PRINT ISSN 1119-8362
Electronic ISSN 1119-8362

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://ww.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 25 (8) 1535-1539 August 2021

Assessment of Vehicular-Induced Emissions in some Selected Areas in Benin City, Edo State, Nigeria

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ABSTRACT: Vehicular emission is a major environmental health problem in the world today especially in developing countries including Nigeria. This study was centered on assessing the vehicular emissions pollutants such as Carbon monoxide (CO), Hydrogen Sulphide (H_2S), Formaldehyde (HCHO) and Total Volatile Organic Compound (TVOC) in Benin City, Edo State, Nigeria. The sampling of the CO and H_2S gaseous pollutants was done using H-4S gas analyzer while JCG60 gas detector was used to measure TVOC and HCHO. The meteorological parameters were measured with HTC-1 hygrometer thermometer. AQI was calculated to determine the status of the ambient air quality of the study areas. Carbon monoxide concentration obtained from the result ranges from 3.12-16.1 ppm with location C having the highest amount of 16.1 ppm which exceeds the Federal Environmental Protection Agency (FEPA) standard of 10 ppm. The calculated AQI shows that the study areas are all polluted. Continuous measurement and inventory of air pollutants should be encouraged, as this will enable the policymakers to effectively implement control measures on air pollution.

DOI: https://dx.doi.org/10.4314/jasem.v25i8.38

Dates: Received: 10 May 2021; Revised: 28 June 2021; Accepted: 01 July 2021

Pollution due to vehicular emission remains a threat to environmental health problem which is expected to increase reasonably as motor vehicle population increases (Chao *et al.*,2014; Ji *et al*.,2018; Mishra *et.al*., 2019). The growth in vehicles population and the corresponding emissions has led to the degradation of the air quality which in turns affect man and his environment (Xiaonian *et al.*, 2019; Nathaniel and Xiaoli, 2020). Vehicular emission is the direct release of pollutants into the atmosphere and it is the dominant source of gaseous pollutants, such as Carbon monoxide (CO), Nitrogen oxide (NO_x), Sulphur oxides (SO_x), Total Volatile Organic Compounds (VOCs), Hydrogen sulphides (H_2S), Total Particulate Matters (TPMs), Formaldehyde (HCHO) and water vapour (Schifter *et al.*, 2000; Guttikunda *et al*., 2012; Abaje *et al.*, 2020; Adeyemi *et al*., 2020). Several epidemiological studies have shown that human exposure to these pollutants in areas with high level pollutants concentrations constitute severe health problems such as headaches, dizziness, irritation of the eyes, nose and throat, shortness of breath, upper respiratory infections, brain damage, lung cancer, liver and kidney damage, heart diseases and death (CPCB, 2001; Baldacci, 2015; Almeida *et al*., 2015; Chen *et al.* 2016; Kolpakova *et al*., 2017; Robert *et al.* 2017; Javeria *et al.* 2018; Sui Zhhu et al 2018; Lei *et al.* 2020). Nigeria, as a developing nation is also faced with rapid urbanization resulting in uncontrolled growth characterized by lack of physical planning and increasing vehicular traffic which creates high-level traffic related air pollution (Etim, 2016). The reliance on fossil fuel in running vehicles in Nigeria has made vehicular emissions to be at the high side, thereby, aggravating the urban air quality (Muhammad and Yinusa, 2016; Dongqi *et al*., 2017). Few studies have been carried out in Nigeria on the assessment of vehicular induced emissions and the reports from all the studies show positive relationship between increase in motor vehicles and pollutants concentrations. Abam and Unachukwu (2009) investigated vehicular emissions in some selected areas in Calabar, Nigeria. The study reported high concentrations of CO, SO_2 and NO_2 in the study areas and linked the cause to high traffic congestion. Ojo and Awokola (2012), also investigated air pollution from vehicles at intersections on some selected major roads in Ogbomoso, South Western, Nigeria. Four sampling routes were considered with ten sampling points to assess SO_X, NOx and CO concentrations. The pollutants concentrations were highest at intersections with high traffic congestion where long waiting time for vehicles was observed. Furthermore, the air quality in the study areas were rated very poor when compared to air quality level (Air quality index). The outcomes of the studies carried out on vehicular emissions in some selected intersections in Nigeria shows the presence of air pollutants in the sampling locations. Hence, there is a need for air pollution monitoring so as to safeguard the residents in the areas experiencing

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traffic congestion due to increased number of motor vehicles, as this will provide important information on air quality for policymakers for the formulation of effective air pollution control measures. Therefore, the objective of this paper is to assess vehicular emissions pollutants such as Carbon monoxide (CO), Hydrogen Sulphide (H_2S), Formaldehyde (HCHO) and Total Volatile Organic Compound (TVOC) in Benin City, Edo State, Nigeria.

MATERIALS AND METHOD

Sampling Sites / Sampling Locations: Benin City is an ancient city in South-Western Nigeria (Figure 1) and is bounded by latitude 6°30′N, 6°06′N and longitudes 5°30′E and 5°45′E (Western and Eastern boundaries) and has an estimated land area of 500 square kilometres (Iwuala and Oriaku, 2019). Benin City in Edo State is the 6th largest city in Nigeria with an estimated population of 1,125,058 (World Population Review, 2019). The influx of vehicles in the city causes high traffic congestion which in turns results to high emissions. Nwankwo *et al*., (2010) identified Sapele road, Akpakpava road and Airport road as some of the busiest roads with high traffic congestion in Benin City. Figure 2 shows the sampled locations.

Fig 1: Showing Map of Nigeria and Benin City.

*Vehicle Population Density***:** High traffic congestion is a daily occurrence in the selected study areas owing to their connections to major commercial areas. Although, traffic congestion varies according to the time of the day which necessitates a traffic count in order to ascertain the periods of high pollution as related to traffic congestion. In this study, the traffic count (traffic flow per hour) was done manually over a period of 21 days in the morning, afternoon and evening hours whereby, the vehicles were categorized as cars, buses, trucks and motorcycles (Bike).

Fig 2: Map showing sampling locations; A (Sapele road), B (Akpakpava road) and C (Airport road) in Benin City, Edo State.

Sampling: The emission of CO and H_2S were monitored with the use of H-4S gas analyzer while TVOC and HCHO were monitored using JCG60 Gas detector. A handheld hygrometer thermometer, Eagletech HTC-1, was used to measure the meteorological parameters such as temperature and relative humidity. The study was conducted over a period of 21 days during week days, between July 10th and 6th August. The measured concentrations of the pollutants were extrapolated to one hour averaging period using an atmospheric stability formula (Bashar et al., 2009) given in Equation 1. Air quality index (AQI), a technique that determines how clean or polluted the air is, was used to assess the study areas by adopting equation 2. The impact of the pollutants on human health was also studied via the distribution of questionnaire to the residents around the host environment.

$$C_0 = C_1 X\, F \qquad 1$$

Where C_0 = the concentration at the averaging period t_0; C_1 = the concentration at the averaging period t_1; F = factor to convert from the averaging period t_1 to the averaging period to = $\left(\frac{t_1}{t_0}\right)^n$; n = 0.28, the stability dependent exponent

$$AQI = \frac{MEASURED\ POLLUTANT\ CONCENTRATION}{STANDARD\ CONCENTRATION} * 100 \qquad 2$$

RESULTS AND DISCUSSION

Table 1 shows the variation in vehicle population density in the study areas in the three locations at an hour averaging period. The volume of cars was found to be the highest in all locations which is an indication that majority are car owners while motorcycles (bikes) are found to be the least in volume because it has been banned in Edo state, Benin City.

Table 1: Vehicle Population Density

	MORNING HOURS				AFTERNOON HOURS				EVENING HOURS			
Location	Cars	Buses	Trucks	Bikes	Cars	Buses	Trucks	Bikes	Cars	Buses	Trucks	Bikes
A	1987	373	41	7	2091	487	51	21	1680	276	29	4
B	2259	713	49	9	1903	781	57	36	2389	388	102	28
C	2227	209	51	25	1956	321	28	40	3587	208	35	60

Generally, vehicle density reduces in the afternoon hours across the locations owing to lower activities and it is assumed to be the off peak period while the morning and evening hours are marked as peak periods because various activities go on during this periods whereby, workers, business men and women and students leave and return to their homes. Figures 3-6 shows the concentrations of the measured priority pollutants in location A,B and C at morning, afternoon and evening periods. In Figure 3, the concentrations of carbon monoxide (CO) in location C was found to be the highest in the morning hours irrespective of the lower car density recorded against location B. This could be as a result of the effect of climatic element, temperature. The temperature (39.9 ^{O}C) was very high at location C when compared to location B(28.4 ^{O}C). The increase in temperature increases the emission rate of CO. This observation is in agreement with Nkwocha et al. (2017) findings. All the three locations exceeded the FEPA (1991) allowable limit of CO of 10ppm and this implies that the study areas are polluted with CO. Hydrogen sulphide (H_2S) is one of the main pollutants emitted from diesel-operated engines. Most trucks in Nigeria use diesel for fueling. The average truck density in location A(47), B(45) and C(55) were few in number when compared to other vehicles. An appreciable number was recorded which was enough to cause pollution. Figure 4 shows the concentration of H_2S observed at the study areas. The concentrations were found to be in the range of 0.7-1.8 ppm which is above the 0.01 ppm limit of Federal Environmental Protection Agency FEPA (1991) ambient air quality standards. The highest value of 1.8 ppm obtained at location B is as a result of higher number of trucks recorded during the evening period. It is therefore advisable that the sulphur content in Nigerian crude be brought to an appreciable amount by ensuring that the imported petrol into the country is of low Sulphur content. The total volatile organic compounds (TVOCs) is an active precursor of tropospheric ozone and a carcinogenic pollutant. The measured concentration values found at the three locations were, A (1.27 ppm), B (0.85 ppm) and C (0.95 ppm) which exceed the Federal Environmental Protection Agency's (FEPA, 1991) standards of 0.08 ppm for an hour averaging period. These results obtained as seen in Figure 5, is in agreement with the report of elevated levels of TVOC in Adeyemi *et al*., (2020) findings. The average measured values of Formaldehyde (HCHO) also exceeds the FEPA standard.

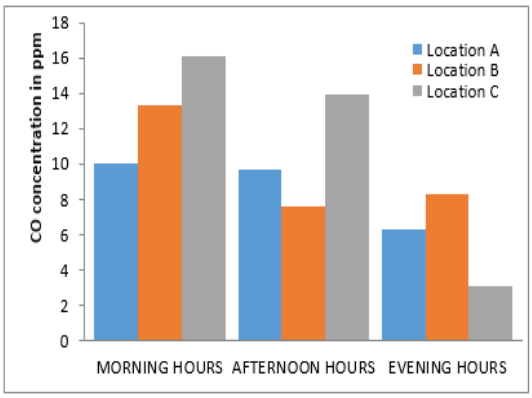

Fig 3: The Average Concentrations of Carbon monoxide at Location A, B & C.

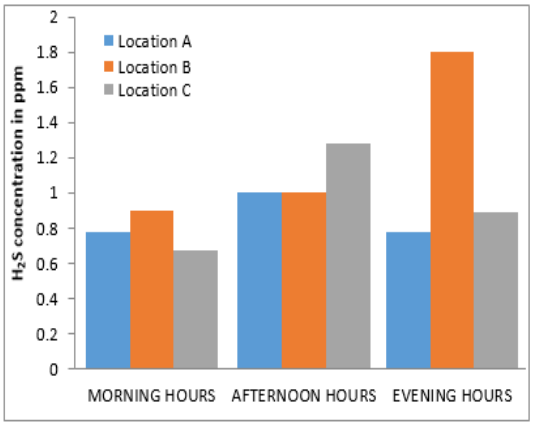

Fig 4: The Average Concentrations of Hydrogen Sulphide at Location A, B & C.

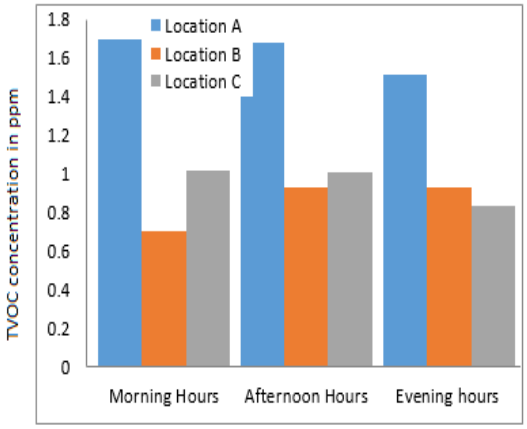

Fig 5: The Average Concentrations of Total Volatile Organic Compound at Location A, B & C

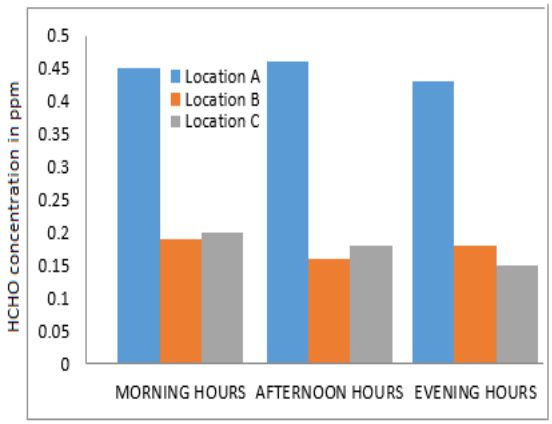

Fig 6: The Average Concentrations of Formaldehyde at Location A, B & C

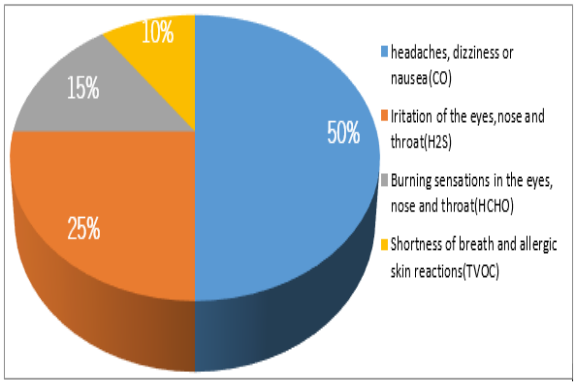

Fig 7: The Evaluation of Health Impact of the Pollutants on human

Air quality index (AQI) is used to obtain and convey information regarding the air quality of a region. According to USEPA (2000), the ambient air pollutants are classified into categories ranging from very good to very poor. From (0 – 15) AQI rating is very good, (16 -31) AQI is good, (32 – 49) AQI is moderate, (50 – 99) AQI is poor and (100 or above) AQI is very poor. Table 2 depicts the air quality status of the three locations studied in this work. Computed air quality index of location A, B, C shows 90.13%,97.13% and 110.4% respectively. Location A and B air quality is rated poor while Location C is very poor. This is as result of high pollutants concentration in location C especially carbon monoxide. Hence, the air quality of the three locations is considered not safe for the commuters.

Table 2: AQI rating for ambient air quality of CO from this study

LOCATION	AQI value	AQI category
A	90.13	Poor
B	97.13	Poor
C	110.4	Very poor

The impact assessment of pollutants on human health of the people living and trading around the study areas was carried out based on the distribution of questionnaires, depicted in the pie chart in figure 7. About 50% of the commuters often experience headaches, dizziness or nausea which are symptoms of carbon monoxide inhalation while 25% complained of eyes, nose and throat irritation which is also an indication of H_2S exposure. 10% experiences shortness of breath and skin allergy reaction as a result of being exposed to total volatile organic compounds.

*Conclusion***:** The outcome of the assessment of CO, H_2S, HCHO and TVOCs in Benin City, Edo State, Nigeria, showed that all the pollutants concentrations in the sampling locations exceeded the Nigerian local standard as stipulated in FEPA (1991). The ambient air quality of the three locations are rated poor based on the calculated Air Quality Index (AQI). Hence, it is important to engage in continuous air monitoring, as this will serve as a guide for governmental bodies to plan actions on air quality management such as the decongestion of the traffic-related junctions in the host environs.

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