87 ppm (table 4.1), this value does not comply with governmental or health standards (figure 5.5). For sampling route 6, the control road (Woji), concentration values obtained are within the range 0-10 ppm (table 7.6) all values comply with the set governmental and health standards (graph 5.6) , the mean concentration values obtained from sampling the road, gave a value of 4.53ppm (table 4.1) which is the lowest mean concentration value from all sampling routes (figure 5.7), the average value is in alignment with governmental, health and environmental standards , as the maximum allowable concentration of carbon monoxide an individual should be exposed to before considered hazardous is 9-10ppm (figure 5.6). The mean concentration value for 1-hour averaging time obtained for various sampling sites is illustrated in the graph below (figure 5.7) in order of decreasing average concentration.

For the 8-hour and 24-hour averaging period (table 4.1.1 and table 4.1.2), For Ikwerre road (Sampling route 1), Trans Amadi (sampling route 2) and Rumuokoro (sampling route 3), the exposure rate for an average of 8 hours still show a value above set standards, while values of East West Road (sampling route 4), Eliohani (sampling route 5) and Woji (sampling route 6) comply with set standards (figure 5.8). Research has shown that exposure to 9 ppm of CO for 8 hours and 20 ppm of CO for 1 hour can increase carboxyhaemoglobin (COHb) levels above 2.5% which in turn increases health risk. The 8-hour and 24-hour averaging period also shows that, in the case of traffic decongestion carbon monoxide is still present in the atmosphere, for Ikwerre road, Trans Amadi and Rumokoro Road, carbon monoxide is present in concentration enough to harm the health of not just passengers but also individuals either working or living in the area.

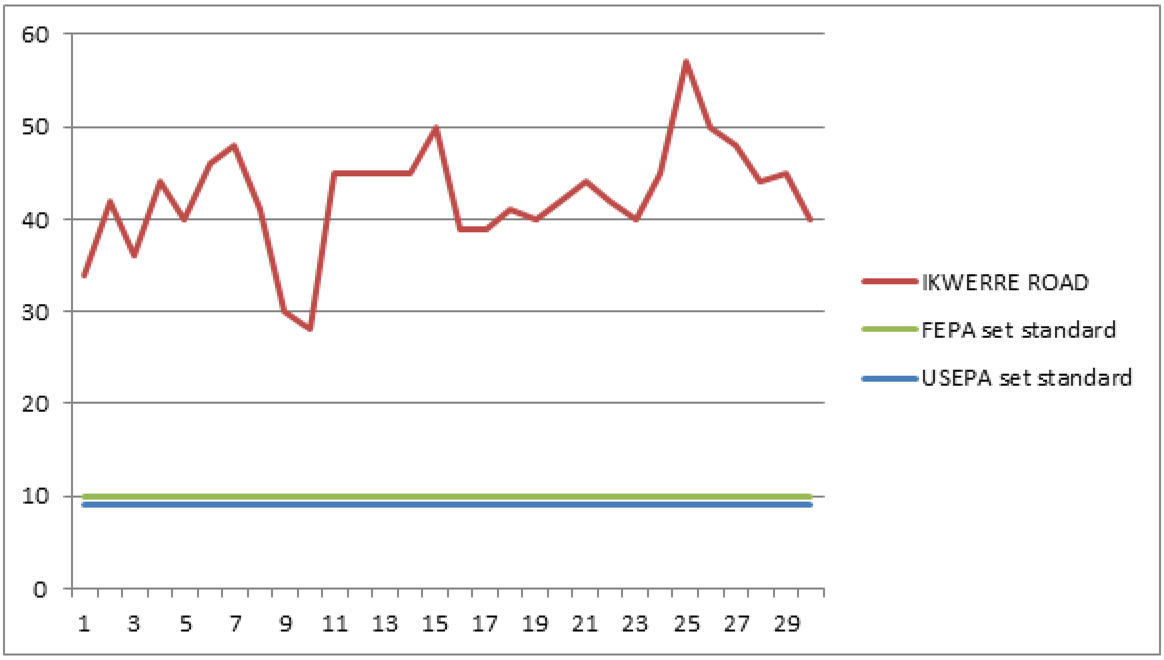

Figure 5.1 Graph showing comparison of Carbon monoxide concentration values for Ikwerre Road with values of set standards.

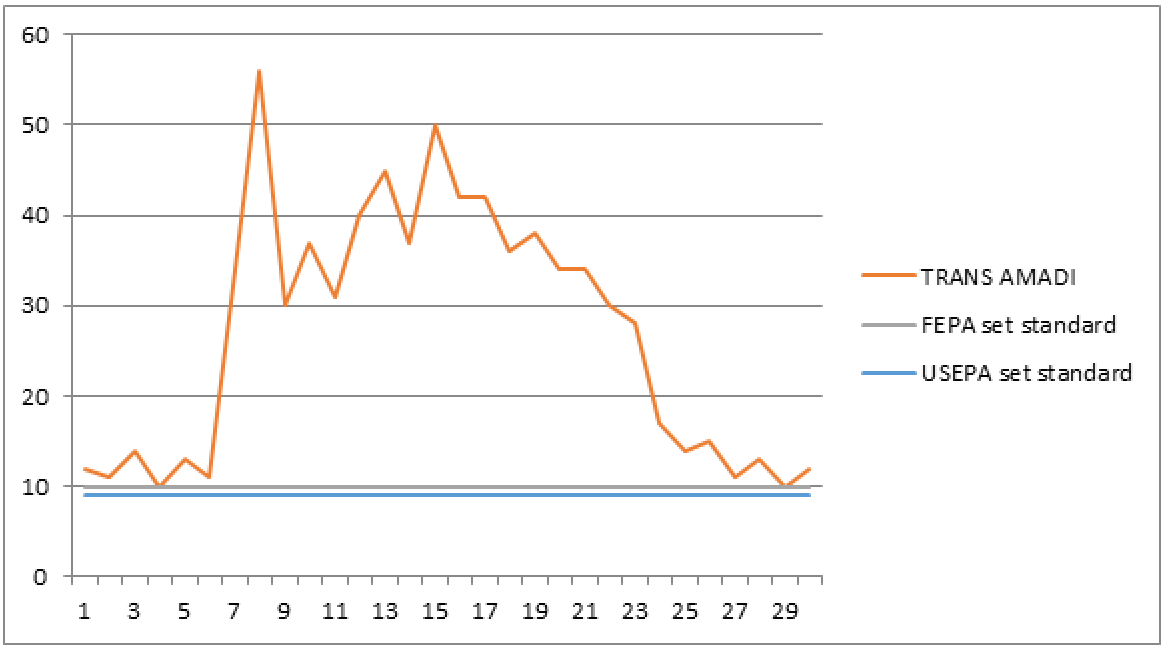

Figure 5.2 Graph showing comparison of Carbon monoxide concentration values for Trans Amadi Road with values of set standards.

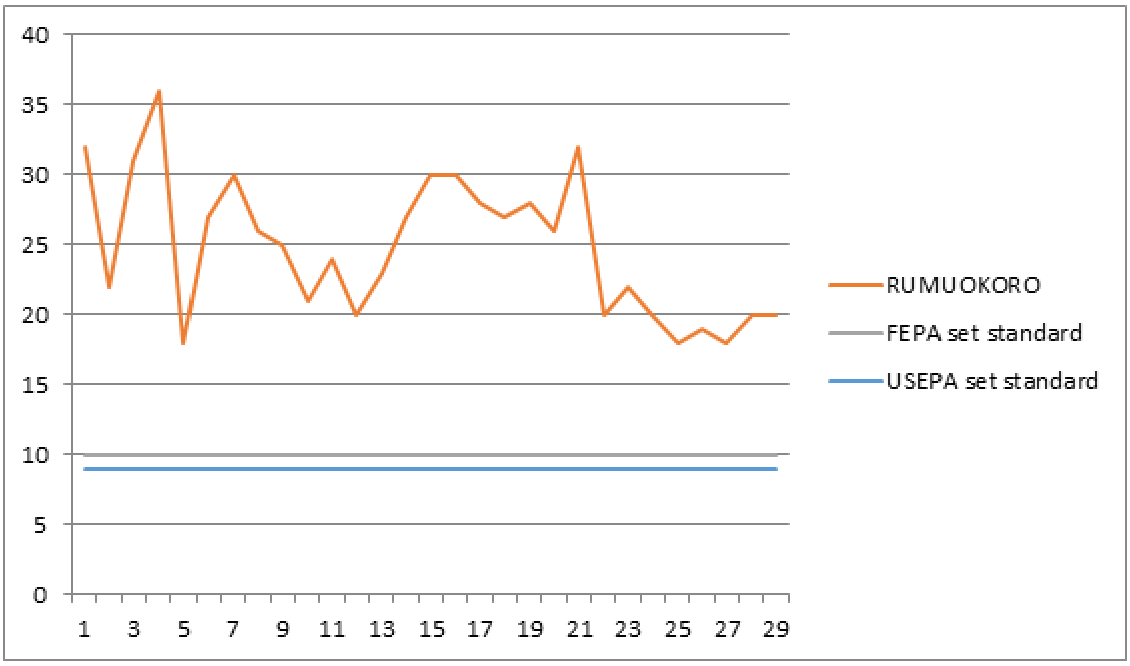

Figure 5.3 Graph showing comparison of Carbon monoxide concentration values for Rumuokoro with values of set standards.

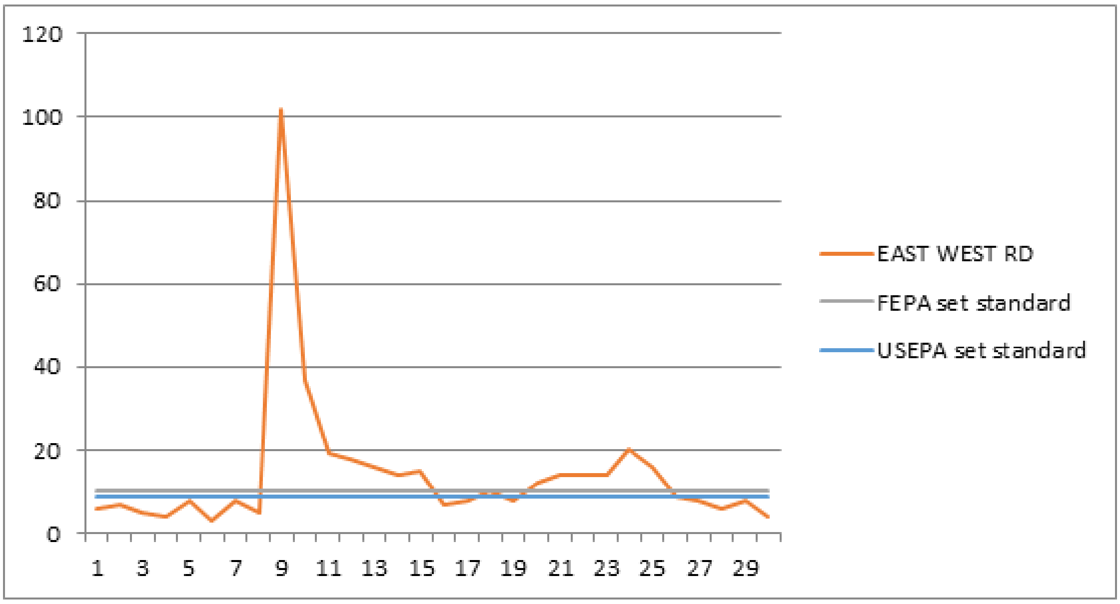

Figure 5.4 Graph showing comparison of Carbon monoxide concentration values for East West Road with values of set standards.

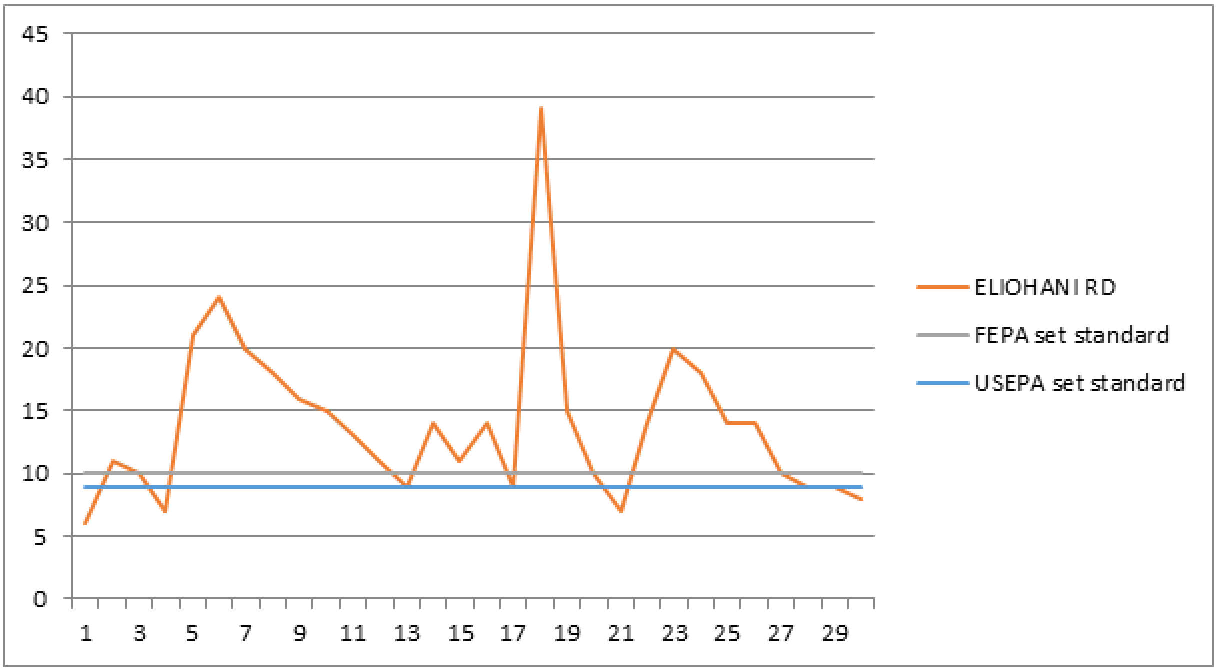

Figure 5.5 Graph showing comparison of Carbon monoxide concentration values for Eliohani Road with values of set standards.

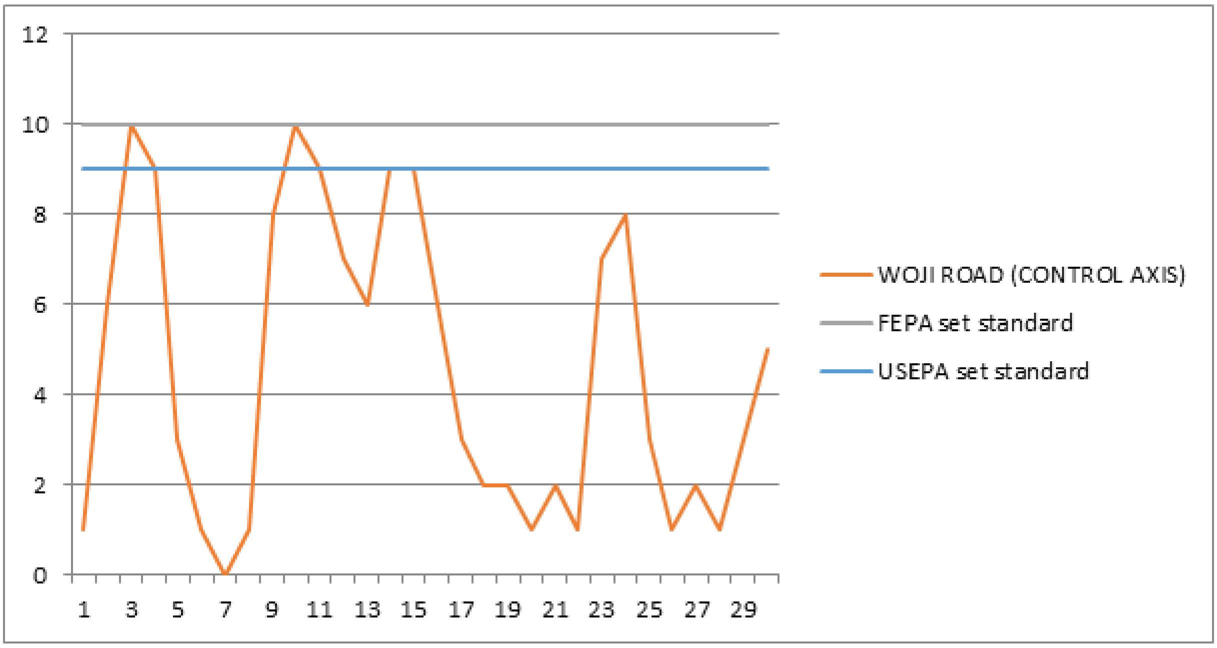

Figure 5.6 Graph showing comparison of Carbon monoxide concentration values for Woji Road with values of set standards.

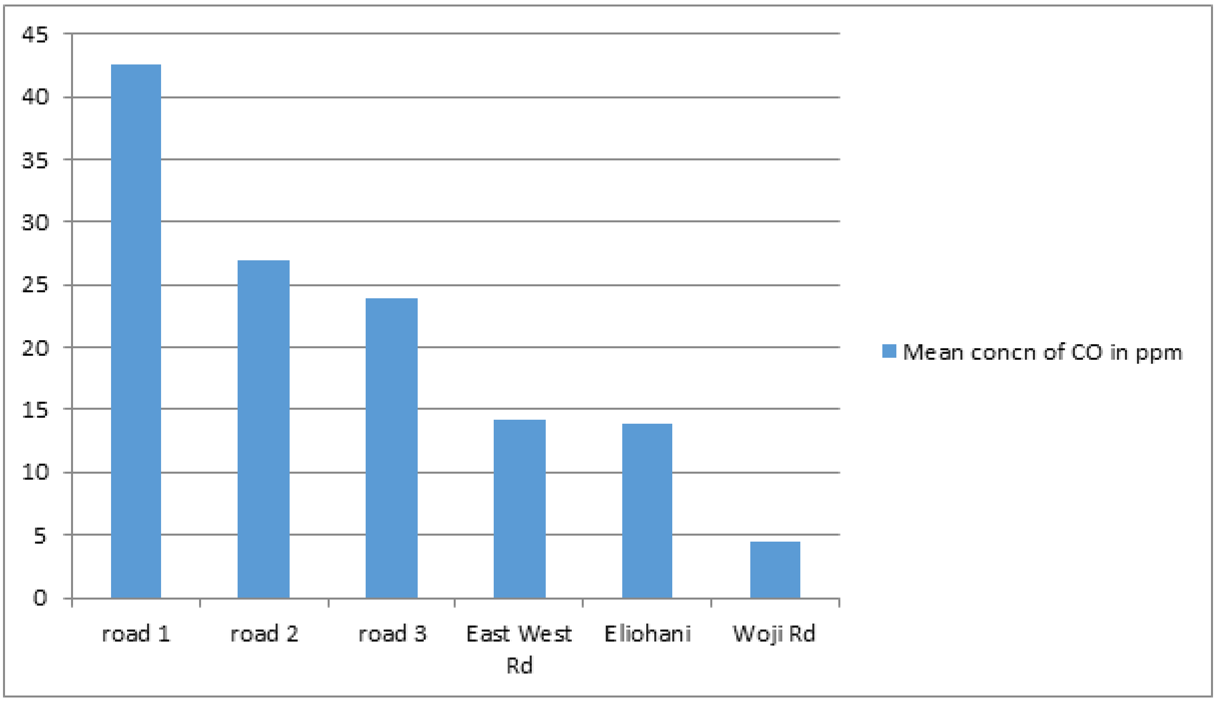

Figure 5.7 Mean concentration of carbon monoxide at the six sampling routes.

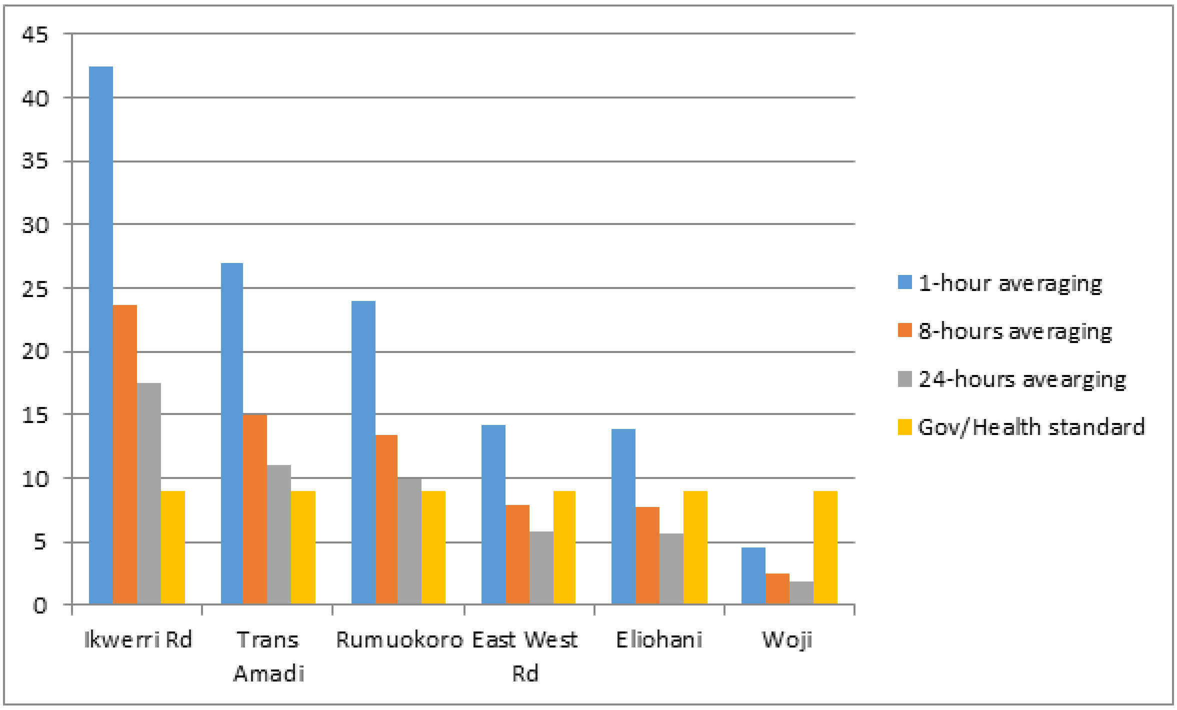

Figure 5.8 Showing comparison of 1-hour, 8-hours and 24-hours averaging period for the six sampling routes.

4. CONCLUSION

From the results obtained, statistical and graphical analysis carried out, it is evident that five out of the six sampling routes do not comply with standards of environmental bodies, in that their average carbon monoxide concentrations exceed 9-10ppm.

It was observed that passengers are exposed to carbon monoxide in tricylces. In –tricycle exposure to carbon monoxide has been proven to exist in concentrations enough to harm the health of passengers. The control road depicts an ideal in-tricycle carbon monoxide level due to less traffic, therefore considered safe. This research also shows that the level of exposure to carbon monoxide depends on the extent of traffic jam.

The 8-hour and 24-hour averaging period also showed that, in the case of traffic decongestion carbon monoxide was still present in the atmosphere, for Ikwerre road, Trans Amadi and Rumokoro Road, carbon monoxide was present in concentration enough to harm the health of not just passengers but also individuals either working or living in the area.

4.1. RECOMMENDATIONS

1. Better road networks, especially in urbanised areas of Nigeria will help reduce traffic congestion.
2. Reduction in the importation of second hand tricycles.
3. Regular maintenance of vehicles to enhance complete combustion in the engine.

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