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AIR POLLUTION ARISING FROM VEHICULAR EMISSIONS AND THE ASSOCIATED HUMAN HEALTH PROBLEMS IN ABEOKUTA METROPOLIS, NIGERIA

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ABSTRACT

Vehicular traffic contributes immensely to urban air pollution in the less developed countries, Nigeria inclusive. The present study assessed the level of some selected air pollutants which are largely products of internal combustion in motor vehicle engines namely; nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), carbon monoxide (CO) and methane (CH_4) in Abeokuta city. Moreover, the health problems suffered by residents living near motorways were also investigated. Number of vehicles was counted at morning, afternoon and evening while gasman auto-sampler (ATEX4 model) was used for monitoring the concentrations of the five gases at the selected motorways in the city. Questionnaire survey was conducted to elicit information about perception of risks and health problems treated by the residents living near motorways. Traffic volume ranged between 792±297 and 2037±70; 641±228 and 2037±95; and 489±169 and 1875±101 at morning, afternoon and evening respectively for the various categories of motorways. The concentrations of CO, SO_2, NO_2, H_2S and CH_4 ranged between 73.72±0.92 and 82.89±3.38; 0,046±0.005 and 0.067±0.017; 0.217±0.02 and 0.399±0.02; 0.167±0.017 and 0.265±0.011; 0.171±0.024 and 0.442±0.385 mg/m^3 respectively. There is significant variation ($p > 0.05$) in the volume of traffic and the concentrations of the sampled gases between the periods of the day at the selected motorways. There is also a significant ($p > 0.05$) correlation between traffic volume/density and CO ($r = 0.806$), NO_2 ($r=0.716$) and H_2S ($r = 0.704$). Hence, traffic volume accounted for 15.5, 49.5, 51.2 and 64.9 percent of CH_4, NO_2, SO_2 and CO concentrations in air sampled along the selected motorways. Health problems suffered and reported to health facilities include cough (56.4%) and breathing impairments (23.6%) among others. Measures that seek to minimize emission of pollutants from automobile are urgently required in cities of the developing countries.

Key words: Air pollution, vehicular emissions, Nigeria, urban, health problems

INTRODUCTION

Globally, over 500 million motor vehicles ply the roads. As a result of this, traffic-related air pollution, traffic congestion, traffic control and road safety are major issues in developed and developing countries. Although the developing countries should fare better due to fewer motor vehicles share, but the contrast obtains since policies aimed at reducing vehicular emissions are loosely applied. Hence, noxious emissions arising from increased industrialization and motor traffic are major air pollutants in the developing countries. Indeed, there is a growing awareness that the present trends in motorization are not sustainable judging from the high level of air pollution, heavy demands on space and unequal access to private and public motor transport.

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Use of automobile is one of the most polluting acts an average citizen commits in the less developed countries (LDCs). Emissions from passenger vehicles are largely on the increase due to massive importation of "second-hand" or fairly used automobile to developing countries, Nigeria inclusive. In reality, some of the vehicles that managed to appear in the local market are not road-worthy due to over-age and inefficient engine performance. The poor state of the economy which priced new vehicles above the economic power of most citizens encourages the sales of these used vehicles.

Spatial disparity in the distribution of these vehicles favours the urban centres in terms of number. This disproportionate increase in the number of vehicles on urban roads experienced by cities is due to their position as seat of political and economic power. Expectedly, there has been a significant soaring of pollutants in cities of LDCs. The bulk of energy for powering vehicles is sourced from fossil fuel, which is renowned for emitting carbon into the atmosphere. For instance, every gallon of petrol consumed by a motor vehicle is expected to release about 19 pounds of carbon dioxide into the atmosphere (Walsh, 1992). As carbon dioxide is not released in isolation, other pollutants that associate with use of fossil fuel are emitted simultaneously into the air. Basically, this is due to the internal combusting mechanism in motor vehicle which has products such as; carbon dioxide, sulphur oxides, nitrogen oxides, water vapour, oxygen, carbon monoxide, and unburned hydrocarbons (Kotz and Purcell, 1987). According to the reports of Wood (2004) and the Environmental Health Committee (2004), these pollutants have reached a worrisome level. Exhaust from all combustion engines which contain these pollutants, combine to produce local adverse effects on the health of car users and innocent bystanders.

On the larger environment, combustion engines contribute to carbon dioxide accumulation in the atmosphere and are responsible for climate changes (Gislason, 2006). Emission of air pollutants such as carbon dioxide and methane, which are green house gases (GHG) play notable role in global warming, as they trap heat without returning them as infrared or thermal radiation thereby contributing to the emerging global hazard (Pearce, 1999). According to recent estimation (NASA, 2005), the effects of methane, a chemically reactive GHG is substantially larger than ever estimated. In case of sulfur dioxide, both terrestrial and aquatic ecosystem are adversely affected by acid rain that it produces (NPI, 2006).

The adverse effects of vehicular emissions on humans are quite pervasive. Specifically, the pollutants have known adverse effects on human health especially children, who are the most susceptible age group due to their peculiarities. Ozone, sulphur dioxide, nitrogen dioxide and particulate matter cause increased respiratory tract illness, asthma exacerbations, and decreased lung function. In some communities, respiratory and cardiovascular hospitalizations, cardiovascular mortality and even lung cancer are attributed to negative effects of air pollutants.

At high concentration, nitrogen dioxide (NO_2) cause serious lung damage which results in shortness of breath and chest

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pain. Methane as an asphyxiant is known to displace oxygen, and when the displacement is 18 percent, asphyxia can result in exposed persons. In the case of H_2S, short-term exposure to high concentration may cause eye irritation, sore throat and cough, nausea, shortness of breath, and fluid in the lungs. On long term, it may result to fatigue, loss of appetite, headache, irritability, poor memory, dizziness and miscarriages in women (en.Wikipedia.org 2007). Exposure to high concentration (10 – 50ppb) of SO_2 causes irritation of eye, throat and nose, choking and coughing (NPI, 2006).

Cities have become 'islands' of toxic air pollutants arising from massive use of vehicles burning fossil fuels. Within some cities in northern Nigeria, the concentration of CO has been shown to be higher in areas with traffic congestion (Ndoke *et al.*, 2007). Nitrogen dioxide has been identified as a traffic-related pollutants, hence are found to be highest in urban areas (Hao, et al., 2000). Specifically, the rush hours traffic period are known to record highest NO_2 levels. The impact of vehicular emission is high among residents living close (below 300m) to motorways (Brunekreef et al., 1997).

Identification of the contribution of vehicular emission to urban air quality especially along motorways has become imperative. Moreover, the determination of pollutant concentration will assist in marking out pollutant "hot spots" or risk zones for priority attention in terms of best intervention programme to adopt for mitigating the resultant hazardous effects on man. For instance, urban greening as a strategy can effectively sequester carbon dioxide among other benefits (Nowak, 2000; Rowntree and Nowak, 1991), thereby safeguarding human health and that of the environment.

The present study focused on determination of vehicular traffic density and concentration of pollutants in some selected areas of Abeokuta city, Nigeria. It also examined the relationship between vehicular traffic density and the concentration of the selected pollutants. Finally, the survey of prevalent health problems of humans exposed to pollutants along motorways was conducted.

The study area

Abeokuta is an ancient city which serves as the administrative headquarters of Ogun state located in the southwestern part of Nigeria on Longitude 3.33^{o}E and latitude 7.17^{o}N. The city enjoys accessibility due to series of road network between it and other bigger cities. It is about 80km north of Lagos. The whole city falls within four of the local government areas of Ogun State namely; Abeokuta south, Abeokuta north, Odeda and Obafemi/Owode local government areas. Specifically, the city is located within the humid tropical region with a mean annual rainfall of 1090.5mm (Akanni, 1992).

Traditionally, the people of Abeokuta are farmers, but in the recent decades the city has been witnessing some socio-economic transformation due to industrial development and establishment of government and private tertiary institutions. Consequently, some of the residents engage in industrial, commercial administrative and professional services. These socio-economic changes are partly responsible for the rapid increase in the population of the city proper from 377,000 in 1991 (Columbia encyclopedia, 1991) to 451607 people in 2006 and with the addition of its' environs 596,496 inhabitants being 16 percent of 3,728,098 - Ogun state 2006 population figure (National Bureau of Statistics, 2006).

Open spaces along major roads in Abeokuta are commonly used for displaying varying grades of "used" vehicles meant for sale. Different categories of vehicles are found within the town, especially heavy duty vehicles that are used for conveying granite from numerous quarry sites located within the city's neighbourhood. Some of these vehicles are peculiar for thick "clouds" of exhaust that accompany their passage on roads.

The health problems found rampant in the city are malaria, typhoid fever, infant communicable infections and respiratory diseases among others (John, 1992).

MATERIALS AND METHODS

Data collection and analysis

Three categories of primary data namely; vehicular traffic count, roadside air quality and vehicle emission assessment, and questionnaire survey were collected for this study. Eight study sites/locations were carefully selected to include areas with low, medium and high vehicular traffic. Vehicular count was conducted at these selected sites in the morning (8-9am), afternoon (12-1pm) and evening (6-7pm) on Monday, Wednesday and Saturday for three weeks. At the same periods, gasman auto-sampler (ATEX4 model) was used to determine the concentration of CO, SO_2, NO_2, H_2S and CH_4 in roadside air at several points along the selected roads. As a check, the concentration of NO_2 and SO_2 (found feasible) were measured directly from the exhaust of some randomly sampled vehicles. The auto-sampler was placed close to the exhaust of the sampled vehicles; thereafter the reading of the selected gas was taken.

Gasman auto-sampler is a gas detector designed to indicate the concentration of sensed gases in the immediate vicinity. In order to take samples, the gadget is switched on and a green light beeps thereafter to confirm attainment of normal operation. Once this is achieved, the digital reader shows the concentration of the selected gas.

In the areas where air quality was monitored, a validated well-structured questionnaire was administered to residents living near motorways so as to elicit information on their socio-demographic characteristics, duration of residence, perception of hazards associated with living near motorways and the health problems frequently experienced and treated. Information analysed in this study was collated from 110 respondents with adequate responses out of 120 randomly sampled on the basis of 15 respondents per location.

Data generated via these sources were analysed using both descriptive and inferential statistics such as frequency, ANOVA, correlation and regression analysis.

RESULTS AND DISCUSSION

The concentration of NO_2 and SO_2 measured directly from exhaust of sampled vehicles ranged between 0.86 to 8.40 mg/m^3 and 2.26 to 8.76 mg/m^3 (Table 1). There is a significant variation ($p< 0.001$) in the

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concentration of these two gaseous pollutants from the three vehicle categories. The highest level of pollutants were emitted by lorries and trucks (heavy duty) while cars had the least concentration of pollutants.

Table 1: Concentration of NO_2 and SO_2 (mg/m^3) in the exhaust of selected Vehicles

Type of Vehicle	Mean Conc. of NO2	Mean Conc. of SO2
Heavy duty (lorry, truck etc)	8.40±0.99	8.76±0.93
Medium duty (buses)	2.88±0.26	3.26± 0.34
Light duty (motor cars)	0.86±0.34	2.26±0.59
Overall mean	4.04±3.35	4.76±3.02
ANOVA result (F-value, α)	196.14, 0.001	137.74, 0.001

The levels of SO_2 and NO_2 measured in the road-side air (Table 2) were less than the concentration monitored directly from vehicle exhaust. The difference in concentration is due to air diffusion which transports and mixes pollutants both vertically and horizontally in the atmosphere, thereby reducing the concentration away from the point of emission.

Table 2: Overall mean concentration (mg/m^3) of selected pollutants in road-side air

Location	CO	SO2	NO2	H2S	CH4
Camp	73.72±0.92	0.046±0.005	0.224±0.04	0.177±0.016	0.171±0.024
Asero	76.06±3.96	0.060±0.006	0.257±0.04	0.193±0.017	0.202±0.033
Adatan	77.11±3.34	0.067±0.017	0.279±0.05	0.209±0.017	0.202±0.041
Sapon	76.17±2.25	0.052±0.009	0.217±0.02	0.178±0.009	0.188±0.023
Ibara	75.56±3.10	0.052±0.012	0.236±0.01	0.167±0.017	0.164±0.034
Itoshin	82.44±2.15	0.065±0.009	0.323±0.03	0.242±0.016	0.442±0.385
Lafenwa	82.89±3.38	0.053±0.036	0.399±0.02	0.265±0.011	0.245±0.011
Itoku	81.83±2.67	0.064±0.009	0.262±0.03	0.237±0.017	0.246±0.018
Overall mean	78.22±4.18	0.057±0.015	0.275±0.06	0.208±0.037	0.232±0.144
Permissible limit (FEPA)	**10.0**	**0.01**	**0.04 – 0.06**	**0.06**	**0.06**

Table 3: ANOVA result of pollutants concentration and traffic volume among the locations

Variables	Morning (F value, Sig. level)		Afternoon (F value, Sig. level)		Evening (F value, Sig. level)	
CO	8.147	0.001	3.871	0.003	5.973	0.001
SO2	5.905	0.001	1.782	0.118	2.857	0.016
NO2	12.107	0.001	12.257	0.001	18.519	0.001
H2S	5.897	0.001	4.867	0.001	24.326	0.001
CH4	7.827	0.001	7.930	0.001	14.234	0.001
Traffic volume	11.949	0.000	20.455	0.000	32.068	0.000

The mean concentration of CO was relatively high at Lafenwa, Itoshin and Itoku (81.83 to 82.89 mg/m^3) while the least was measured at Camp (73.72 mg/m^3). For SO_2, NO_2, H_2S and CH_4, a similar area pattern was portrayed (Fig. 2a, b, c, d and e). Except for the concentration of CO, all other pollutants vary significantly among the selected locations in the City. Generally, each of these pollutants monitored at the selected locations was higher than the FEPA permissible limits as shown in Table 2. Similarly, vehicle volume vary significantly ($p<0.001$) among the motorways selected for the study. Spatial variation in the concentration of gaseous pollutants in urban has been reported by Bamgboye (2006) for Lagos and Ndoke et al. (2006) for Kaduna and Abuja cities. The mean values of these pollutants found above limits portend a worrisome situation giving negative health consequences of such pollutants monitored within permissible limits (Katsouyami et al., 1997; Katsouyami, 2003).

As shown in Fig. 1, traffic volume was highest in the morning, followed by afternoon and evening. The daily pattern of CO, SO_2, NO_2, H_2S and CH_4 followed the same pattern depicted by traffic volume among the selected locations. The relatively low level of CO, SO_2, NO_2, H_2S and CH_4 at Camp and Ibara are largely due to lower vehicular volume found on these roads at the selected periods. On the other hand, Itoshin, Lafenwa and Itoku, with higher vehicular volume showed relatively higher concentration of the pollutants. All these pollutants vary significantly ($p<0.01$) among the locations at morning, afternoon and evening (Table 3).

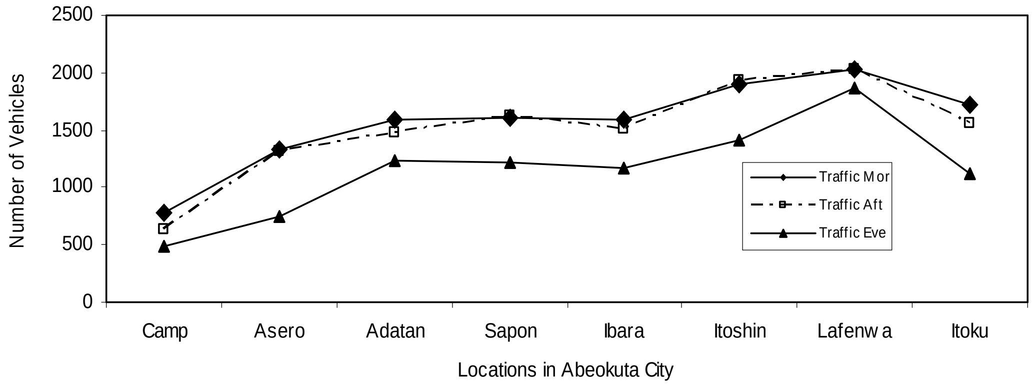

Fig. 1: Traffic density at the selected locations

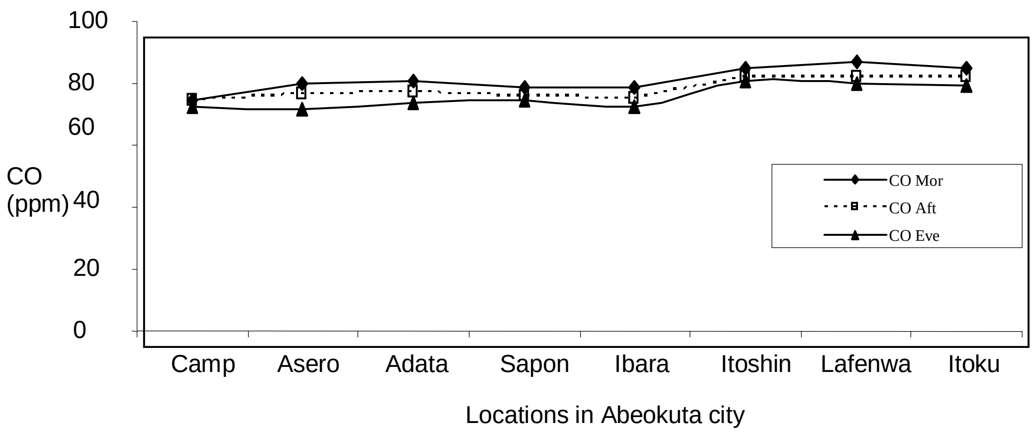

Fig. 2a: Mean concentration of CO at the selected locations

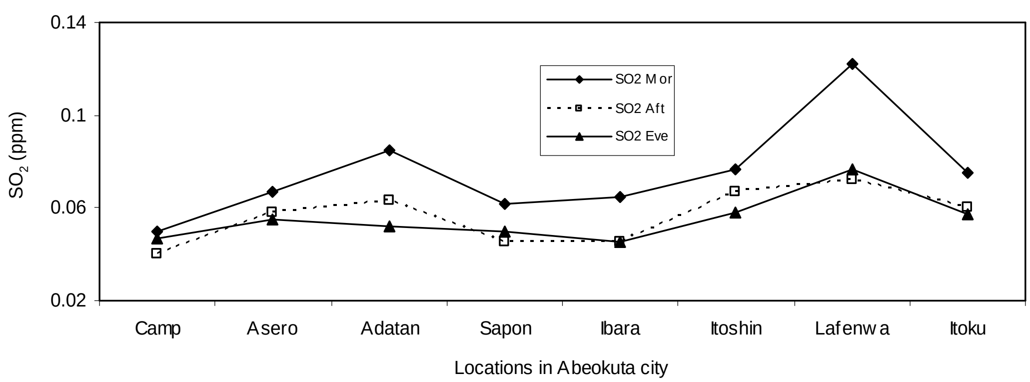

Fig. 2b: Mean concentration of SO_2

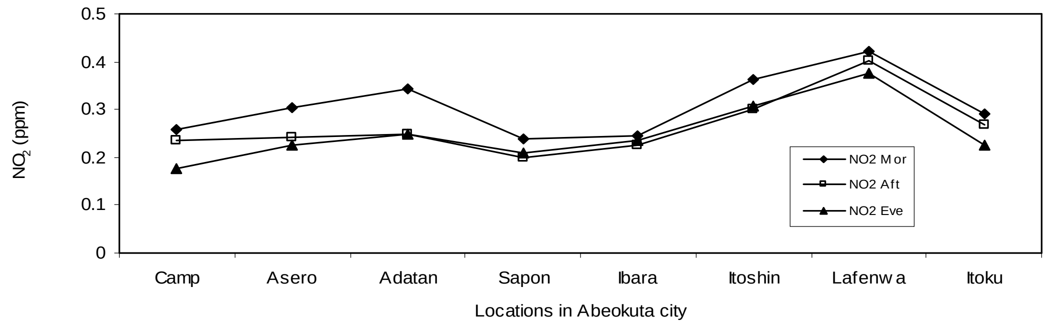

Fig. 2c: Mean concentration of NO_2

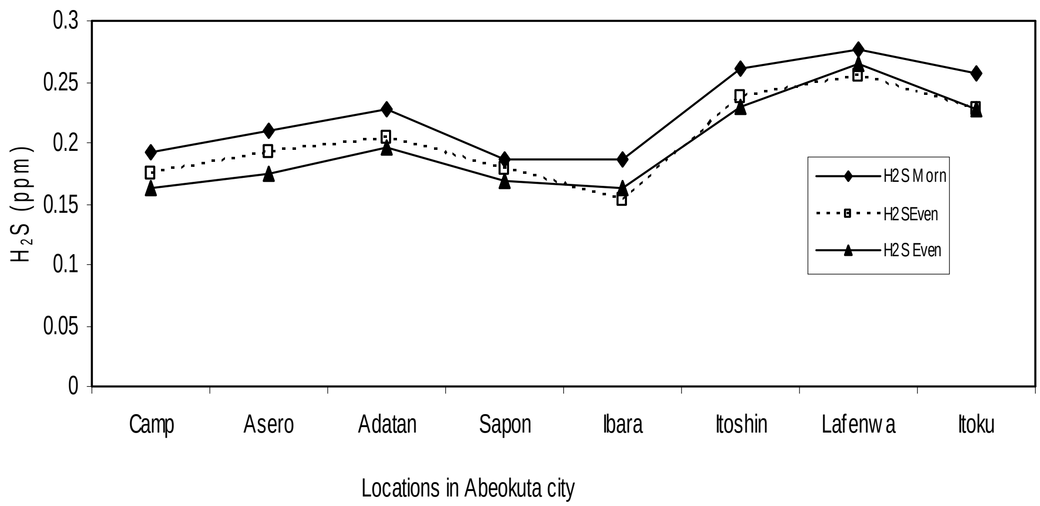

Fig. 2d: Mean concentration of H_2S in Abeokuta city

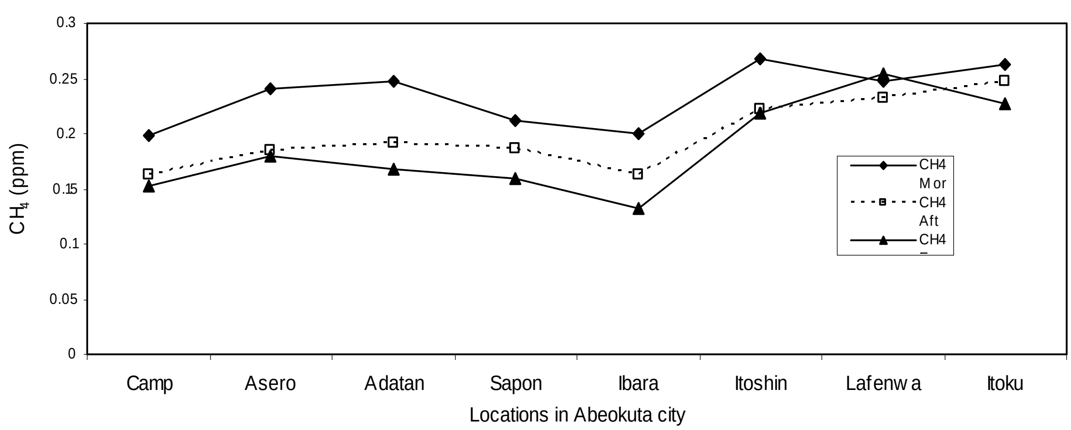

Fig. 2e: Mean concentration of CH_4 in Abeokuta city

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Table 4 showed significant ($p<0.01$) positive correlation between traffic volume on one hand and CO, NO_2 and H_2S ($r = 0.70$ to 0.81) on the other. There is significant inter-correlation between CO, NO_2, CH_4 and H_2S which may be an indication that these pollutants are associated and are released from the same source (Kotz and Purcell, 1987; Wood, 2004). The regression model (Table 5) gives an indication that vehicular volume on the selected roads accounted for 15.5, 49.5, 51.2 and 64.9 percent of CH_4, NO_2, SO_2 and CO concentration in roadside air of the selected locations. The low contribution of vehicles emission to methane in the roadside air suggests the existence of other major sources of methane as indicated by Wikipedia encyclopedia (2007). Moreover, the concentration of pollutants at the morning hours being the peak period of the day was supported by Bamgboye (2006), that such period constitute air pollution risk period in cities.

Residents living near motorways (Table 6) perceived cough (40.9%), impaired breathing (24.5%), and chest pain/tightness (10.9%) as the major health risks associated with living near motorway. Similarly, the health problems treated recently by the residents living near motorways includes; cough (56.4%) and breathing difficulties (23.6%) among others.

Table 4: Inter -correlation between traffic density and selected pollutants

Variables	Traffic density	CO	SO2	NO2	CH4	H2S
Traffic density	-					
CO	0.806**	-				
SO_2	0.297	0.277	-			
NO_2	0.716**	0.790**	0.242	-		
CH_4	0.392	0.535**	0.373	0.454*	-	
H_2S	0.704**	0.900**	0.326	0.877**	0.502*	-

* significant at 0.05 probability level
** significant at 0.01 probability level

Table 5: Summary of regression model of selected pollutants on traffic density

Model	R	R square	R square%	F – value	Sig. level
1a (CO)	0.806	0.649	64.9	40.683	0.01
1b (H_2S)	0.297	0.088	8.8	2.129	0.15
1c (SO_2)	0.716	0.512	51.2	23.090	0.01
1d (NO_2)	0.704	0.495	49.5	21.607	0.01
1e (CH_4)	0.392	0.154	15.4	3.999	0.05

Table 6: Health problems perceived and those recently treated by residents living near motorway

Perceived health problems	Frequency	Percentage
Cough	45	40.9
Poor breathing	27	24.5
Chest pain	12	10.9
Cold	8	7.3
Respiratory tract infection	3	2.7
Malaria	3	2.7
Fever	3	2.7
Dermatitis	2	1.8
Headache	2	1.8
Others	5	4.3
Total	**110**	**100.0**
Recently treated health problems		
Cough	62	56.4
Breathing difficulty	26	23.6
Body weakness	7	6.4
Malaria	6	5.5
Catarrh	4	3.6
Pneumonia	3	2.7
Accident injury	2	1.8
Total	**110**	**100.0**

Table 7: Socio-demographic characteristics of sampled residents living near motorways

Characteristics	No. of respondents	Percentage
Age group		
20 – 35 years	60	54.5
36 – 50 years	41	37.3
51 – 65 years	8	7.3
Above 65 years	1	0.9
Total	**110**	**100.0**
Gender		
Male	61	55.5
Female	49	44.5
Total	**110**	**100.0**
Education level		
No formal education	13	11.8
Primary education	16	14.5
Secondary education	50	45.5
Post secondary education	31	28.2
Total	**110**	**100.0**
Occupation group		
Traders	60	54.5
Technicians	18	16.4
Civil servants	10	9.1
Drivers	10	9.1
Students	4	3.6
Others	8	7.3
Total	**110**	**100.0**

These diseases are largely manifestations of lung malfunctioning as a result of exposure to pollutants which enter into the respiratory tracts (Wieland et al., 1994; Ciccone et al., 1998; English et al., 1999) as volatile gas, liquid droplets and or particulates. The prevalence of respiratory disorders among roadside residents agrees with the results of other studies that impairment of lung functioning are the most immediate outcome of human exposure to air pollution. Occurrence of other systemic and chronic diseases such as cardiovascular disorders may not be unlikely among residents living near motorways (Goodwin, 2004; Gislason, 2006).

The socio-demographic characteristics of the respondents (Table 7) shows that 91.8 percent of the residents living motorways constitute the active labour force (20 -50 years). Moreover, about 56 percent of the respondents living in close proximity to motorways, and are invariably exposed to various health problems are males. In spite of 73.7 percent of the respondents having secondary and post-secondary education, they chose their places of living near motorways. This may support the assertion that affordability determines choice of residence in the cities of low income countries (Mueller and Tighe, 2007) rather than level of education and other considerations such

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as comfort and quality of neighbourhood.

CONCLUSION AND RECOMMENDATIONS

As demonstrated by the findings of this study, vehicular emissions contribute significantly to urban air quality. Health risks associated with continuous exposure of humans to gaseous pollutants emanating from vehicle exhaust are largely impairment of respiratory system. In order to minimize the problems of noxious gases emitted by automobiles, the developing countries should ensure that imported vehicles and those locally assembled meet emission standard. Moreover, programme should be put in place to establish enforceable standards for permissible levels of vehicle emissions. Such standard will be used to screen vehicles already in use to determine their road worthiness and check emission level. Functional and effective public-mass transportation programme/ scheme must be pursued with high sense of commitment so as to reduce the volume of private cars in urban centres. To make this achieve the desired result, subsidies should be introduced in the operation of the mass transport system while fees will be charged from private car owners plying some selected routes at certain periods of the day. Traffic volume in some busy zones within the city should be minimized through the introduction of toll fees so as to discourage the use of private vehicles in such area. It will be appropriate for authorities in the developing countries to source alternative energy for automobile use other than fossil fuel. Indeed, Nigeria should seek to legalize the clean Air Act. Finally, the use of open space besides roads for residential purpose should be prohibited in order to minimize human exposure to air pollutants from vehicles. The use of simple and cheap nose mask should be introduced to workers whose jobs require staying several hours near motorways.

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