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Effects of Vehicular Emission on Environmental Pollution in Lagos

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ABSTRACT

The air we breathe is a mixture of gases and particulate solid and liquid matter. Some of these substances come from natural sources while others are caused by human activities such as our use of motor vehicles, domestic activities, industries and businesses. Air pollution occurs when the air contains substances in quantities that could harm the comfort or health of humans and animals, damage plants and materials. The study investigates the concentrations of CO, NO_2, SO_2, CO_2 and HC arising mainly from the activities of motor vehicles on the ambient air quality of selected sites in Lagos metropolis and the locations are Oshodi, Ojota, Yaba and Lekki while a fourth location (Lekki) was used as a control due to its low level pollution. The sampling was carried out over both the dry and wet season. Results from dry season vehicular emission experimentation indicate that the average CO concentrations at the Oshodi peaked at 29.04ppm. The site also recorded highest concentrations for NO_2, SO_2, CO_2 and HC at 0.042ppm, 0.040ppm, 370.92ppm and 0.030ppm respectively. In the wet season, Oshodi also recorded highest CO concentrations at 18.72ppm. NO_2 was highest at 0.03ppm in Yaba and Ojota. Both Oshodi and Ojota area recorded highest SO_2 concentration at0.032ppm. Oshodi recorded highest concentrations for both CO2 and HC at 370.92ppm and 0.028ppm respectively. Results from comparison of the average CO concentration with the National Ambient Air Quality Standard (NAAQS), showed that CO concentrations in virtually all sites exceeded the 10ppm for an averaging time of 1 hour in both seasons. The same was true for SO_2, which exceeded the 0.01ppm limit for an averaging time of 1 hour. NO_2 limit of 0.04ppm for a 1 hour averaging time was exceeded at Oshodi in the morning hour, Ojota in the afternoon, and in the evening hours at Ojota, Oshodi and Yaba all in the dry season. All sites were within limit in the wet season. Results from comparison of the pollutants concentration at the three classified locations indicates that all pollutants concentration decreased with increased distance away from the traffic sites. The model developed is therefore useful for planning of residential and other facilities in Lagos metropolis and beyond. In addition, the results obtained from questionnaire on the effect of vehicular emission on human health show that on the average, 28.3%, 16.6%, 23.3%, 18.3%, 13.3% were respectively affected by sleeplessness, running nose, heavy eyes, asthmatic attack, and headache respectively. The location (distance from the coast type of fuel, availability of industries, and concentration of traffic) determine the impacts of these emissions on the ecosystem.

Key words: Vehicular Emissions, Environmental, Pollution, illness, Survey, Lagos.

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INTRODUCTION

Smog caused by air pollutants has a significant adverse impact on the health of Nigerians, the Nigerian economy, and the environment. Smog is a noxious mixture of gases and particles, primarily ground-level ozone (O_3) and particulate matter. It has been identified as a contributing factor in thousands of premature deaths across the world each year, as well as in increased hospital and doctor visits and hundreds of thousands of lost days at work and school. Environmental problems attributed to smog include effects on vegetation, buildings and visibility.

The operation of motor vehicles is a major source of smog-forming air pollutants. Motor vehicle emissions are a result of combustion and evaporation of fuel. The most common types of transport fuels are gasoline and diesel. When the fuel in a vehicle is burned, pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), total nitrogen oxides (NOx), sulfur oxides (SOx), hydrocarbons (HC) and particulate matter (PM) are emitted.

Some of these gases are called Green House Gases (GHGs). These same gases occur naturally in the atmosphere, and have the capacity to trap heat emitted from the earth's surface, for the insulation and warming of the planet, by a process called the Greenhouse Effect. Without this process (thermal blanketing of the natural greenhouse effect), the earth's climate would be too cold for most living organisms to survive.

The greenhouse effect has naturally warmed the earth for over 4 billion years. The GHGs in their normal concentrations in the atmosphere sustain life on earth, but a very big challenge emerges when there is an increase in their concentrations. Researchers are growing increasingly concerned that human activities, particularly in the transport sector, are modifying this natural process, raising the concentrations of these gases to toxic levels, with potentially dangerous environmental and human health consequences.

Air pollution causes severe environmental hazards such as acid rain, global warming, depletion of the ozone layer, and are leading causes of climate change. There is a great concern about the climatic problems being faced all over the world such as excessive flooding, droughts etc. Nigeria is already a victim of these environmental disasters.

Other environmental hazards include soil pollution, leading to poor agricultural yield, and water pollution that causes aquatic death. Air pollution causes eye irritation, affects the respiratory system (cough, bronchitis, etc), kidneys, nervous and immune system, cardiovascular, reproductive and developmental systems, leading to neurological dysfunction, heart disease and high blood pressure, birth defects, cancer and sometimes death. The most vulnerable groups are children, aged and people with respiratory infections such as asthma. Despite the environmental and health consequences attributed to vehicular emissions, no nation can do without vehicles. Vehicles are very important assets for the socio-economic development of a nation. They serve as rapid and efficient means of transport for people and movement of goods and services from one place to another. They bring convenience and ease to our lives.

The various transportation modes include tricycles, motorcycles, cars, buses, trucks, trains, airplanes, engine powered boats, etc. Considering the huge benefits derived from the use of vehicles, vis-à-vis their environmental and health implications, vehicular emissions have now become a global issue. In Nigeria, majority of the vehicles used are poorly maintained and are second hand ("tokunbo") with poor engine performance. These categories of vehicles are known to emit huge quantities of harmful air pollutants (GHGs) in the atmosphere, causing severe air pollution with their attendant environmental and health consequences.

Studies and the aerial view of Nigeria have shown that our atmosphere is highly polluted. This is very evident in the number of smoky vehicles plying our roads on daily basis, causing visibility problems and sometimes accidents.

In developing countries, enormous environmental problems due to inadequate environmental planning and monitoring have emanated. This situation is being further complicated in many areas of certain developing countries by environmental problems, which are often associated with development (Oluwande, 1977). In such places, environmental problems, like, air pollution in urban centers due to increased volume of traffic on ill-planned roads, are aggravating the already serious problems caused by poor, absent or inadequate sanitary facilities (Arokodare, 1976; Alo *et al*., 2007).

In most developing countries of the world vehicular growth has not been checked properly by environmental regulating authorities leading to increased levels of pollution (Han, and Naeher, 2006). Traffic emissions contribute about 50-80% of NO_2 and CO concentration in developing countries (Fu, 2001; Goyal, 2006). This situation is alarming and is predicated on the poor economic disposition of developing countries. Poor vehicle maintenance culture and importation of old vehicles, which culminates in an automobile fleet dominated by a class of vehicles known as ''super emitters'' with high emission of harmful pollutants, has raised high this figure of emission concentration (Ibrahim, 2009). The increase in this traffic-related pollution is not based on the aforementioned factor only, but also on low quality fuel, poor traffic regulation and lack of air quality implementation force. These are clear indices to high levels of traffic-related pollution in developing countries.

In Nigeria as well as in other developing countries, which are not yet fully industrialized, majority of the air pollution problems result from automobile exhaust. In the major towns of some developing countries, because of tropical nature of the climatic conditions, many activities are performed outdoors. People stay along the busy roads every day either to do their work or to sell their wares. Therefore, the ill effects on health due to air pollution resulting from automobile exhaust emission must be very serious indeed (Ayodele and Bayero, 2009).

Also, much attention is given to general industrial pollution and pollution in oil industries, with little reference to damage or pollution caused by mobile transportation sources of air pollution (Faboya, 1997; Iyoha, 2002; Magbagbeola, 2001). Pollution from mobile transportation is on the rise due to increase in per capital vehicle ownership, thus resulting in high congestion on Nigeria city roads and increase in the concentration of pollutants in the air, consequently, increasing health risks for human population. In addition compared with the large volume and varieties of studies carried out in the developed world, exposure studies carried in Nigeria are relatively scarce. So as a first step in focusing attention on these problems, it is necessary to know the types of air pollutants present along with the level of each.

The current focus of Environmental Protection Agency (EPA) is to reduce the sulfur content from diesel fuels. Effective 2007, EPA has mandated the use of 15 parts per million (PPM) of sulfur content in all diesel fuels. A variety of fuels and fuel blends have been proposed as alternatives to the existing fossil fuels to meet these strict emission and fuel standards. Several countries and private fleet authorities have begun testing various fuels blends and alternatives such as ethanol, compressed natural gas (CNG), hydrogen, biodiesel blends and ultra-low sulfur diesel (ULSD, sulfur content is 15ppm). Nigeria diesel sulphur content is currently at about 1330 parts per million as shown in Table 1.

Very few studies have reported tail pipe emission comparison for vehicles operating on biodiesel and ULSD. The major drawback in most of these studies has been the small size of the vehicle fleet considered and also the need to collect engine and emission data simultaneously to study the effect of engine parameters on emissions (Denis et al., 1994).

Table 1: Nigerian Diesel Oil Specifications

Qualities	Unit	Requirement	Actual from Nigerian Refineries
Sulphur	ppm	3000	1330
Density	Kg/m^3 (Maximum)	820 - 870	871
Cetane number	minimum	47	50
Total Acid Number	Mg KOH/g (maximum)	0.5	
Final Boiling Point	℃ (max)	385	358

AIR POLLUTION

The atmosphere is one of our greatest resources. Ever since life began on earth, the atmosphere has been an important resource for chemical elements and a medium for the deposition of wastes. The movement of air across the earth‟s surface continually renews the air around us. Chemical pollutants can be thought of as compounds that are in the wrong place at the wrong time in the wrong concentrations (Mishra, 2008). Many industrial activities, and particularly energy generation, industrial production and vehicular traffic, have brought significant increase in the atmosphere contamination, in addition to the pollutants released from natural sources. There are two main groups of air pollutants: primary and secondary. Primary pollutants are those that are emitted directly into the air, including particulates, sulphur dioxides, carbon monoxide, nitrogen dioxides and hydrocarbons. Secondary pollutants are those produced through reaction among primary pollutants and normal atmospheric compounds. Ozone is a secondary pollutant formed through photochemical reactions among primary pollutants and the natural atmospheric gases.

Unfortunately, pollutants are not evenly distributed. They are produced locally or regionally. It is useful to distinguish two major kinds of pollution sources – point and non-point sources. An example of a point source is a smokestack from a large power plant and an example of a non-point source is the exhaust from automobiles during rush hour in a city. The primary pollutants such as particulates, hydrocarbons, carbon monoxide, nitrogen oxides and sulphur oxides, account for more than 90 percent of air pollution problems in the developed countries (Mishra, 2008). An assessment of the potential for increased vehicular pollution requires some basic information relating to traffic volume and the intensity of pollutant emissions on road corridors. With respect to traffic volume, the critical factors will include population size, fuel consumption per capita and the proportion of the population that owns motor vehicles as well as annual average distances covered (Orubu, 2004).

Air Pollutants and Their Effects

Air pollution is a basic problem in today‟s world. Exposure to ambient air pollution has been linked to a number of different health outcomes, starting from modest transient changes in the respiratory tract and impaired pulmonary function, continuing to restricted activity/reduced performance, emergency room visits and hospital admission and to mortality. There is also increasing evidence of adverse effects of air pollution not only on the respiratory system, but also on the cardiovascular system (WHO, 2004). Physical damage functions relating health (mortality and morbidity) to air pollution levels have been estimated over a number of years in different countries. Although the net effect of pollutants on health is unclear, the Committee of the Medical Effects of Air Pollution (COMEAP), set up by the United Kingdom government has found the strongest link between health and pollution to be for particulates (PM10), sulphur dioxide (SO2) and Ozone (O3) (Powe and Willisc, 2002). Cars, trucks, motorcycles, scooters and buses emit significant quantities of carbon monoxide, hydrocarbons, nitrogen oxides and fine particles. Where leaded gasoline is used, vehicles are also a significant source of lead in urban air. The adverse health and environmental consequences resulting from these pollutants are summarized below

Particulate matter

Particulate matter (PM) represent a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplet or solids) over a wide range of sizes. Particle matter may be emitted directly into the atmosphere or may be formed by transformation of gaseous emissions such as sulphur dioxide, nitrogen oxides and volatile organic compounds (VOCs). Some particulate matter occurs naturally originating from volcanoes, dust storm, forest and grass land fires, and sea spray. Particulate matter is a core emission by automobile especially diesel engine vehicles. Vehicular emission is connected to two types of particulate matter, the fine particulate matter (PM2.5) and the coarse particular (PM10). PM2.5 consist of particles less than one-tenth the diameter of human hair and poses the most serious threat to human health (Ronni, 2012). The size of particle is directly linked to their potential for causing health problems. Particles that are ten micrometer (PM10) in diameter generally pass through the nose into the lungs. Once inhaled these particles can affect the health and lungs and cause serious health effect. Particles less than 2.5 micrometers in diameter are termed "fine particle or PM2.5 as mentioned before, they are so small that they can be inhaled deeper into the lungs than the PM10, hence it causes more health problem than PM10 (Walsh, 2000).

Carbon monoxide

Motor vehicles significantly contribute to ambient carbon monoxide (CO) concentrations. Although CO emissions from motor vehicles have declined through emission control technologies and regulations in many countries, motor vehicles remain the primary source of this pollutant in most locations. All motor vehicles emit CO, but the majority of CO emitted from this source occurs from light-duty, gasoline-powered vehicles. In addition to health concerns from CO exposures, CO may be a useful indicator of the transport and dispersion of inert, primary combustion emissions from traffic sources since CO does not react in the near-road environment (Baldauf *et al*., 2009).

Oxides of nitrogen

NOx represents the sum of the various nitrogen gases found in the air, of which Nitric oxide (NO) and Nitrogen dioxide (NO2) are the dominant form. The emission sources are varied but tend to result from high temperature combustion of fuel for industrial activities and residential heating, and vehicle use. Motor vehicles also significantly contribute to ambient nitrogen oxides (NOx) emissions in most countries. Although all motor vehicles emit NOx, the majority of on-road emissions occur from diesel vehicles. In terms of primary emissions, the majority of NOx exhaust is in the form of nitrogen oxide (NO). Nitrogen dioxide (NO_2), which is the focus of concern in terms of adverse health effects, quickly forms by a photochemical reaction in the ambient air in the presence of NO and ozone (O_3). However, primary NOx emissions from more technologically advanced heavy-duty diesel engines with after treatment devices may contain a much greater percentage of NO_2 in exhaust emissions. Thus, NO and NO_2 will be present in varying concentrations in the near-road microenvironment (Baldauf *et al*., 2009). NOx causes severe respiratory problems, especially in children. When combined with water, it forms nitric acid and other toxic nitrates. NO_2 is a main component in the formation of ozone at ground level. The gas irritates the lungs and has been known to lower the immune system (Wai and Steven, 2007).

Sulfur dioxide

Although motor vehicles emit sulfur dioxide (SO_2) and other sulfur-containing compounds, traffic sources typically make only small contributions to ambient concentrations. In addition, the introduction of low-sulfur fuels in most countries should further reduce SO_2 emissions. Therefore, this pollutant is not commonly monitored in near-road applications. However, the monitoring of SO_2 may be useful near other types of transportation facilities, such as airports, railway yards, and seaports, as sources at these locations may still burn high sulfur fuels. In addition, it may be useful to measure this pollutant (or other sulfur-containing compounds) in specific situations to identify the influence of other sources at the monitoring site, such as power generation or ship emissions (Baldauf *et al*., 2009). The gas irritates airways and eyes and is known to cause longer-term heart diseases, other cardiovascular ailments, and bronchitis. It also readily causes shortness of breath and coughing amongst asthma sufferers. SO_2 is also a major contributor to acid rain, which damages the environment and upsets the ecosystem (Wai and Steven, 2007).

Ozone

Ozone is not directly emitted from motor vehicles, and O_3 measurements are not typically collected for near road applications. However, the presence of elevated NO concentrations in the near-road microenvironment may lead to lower concentrations due to "ozone scavenging" as part of the formation of NO_2 from NO and O_3. Thus, O_3 measurements may be useful under select circumstances as support for health studies investigating the role of O_3 and other co-pollutants on adversely affecting public health given the potentially lower concentrations of this pollutant relative to other pollutants in this microenvironment (Baldauf *et al*., 2009).

Lead

Before the introduction of unleaded gasoline in most countries of the world, motor vehicle lead (Pb) emissions were a major public health concern. While Pb is no longer added to gasoline in many countries, motor vehicle fuels still contain trace amounts of Pb from crude oil. Lead is also present in trace amounts in lubricating oil. Other sources that may contribute to ambient Pb concentrations in the near-road environment include brake wear, tire wear, and the degradation of wheel weights used for aftermarket tire balancing. Re-suspended road dust may also contain Pb from historically deposited industrial or mobile source emissions (Baldauf *et al*., 2009).

Hydrocarbon

These are otherwise known as Volatile Organic Compounds (VOC). They are essentially fuel which was unburnt during combustion process or which has escaped into the atmosphere through fuel evaporation. Hydrocarbons can often be divided into separate categories of methane (CH_4) and non-methane (NMVOCs). Vehicles are also a major source of atmospheric hydrocarbons. Stationary sources of hydrocarbons include petrochemical manufacture, oil refining, incomplete incineration, paint manufacture and use, and dry cleaning (Mishra, 2008). Methane is a greenhouse gas and has prominent role in global warming even though majority of gaseous pollutants are inhaled and may affect respiratory system. They can also induce hematological (blood-related) problems (Baldauf *et al*., 2009).

Carbon dioxide

Carbon dioxide, methane, and gas molecules that have similar structures may influence the global climate by internal molecular vibration and rotation which cause these molecules to absorb infrared radiation. When these gases form part of the atmosphere, they absorb some of the heat that the earth normally radiates into space (Pierre *et al*., 1998). Carbon dioxide is a “greenhouse gas” which is a major player in global warming.

EPA RESEARCH AND REGULATIONS

In 1990, the Clean Air Act Amendment (CAA) introduced fuel along with engine technology to be a potential source for the reducing toxic emissions. The increased concern among people with the rising of these toxic emissions has made many countries lay stringent rules. USEPA in 2006 has introduced a law where all the on-road diesel vehicles in the USA use ULSD. Law 11.097/2005 in Brazil similarly established minimum percentages to mix diesel and biodiesel, besides monitoring on the introduction of this new fuel into the market. According to 2008 Brazilian law, two percent biodiesel blending was mandatory, which increased by five percent starting in 2003 (Brazil Law 11.097/2005). EPA has reduced the standards of sulfur content present in diesel and gasoline to 15 parts per million (ppm) since 2007. These stringent rules laid by the EPA have created awareness and made a need to switch to cleaner burning fuels.

The state of Minnesota began blending two percent biodiesel into nearly all the state’s diesel fuel in 2005 and came up with ULSD which had lubricating properties inferior to those of the previously used number 2 diesel. A summary of U.S. air pollution control acts established by the EPA over recent years have been tabulated in Table 2.There are a few standards on the emissions that are laid down by the EPA known as the National Ambient Air Quality (NAAQS) for pollutants considered being harmful to public health and the environment. The Clean Air Act (CAA) which was amended in 1990 requires EPA to set these standards and has established two types of national air quality standards. Primary Standards which are set to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. They are listed in Table 3.0. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb - 1 part in 1,000,000,000) by volume, milligrams per cubic meter of air (mg/m3), and micrograms per cubic meter of air (µg/m3).

Table 2: EPA control acts over the past

Federal Acts	Addressed Issues
1955	First Air Pollution Act, to address national environmental problem of air pollution
1963	First Clean Air Act, to strengthen and accelerate programs for the prevention and abatement of air pollution
1965	Motor Vehicle Air Pollution Control Act to establish standards for automobile emissions
1966	Expanded local air pollution control programs
1967	Air Quality Act, national emissions standards for stationary sources
1969	Extended research on low emission fuels and automobiles
1970	National Ambient Air Quality Standards, to protect public health and welfare, and regulate emissions of new source entering an area
1977	First attempt to prevent destruction of stratospheric ozone
1990	Emissions trading and reduction of sulfur using low-sulfur fuels as well as alternative fuels
1992	Energy Policy Act, to address energy efficiency and encourage fleets to use alternative fuels
1998	Energy Conservation Reauthorization Act, to allow agencies and alternative fuel providers to purchase alternative fuel vehicles
2001	The Highway Diesel Rule, effective from 2007, the sulfur content in diesel fuel to be reduced by 97%
2005	Energy Policy Act, federal tax credits for energy efficient products such as electric vehicles, ethanol, biodiesel

Source: (www.epa.gov)

Table 3: National Ambient Air Quality Standards (U.S. EPA)

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide [76 FR 54294, Aug 31, 2011]	9 ppm (10 mg/m3)	8-hour	None	
	35 ppm (40mg/m3)	1-hour		
Lead [73 FR 66964, Nov 12, 2008]	0.15 μg/m3	Rolling 3-Month Average	Same as Primary	
	1.5 μg/m3	Quarterly Average	Same as Primary	
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]	53 ppb	Annual (Arithmetic Average)	Same as Primary	
	100ppb	1-hour	None	
Particulate Matter (PM10)	150 μg/m3	24-hour	Same as Primary	
Particulate Matter (PM2.5) Dec 14, 2012	15.0 μg/m3	Annual (Arithmetic Average)	Same as Primary	
	35μg/m3	24-hour	Same as Primary	
Ozone [73 FR 16436, Mar 27, 2008]	0.075 ppm (2008 std)	8-hour	Same as Primary	
	0.08 ppm (1997 std)	8-hour	Same as Primary	
	0.12 ppm	1-hour	Same as Primary	
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]	0.03 ppm	Annual (Arithmetic Average)	Same as Primary	
	0.14 ppm	24-hour	0.5 pm	3-hour
	75 ppb	1-hour	None	

Source: (USEPA 2003 - http://www.epa.gov/air/criteria.html)

Vehicle emissions significantly pollute air and require control (Karlsson, 2004). With increasing concern for air toxics and climate modification caused by exhaust emissions, the need for tighter control increases in importance. There is therefore a great need for studies involving emission factors and impact. In recent years, there has been considerable research on vehicle emissions and fumes (Ababio 2003). Carbon monoxide causes blood clotting when it reacts with haemoglobin, which cuts the supply of oxygen in the respiration system after long exposure. This is a common occurrence in urban centres with a high level of commercial activity (Ackerman *et al* 2002). The worst levels of pollution are seen in such urban cities as are densely populated with a low standard of living (Addy and Pietrass 1992; Washington *et al* 1998).

Among the most common, yet most ignored vehicles on the roads are garbage trucks. Heavy-duty diesel-powered vehicles, including garbage trucks, make up only 7 percent of vehicles on the road, but they produce 69 percent of on-road fine particulate pollution and 40 percent of the NOx emissions (Kilkarr 2007).

Diesel engines are a major source of pollution emitting particulate matter (soot), nitrogen oxides which contribute to the production of ground-level ozone (smog), acid rains, hydrocarbons and air toxics. These emissions can damage plants, animals, crops, and water resources. Emissions from diesel exhaust can lead to serious health conditions, such as asthma and allergies as shown in Table 4.0. They can also worsen heart and lung diseases, especially for vulnerable populations such as children and older individuals.

EPA estimates that every $1 spent on clean diesel projects produces up to $13 of public health benefits. Studies conducted in the past have established the fact that a huge percentage of pollutant emissions in ambient air are emitted by vehicles (EPA's National-Scale Air Toxics Assessment, 2002). They have numerous effects on human health as well as on the environment. In fact, a study in the Journal of the American Medical Association cited that people who live in the most heavily polluted areas have a 12% higher risk of getting lung cancer than people in the least polluted areas.

Table 4: A summary of health concerns due to different diesel pollutants

POLLUTANT	HEALTH CONCERN
Nitrogen dioxide	Lung irritation, respiratory illness, and premature death
Carbon Monoxide	Headaches and reduces mental alertness
Particulate matter	Increased respiratory disease, lung damage, cancer and premature death
Sulphur dioxide	Increase in existing heart disease, breathing difficulties and respiratory illness
Ozone	Breathing difficulties, respiratory infections and lung and tissue damage

(Source: Compiled from U.S. EPA)

This study analyzed and evaluated the vehicular emission in several cities in Lagos state and look at the effects on environmental pollution and health hazards on the populace.

METHODOLOGY

The method used for the analysis of vehicular emission in Lagos is experimentation and survey.

Experimentation

Instrumentation

TESTO330-2LL Exhaust Gas Analyzer

The portable emission measurement system used in this experiment to collect vehicular emissions is the TESTO330-2LL system manufactured by Testo Inc. as shown in Figure 1.0. It consists of non-dispersive infrared sensors that can continuously measure up to three gases: oxygen (O_{2-}: 0-21%), carbon dioxide (CO_2), carbon monoxide (CO: 0 - 8,000 ppm H_2 compensated) w/ auto dilution to 30,000 ppm), Flue Temperature, Draft & Pressure, Zero function with probe in stack,12" probe,7ft hose and a temperature sensor.

Figure 1: TESTO330-2LL Exhaust Gas Analyzer

Crowcon Gas Detector - Tetra Multi Gas Detector

The tetra multi gas detector is a true single button operation-the most user friendly product available, easy to read backlit graphic display for gas readings and diagnostics as shown in Figure 2.0. It operates for a minimum of 12hours and a sensor for a wide range of gas constituents. It was used to collect sulfur dioxide (SO_2), HC and nitrogen dioxide (NO_2).

Figure 2: Tetra Multi Gas Detector

The unit of measurement for all the above gases except CO_2 and O_2 is parts per million of volume (ppm), CO_2 and O_2 are measured in % volume. Nokia N8 mobile handset with in-built GPRS was used to monitor the wind speed at the sites. The wind direction was determined by visual observation of the smoke particles released from the tailpipe of moving vehicles. The direction of the particles emitted determined the position assumed when taking emission readings.

EXPERIMENTAL/SURVEY PROCEDURES

Sites of Inquiry

In this study, the emission that were studied specifically were the sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), hydrocarbon (HC) and carbon dioxide (CO_2) at ground level in relation to traffic as shown in Figures 3, 4 and 5. In this study, ground level was defined as 1.524 m above sea level at intersections within the city. The height was chosen because it best represents the height of breathing of people, whether standing or seating. Traffic “hot spots” are defined as intersections/roads with high vehicular levels. As part of the objective of the study to form a basis of comparison of traffic levels in the so-called “hot spots” and “background” air quality measurements from “background” were equally carried out. Measurement at a “control site” was carried out. A control site in this context is an area adjudged free from significant impact of traffic/vehicular emission.

Figure 3: Emission Test Analysis

Figure 4: Emission Test Analysis

Figure 5: Environmental Pollution in Lagos

Spatial and Temporal Coverage

The areas in Lagos metropolis on which the study focused include: Yaba, Ojota and Oshodi. From all these locations, "background" measurements were carried out. Lekki Penninsula was selected as "control site". The collection of information was conducted in two phases. The first phase conducted in the dry season spanned from December 2015 to February 2016. The second phase on the other hand was conducted in the wet season between June 2016 and July 2016. In both seasons, monitoring was conducted on a daily basis though not on consecutive days in the sites due to the long distance between the sites. For convenience, therefore, three sites were monitored daily in most cases and two sites on few occasions. The time blocks chosen covered expected periods of high traffic ("rush hour" – 7:30am - 9:00am) as well as expected periods of low traffic (11:30am - 1:00pm) and again in the evening (3:45pm – 5:15pm). At least three measurements were carried out at each sampling site.

Traffic Congestion

The number and types of vehicles, motor cycles and tricycles that travelled in the survey site where experimentation was conducted in a given time period were counted. All types of vehicles, motor cycles and tricycles were counted and recorded according to their traffic movement. The type of intersection determined the amount of persons conducting the traffic counts.

For a four way intersection, four persons recorded the traffic flow. Each person was responsible for only one directional flow of traffic in order to reduce the probability of human error. The persons were positioned at the corners of the intersection and counted the traffic approaching from their left. All traffic counted was categorized by the type of vehicle. The categories were as follows: Motorcycles/Tricycles; Cars/Buses; Trucks/Lorries.

The traffic density was determined by directly observing and counting the vehicles during the morning (8:00am – 9:00am), afternoon (12:00pm – 1:00pm) and evening hours (4:00pm – 5:00pm) for each day. This was done three times daily for all the sites and the average volume of traffic at each site per hour was calculated.

Correlation between Pollutant emission and Traffic Levels

In order to establish an association or relationship between air pollution and traffic emissions, the collected data were analyzed extensively. There were three logical steps taken to ascertain this connection. First, traffic level information was analyzed.

Second, air quality data was analyzed, and finally, pattern in the two sets of information were identified. Once the traffic and air quality data were analyzed, the correlation between the two sets of information was identified. In order to establish a connection between traffic counts and air pollution, the relationship between high traffic and pollutants concentration was explored. Using the Statistical Package for Social Scientists (SPSS), the pollutants concentrations were graphed versus traffic counts in order to demonstrate a correlation between the two sets of data.

Concentration of Emission at Source, Receptor and Distance from Emission Source

The relationship between concentration at a sources location (CS), concentration at a receptor location (CR) and distance (D) from the source of the emission was established based on the fact that pollutant concentration will decrease with increasing distance from the source of the pollution. Concentration of pollutant emission at a receptor location is directly proportional to the concentration released at source and inversely proportional to the distance from the source.

$$C_R \propto C_S/D \qquad 1$$

$$C_R = K \times C_S/D \qquad 2$$

Where C_R= the concentration of pollutant at a receptor location (ppm),

C_S= the pollutant concentration released from the source of the emission (ppm),

D = the reception distance from the emission source (m),

K =the constant of proportionality.

Taking logarithm of both sides of the equation:

$$\text{Log } C_R = \text{Log } k + \text{Log } C_S/D \qquad 3$$

A plot therefore of Log C_R against Log C_S/D produces a straight line graph whose slope gives the value of Log k. The antilog of which gives the value of the constant, k.

Methods of sampling and samples

The research focused on congested cities of Lagos where heavy vehicular emissions are common. The sample areas are densely populated. They were observed both in the day and night.

A common characteristic of these areas is the presence of heavy flow of transportation and high industrial activities where the heavy combustion of fossil fuel from the internal combustion chambers exists. The sample areas are Oshodi, Ojota and Yaba, while Lekki was used as a control location since it has low levels of pollution. In these study areas, concentration of pollutants such as carbon monoxide, sulphur oxide, nitrogen oxides, organic acids, and hydrocarbons (obtained mostly from exhaust gases) in the atmosphere is high.

However, vehicular emissions account for more than 60% of the total pollutants emitted when compared to other sources. In this investigation, the effects of emission on the health of the people living in the sampled location and impacts were assessed. The effect of emission on health: In determining the health effects in the samples location, questionnaires were prepared and administered on 100 selected individuals each who live or work in the study areas. The data obtained from the questionnaires were analysed based on the information obtained from them. The questionnaire also sampled people’s opinions on what they think should be done to reduce these harmful exhausts.

Questionnaire

Questionnaires were administered in four cities of Lagos: Oshodi, Ojota and Yaba. The fourth city, Lekki, was used as a control site with which comparison of results were made. Lekki is a relatively low-emission area of the four sites. Questionnaires were administered on a total of 310 respondents to determine the effects of emissions on their health, particularly in congested areas of Oshodi where heavy vehicular emissions are common.

Preliminary observations were done for 2 months in many areas before selecting the sampled areas. These are the areas where there are heavy flows of transportations. A total of 100 respondents were carefully selected each from the three locations, while 10 respondents were chosen from the control area. Questionnaires were administered on them over a period of 12 months. The selected respondents include office workers, market women, street hawkers, drivers, conductors, traders and residents.

Those that had difficulty in responding to the questionnaires were assisted by the crewmembers. The questionnaires were analysed based on the factors/symptoms that constitute health problems. The procedure carried out in achieving the objectives of this study is related to questionnaire administration and analysis.

Procedure related to questionnaire administration and analysis

1. A pre-survey is carried out by going to the field to understand what classes of respondents would be involved and answering the questionnaire, and possibly estimating the population so that sample size could be determined.
2. Based on (1), questionnaires are designed and a test-survey is carried out to refine the questions posed in the instrument and to determine its adequacy.
3. Based on the target number of respondents, the questionnaire is designed and administered on the respondents. A response rate of 100% is the target since the questions are simple enough not to consume much of respondents' time, and for economic purpose.
4. Based on the returned questionnaires, analysis of items contained therein is then made.

RESULTS AND DISCUSSION

Tables 4.0 show the average traffic volume per hour in the monitored sites.

Table 4: Average traffic volumes per hour in selected points in Ado Ekiti metropolis

Sampling Site	Average traffic volume per hour			
	Motorcycles/tricycles	Cars/buses	Trucks/ lorries	Total
Yaba	3998 ± 16	4126 ± 12	500 ± 2	8624 ± 30
Oshodi	4106 ± 19	5312 ± 14	1001 ± 1	10419 ± 34
Ojota	3919 ± 20	5128 ± 18	1125 ± 1	10172 ± 39
Lekki	884 ± 8	3913 ± 10	196 ± 4	4993 ± 22

For clarity on the data generated from the field survey as well as in the statistical analysis carried out on the data, the discussion will be done based on the following headings:

- Comparison of pollutants concentration at all the sampled points and at the various times of the day.
- Comparison of data with Federal Ministry of Environment Standards
- Comparison of air quality data with air quality index of the United States
- Comparison of data at traffic points with those at background as well as at the control location
- Predictive modeling of pollutant concentration with increasing distance from source of emission.

Comparison of Pollutants Concentration at Sampled Points for Dry and Wet Season

Dry Season: A summary of the average data obtained during the dry season for morning, afternoon and evening hours are presented in Tables 5 to 7

Table 5.0: Average concentration of pollutants during the morning hours in dry season

AIR Quality Parameter						Meteorology		
Location	**CO (ppm)**	**NO_2 (ppm)**	**SO_2 (ppm)**	**CO_2 (ppm)**	**HC (ppm)**	**Air Temp. (oc)**	**Relative Humidity (%)**	**Wind Speed (km/h)**
Yaba	43.80	0.039	0.099	338.00	0.037	28.0	79.8	13
Ojota	44.73	0.038	0.099	337.33	0.027	28.1	77.8	14
Oshodi	50.67	0.043	0.094	334.67	0.039	28.4	79.8	13
Lekki	21.25	0.028	0.044	373.00	0.004	27.3	73.2	15

Table 6.0: Average concentration of pollutants during the afternoon hours in dry season

AIR Quality Parameter						Meteorology		
Location	CO (ppm)	NO2 (ppm)	SO2 (ppm)	CO2 (ppm)	HC (ppm)	Air Temp. (oc)	Relative Humidity (%)	Wind Speed (km/h)
Yaba	47.30	0.042	0.089	350.00	0.028	29.0	60.8	15
Ojota	49.53	0.043	0.089	355.67	0.026	29.1	69.8	14
Oshodi	50.77	0.039	0.088	340.10	0.012	31.4	69.8	13
Lekki	21.95	0.029	0.047	397.00	0.008	28.3	73.2	14

It is observed from the results in Tables 5.0 to7.0 that the average concentration of CO at the traffic spots was highest at Oshodi for both morning, afternoon and evening hours (30.67, 30.77 and 33.67ppm respectively) and least at Lekki during the same periods (11.25, 11.95 and 15.30 ppm respectively). The same was the case for all other pollutants (NO_2, SO_2, and HC) for both morning and evening hours with highest concentrations recorded at Oshodi and least at Lekki.

The highest concentration recorded at Oshodi in the morning hours is not unconnected with the fact that it coincides with when workers and traders usually go to work and business. With the Oshodi forming the major intersection between the constitution roadsto various part of Lagos, vehicles are at “idle speed” because of the slow pace of traffic at which condition they tend to emit more pollutants. The same is true for the evening hours.

All the sites, however, experiences higher traffic in the afternoon hence most emission in the afternoon are at high side. Business is usually at its peak at this time of the day and as such more vehicular movement is experienced in and around the sites. Ojota and Yaba are areas that equally experience high traffic during the morning hours. Afternoon and the evening hours seem not to be left out as pollutants concentrations are equally high. These areas are known for their high residential provision for the populace in Lagos metropolis.

On a general assessment of the average pollutants concentrations, Lekki experience the lowest pollution in the metropolis. While Oshodi, Ojota and Yaba experience the most traffic in descending order. A careful assessment of the pollutant concentration recorded at various days of the week indicates that in as much as Saturday is a weekend and public civil servants are not expected to go to work, emission concentration was quite high.

Sunday, however recorded the least traffic and hence least pollutant concentration because most places of work and businesses were usually closed.

Table 7.0: Average concentration of pollutants during the evening hours in dry season

AIR Quality Parameter						Meteorology		
Location	CO (ppm)	NO2 (ppm)	SO2 (ppm)	CO2 (ppm)	HC (ppm)	Air Temp. (oc)	Relative Humidity (%)	Wind Speed (km/h)
Yaba	44.60	0.039	0.080	330.00	0.024	31.0	92.8	13
Ojota	49.50	0.044	0.080	349.67	0.033	29.1	99.8	14
Oshodi	53.67	0.047	0.082	340.00	0.042	28.4	99.8	13
Lekki	25.30	0.025	0.048	380.50	0.015	28.2	83.2	14

Wet Season: A summary of results obtained during the wet season are presented in Tables 8.0 to 10.0. The results indicate that the CO concentrations recorded highest values at Oshodi and Ojota. The highest concentration recorded during the morning hours was 19.90ppm at Oshodi and 15.33ppm at Ojota and 14.93ppm Yaba. Lekki recorded the least CO concentrations of 7.3ppm during the morning hours.

A similar observation was noticed during the afternoon and evening hours where CO concentrations peaked at 20.27ppm and 24.0ppm for both afternoon and evening at Oshodi while the Ojota recorded concentrations of 19.37ppm and 22.27ppm in the afternoon and evening hours respectively. It is interesting to know that the peak values recorded for both Oshodi and Ojota were recorded on a Saturday.

This is connected with the fact that commercial and business activities normally reaches its peak in the afternoon, and with traders and buyers itching to return home after the day’s business, traffic and hence pollutants concentration levels will rise. Besides, it is expected that government workers would take out the opportunity of a work-free day to do some buying and selling thereby adding up to the impact around those areas.

Yaba equally recorded a high CO concentration of 20.87ppm in the evening. Therefore, CO concentration is mostly highest during week days at Oshodi throughout the day due to high level of commercial activities and presence of big buses (molue) which emit high pollutants.

Table 8.0: Average concentration of pollutants during the morning hours in wet season

AIR Quality Parameter						Meteorology		
Location	CO (ppm)	NO_2 (ppm)	SO_2 (ppm)	CO_2 (ppm)	HC (ppm)	Air Temp. (oc)	Relative Humidity (%)	Wind Speed (km/h)
Yaba	34.93	0.025	0.084	353.00	0.023	28.97	99.50	13
Ojota	35.33	0.025	0.086	350.67	0.024	28.23	90.87	13
Oshodi	39.90	0.030	0.083	351.67	0.024	29.10	92.30	13
Lekki	17.53	0.026	0.045	373.67	0.019	27.93	96.50	13

Table 9.0: Average concentration of pollutants during the afternoon hours in wet season

AIR Quality Parameter						Meteorology		
Location	CO (ppm)	NO2 (ppm)	SO2 (ppm)	CO2 (ppm)	HC (ppm)	Air Temp. (oc)	Relative Humidity (%)	Wind Speed (km/h)
Yaba	37.10	0.028	0.089	333.33	0.024	29.97	85.40	13
Ojota	39.37	0.025	0.088	351.67	0.018	29.77	84.97	14
Oshodi	40.27	0.027	0.080	352.67	0.023	29.2	88.57	14
Lekki	16.78	0.020	0.041	362.33	0.014	28.50	81.07	13

Table 10.0: Average concentration of pollutants during the evening hours in wet season

AIR Quality Parameter						Meteorology		
Location	CO (ppm)	NO2 (ppm)	SO2 (ppm)	CO2 (ppm)	HC (ppm)	Air Temp. (^oC)	Relative Humidity (%)	Wind Speed (km/h)
Yaba	40.87	0.032	0.084	354.67	0.030	29.90	86.17	13
Ojota	42.27	0.032	0.084	360.00	0.028	28.73	85.03	14
Oshodi	44.00	0.031	0.084	352.67	0.025	28.47	86.33	13
Lekki	21.33	0.025	0.044	373.00	0.023	28.97	89.5	15

Observation on the Nitrogen dioxide (NO_2) concentration indicate that even though formation of NO_2 take place at high temperature, it could not be clearly established whether a high temperature was actually responsible for the results obtained from field. Because, even where temperature was adjudged to be low, it was discovered that NO_2 concentrations were higher compared to when temperature was high. However, when the results were compared with David and Frederikse (1997), taken at 15^{o}C, it was observed that the results recorded on field were higher (between 0.03ppm and 0.04ppm) compared to David and Frederikse (1997) that recorded 0.02ppm at 15^{o}C. A comparison of the general assessment of the air quality situation at the sites for both seasons indicates that the pollutants" concentration during the dry season was higher compared to the wet season concentration.

COMPARISON OF AIR QUALITY DATA (DRY AND WET SEASON) AT TRAFFIC SITES

Dry season

Results of the comparison of air quality data recorded at tested sites during the dry and wet seasons are presented in Figures 6.0 to 10.0. In order to come up with an affirmative conclusion as to the air quality status of Lagos metropolis, descriptive statistics was used in the analysis. The air quality data for Lagos metropolis was compared with National Ambient Air Quality Standard (Table 3.0) as shown in the Figures 1.0 to 5.0.

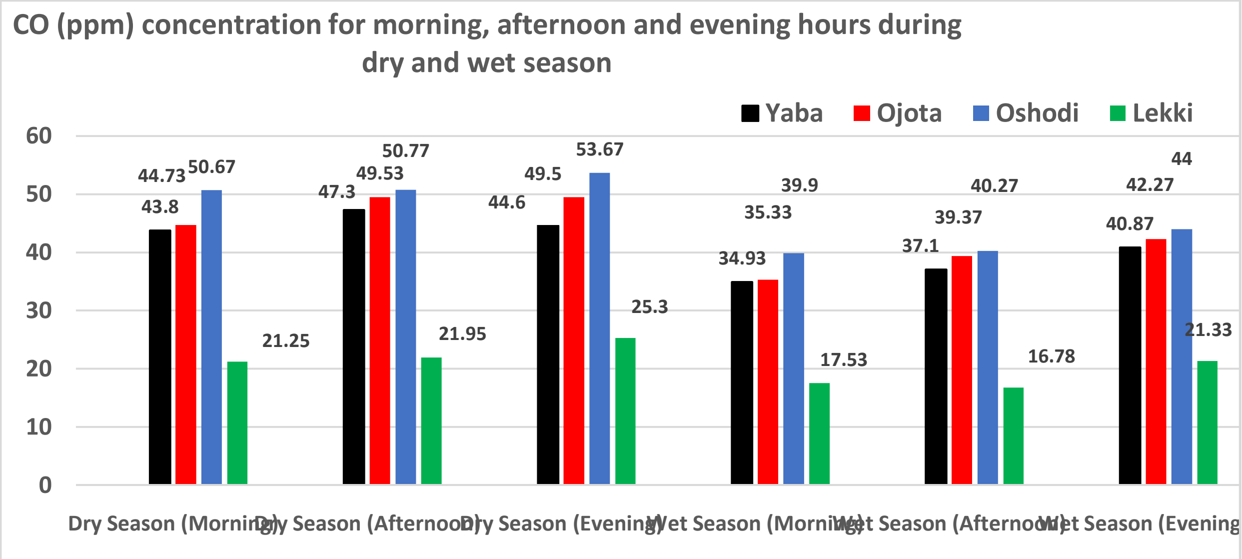

Figure 1.0: CO concentration for morning, afternoon and evening hours during dry and wet season

Figure 1.0 shows that the CO level in all the sites exceeds the 1 hour averaging time of 35ppm. This is more worrisome because it occurs in all the sites tested all through the day except Lekki metropolis. The same is observed for the 8 hours averaging time of 9ppm. The implication of this is that most of the vehicles in all the sites are not well maintained and this might have led to incomplete combustion that produces high pollutant of CO and in as much as people subsist daily in these areas to carry out their business activities, they are constantly exposed to these concentrations of pollutants which are released at ground level (i.e. human breathing level) with their attendant health implication. The short-term limit of 35 ppm based on one hour average is meant to prevent the immediate health effects that may occur from exposure to CO for a short period of time (e.g. one hour). Though, even at 9 ppm, a short-term effect may not be felt but it is important to know that the effect of CO is not only related to the level and duration of exposure but also on an individual's health status. An individual's exposure to a CO level as recorded in the sites is capable of causing headache, dizziness and exertion. It may even be severe in individuals with health conditions such as asthma.

Similarly, a comparison of the nitrogen dioxide (NO_2) concentration reveals that the 0.01 ppm limit for an averaging time of 1 hour is being exceeded in all the sites. Though, these occur at different hours of the day as can be seen in Figure 2.0, they tend to increase above the national standards. For the annual averaging time of 0.053ppm, however, the four sites were well within the EPA National limits.

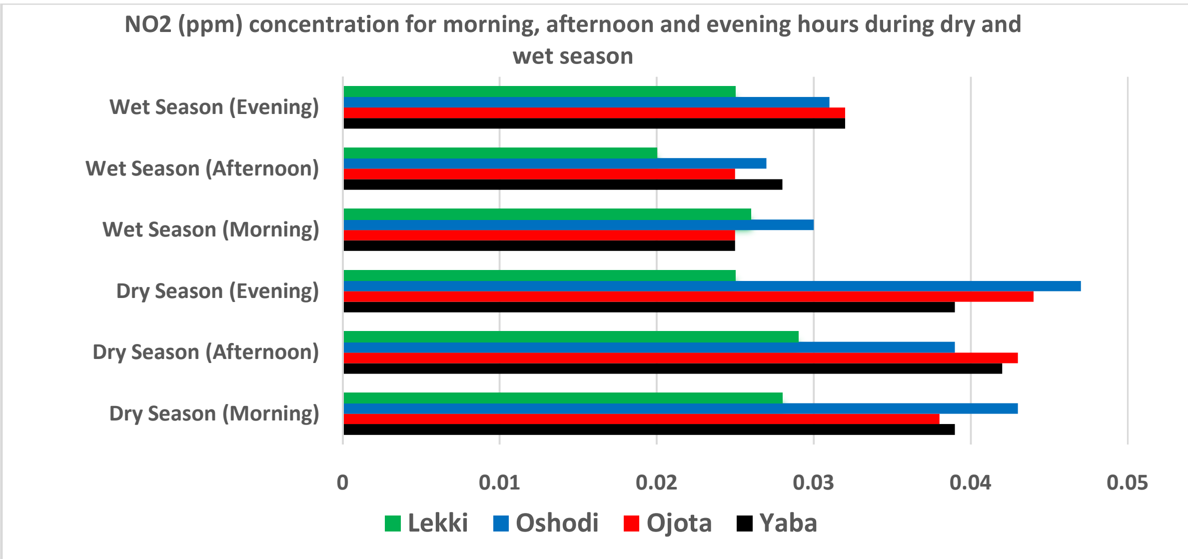

Figure 2.0: NO_2 concentration for morning, afternoon and evening hours during dry and wet season

Figure 3.0 shows the comparison in the case of SO_2. It is observed that the entire site surveyed, fell short of the 0.075ppm for an averaging time of 1 hour except the Lekki site that recorded lower limits all days including 0.5 ppm limits for 3 hours duration.

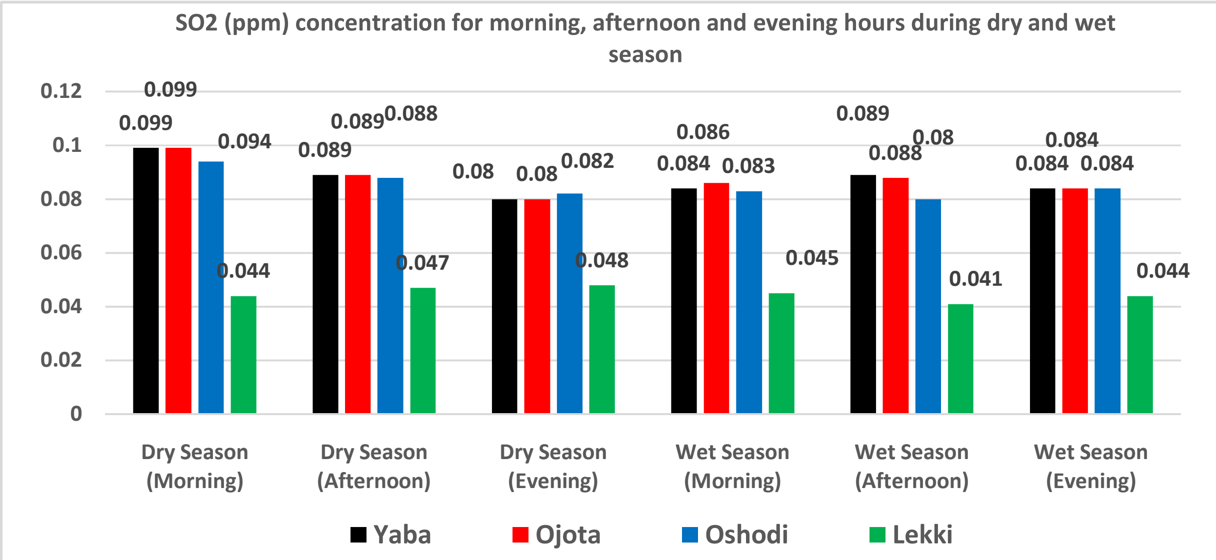

Figure 3.0: SO_2 concentration for morning, afternoon and evening hours during dry and wet season

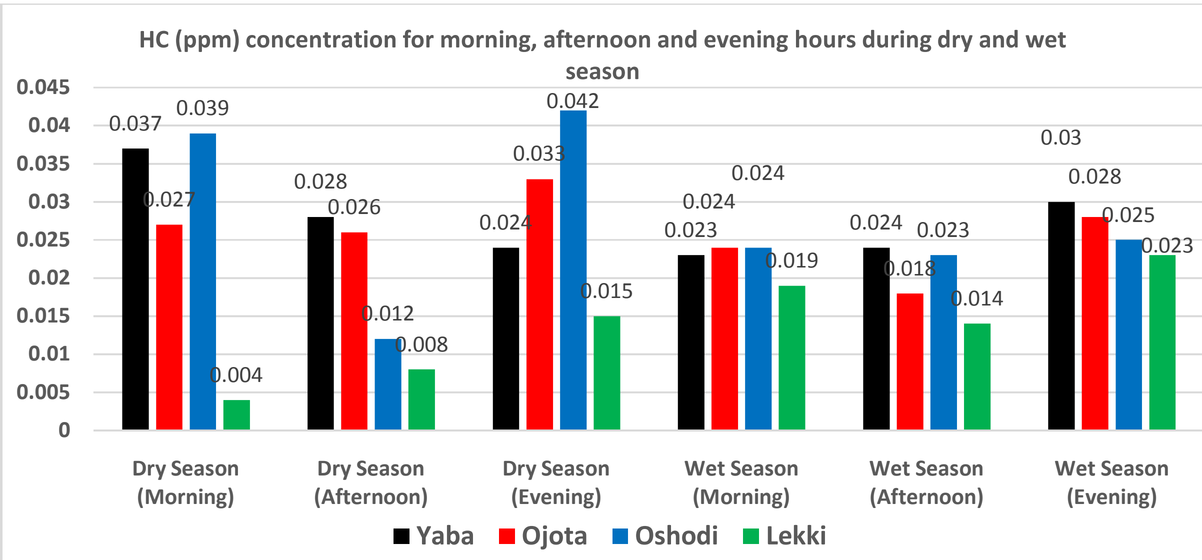

Figure 4.0: HC concentration for morning, afternoon and evening hours during dry and wet season

The sampled sites were all within set limits in terms of the concentration of HC. This is clearly seen in Figure 4.0. Except at crude oil drilling sites or in the event of an oil spill resulting from an accident, it may be difficult for HC concentration to attain the set limit of 0.6ppm.

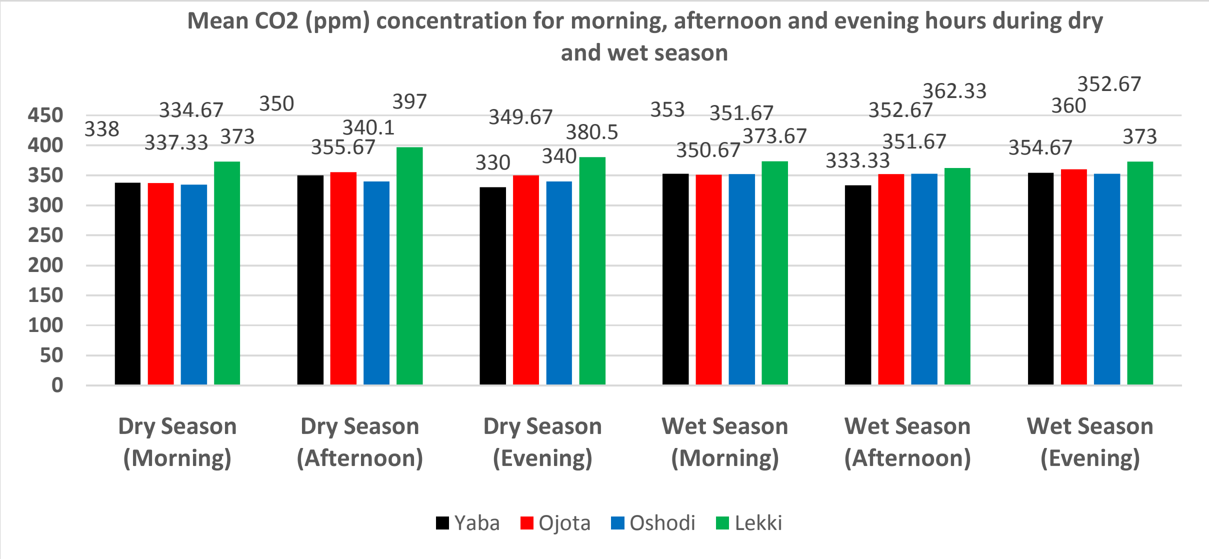

Figure 5.0: CO_2 concentration for morning, afternoon and evening hours during dry and wet season

Figure 10.0 shows the CO2 level for the sampled sites. Low level emission was recorded at Oshodi while high emission was recorded at Lekki this could be due to the fact that most of the trucks and buses operating at Oshodi area lack maintenance which could lead to incomplete combustion that produces high level of carbon monoxide and low level of carbon dioxide whereas most of the vehicles at Lekki metropolis are cars with good maintenance which lead to complete combustion that produces high CO_2 and low CO. There is however no national ambient air quality standards for CO2 concentration in the atmosphere, but literature survey show that the average concentration of CO2 in ambient air stands at 314 ppm (David and Frederikse, 1997). This therefore implies that the average concentration of CO2 in Lagos metropolis is above the ambient standard presented by David and Frederikse, 1997.

SURVEY RESULTS

Tables 11.0, show details of the selected respondents for the survey taking in four cities of Lagos. Table 12.0 shows the results of the responses from the questionnaires administered on the respondents. It should be stated that in allcases, Lekki is chosen as a control area in view of its relatively low emission level.

Table 11.0: Effects of Automobile Emissions on the Respondents at Oshodi (OS), Yaba (YA), Ojota (OJ) and Lekki(LK)-(Control area)

Respondent	Number of people affected by: Sleeplessness (OS,YA,OJ,LK)	Number of people affected by: Catarrh (OS,YA,OJ,LK)	Number of people affected by: Heavy eye (OS,YA,OJ,LK)	Number of people affected by: Asthmatic attack (OS,YA,OJ,LK)	Number of people affected by: Headache (OS,YA,OJ,LK)
Office workers	(2,1,1,0)	(4,3,4,0)	(1,6,5,0)	(0,0,1,0)	(5,4,5,0)
Market women	(2,4,3,0)	(6,3,6,0)	(3,2,2,0)	(0,0,0,0)	(1,1,3,0)
Street hawkers	(3,2,3,0)	(4,6,6,0)	(6,5,5,0)	(1,0,0,0)	(4,3,4,0)
Drivers	(2,2,1,1)	(1,2,3,3)	(4,3,3,2)	(0,0,0,1)	(2,5,3,0)
Conductors	(2,2,2,2)	(3,3,3,2)	(2,3,2,2)	(1,1,1,0)	(0,2,2,2)
Traders	(4,2,5,2)	(5,4,6,5)	(3,5,2,8)	(1,1,1,5)	((3,4,4,2)
Residents	(4,3,1,0)	(2,4,3,0)	(4,7,6,0)	(2,1,2,0)	(3,3,4,0)
Totals	(29,16,16,5)	(25,25,31,10)	(21,31,25,12)	(4,2,4,6)	(18,22,25,4)

Table 12.0: Distribution of the respondents in the study areas

Respondents	Oshodi		Yaba		Ojota		*Lekki (Control)		Totals
	Male	Female	Male	Female	Male	Female	Male	Female	
Office workers	3	8	9	7	9	6	-	-	42
Market women	-	12	-	14	-	10	-	-	36
Street hawkers	6	12	10	8	9	10	-	-	55
Drivers	10	-	10	-	12	-	4	-	32
Conductors	9	-	9	-	10	-	3	-	29
Traders	10	9	6	12	7	10	6	6	50
Residents	6	12	10	7	8	10	-	-	53
Totals	44	53	54	48	55	46	13	6	319

Table 13.0: Effects of automobile emission on the respondents in the study areas

No. of respondents affected					
Ailment	Oshodi	Yaba	Ojota	*Lekki (Control)	Totals
Sleeplessness	19	16	16	9	51 (17%)
Flu	31	25	25	0	31 (27%)
Heavy eye	21	31	25	18	87 (29%)
Asthmatic attack	4	3	2	10	9 (3%)
Headache	25	18	22	7	65 (21.7%)

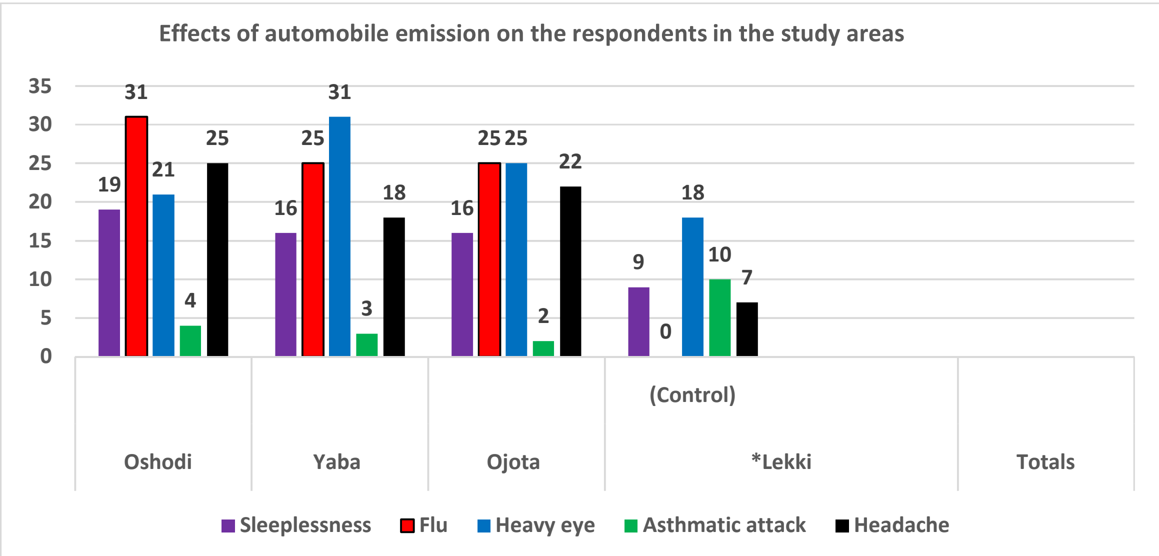

Figure 6.0: Effects of Automobile Emission on the respondents in the study areas

Using the experimental information, it was suggested that the health effects measuredin the areas that experienced higher levels of vehicle emissions were in fact attributable to vehicle emissions as shown in Table 13.0. Variations in the effects of automobile emissions in four Lagos cities were observed in this study as shown in Figure 6.0.

The respondents in Oshodi were frequently affected by Flu.This may be due to the heavy emissions from big buses (*Molue*) that ply Oshodi roads. These vehicles are mainly powered by diesel fuel and in most cases, are not frequently serviced. They operate almost 20 hours a day, hence the possibility of worn rings thereby causing heavy soot from their exhaust pipes.

Asthmatic attacks were rare in all areas, but traders in Lekki showed the highest complaints. Heavy eye, which is closely linked to sleeplessness, ranks first in Oshodi. Since this is a commercial nerve centre of Lagos, there is the possibility of the respondents staying around this area for the greater part of their day.

Therefore after assimilating different kinds of emissions for a large number of hours, they suffer from heavy eye which is the cause of sleeplessness. The percentage of respondents affected by heavy eye was highest in Yaba and this may be due to the fact that small buses and tricycles are more common in this area. The emissions from these vehicles are lighter as compared to those from the big buses that are common in Lagos.

The effects of these emissions may not be more noticeable during the day on the people but a night, the people find it difficult to sleep due to heavy eye. Some of the respondents of Ojota suffered from catarrh. This may be due to the fact that offices, banks and business areas are along the bus stops in this city.

Twenty percent of the respondents in Yaba are affected by headache. It is observed that majority of the small buses that are petrol driven plying Yaba are not well maintained therefore, the more poisonous coexists from exhaust pipes due to worn rings, leakages from the mufflers, etc. Asthmatic effects were very small (3%) in Ojota and this is due to the fact that the small buses and tricycles plying this city are not usually overloaded which gives room for more air spaces inside the vehicles in this area, therefore, there are more spaces for the rapid diffusion of the emission from the vehicles.

In Yaba, there is a mixture of big buses and small buses, this allows for exhaust emission from both diesel and petrol engine. Since these emissions are a mixture of gases from different sources, it results quickly into adverse effects on the respondents hence the greatest percentage of the respondents in this area suffer from heavy eyes. Yaba and Oshodi are the gateway to Nigeria economy, most of the company and markets are located here. There are many types of vehicles plying this area mainly big buses which produce heavy emission.

Twenty-five percent of respondents from Ojota suffer headache and the aftermath is sleeplessness. This is due largely to the amount of gases (exhaust) that they have emitted during theday while undergoing their business activities. There is a high percentage (16%) of respondents being affected by sleeplessness in Ojota. This area is partly residential and commercial. The subtle emission from different kind of second hand vehicles across all the sites are being felt during the nights resulting in sleeplessness.

CONCLUSIONS

Comparison the vehicular emissions of the survey sites with National Ambient Air Quality Standards, CO concentration exceeded both the 1 hour limit of 35ppm and the 8 hours limit of 9ppm in all the sites during the dry season except for Lekki where only the 8 hour limit was exceeded. In the wet season most sites exceeded the 35ppm limit, most however were within the 8 hour limit of 9ppm. For sulphur dioxide (SO_2), both seasons experienced concentrations beyond the 1 hour standard of 0.075ppm. All the sites were above the 1 hour limit of 0.01ppm for nitrogen dioxide in the dry and wet season. Hydrocarbon concentrations in both seasons were within the 0.6ppm limits. Carbon dioxide (CO_2) in both seasons was above the 314ppm obtainable in pure air. In conclusion, an assessment of the carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) quality in the ambient air of Lagos metropolis using the Air Quality Index of the United States indicated a poor air quality in both dry and wet season. While all sites except Lekki, were adjudged “very unhealthy” in terms of CO concentration during the wet season, Oshodi, Ojota and Yabawere adjudged “very unhealthy” in the wet season. NO_2 quality was “good” in both seasons in all the sites surveyed. On the other hand, SO_2 quality in the dry season was “moderate” in all sites except Lekki which was “good”.

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